



research for a sustainable future



Groundwater management in the Namoi: a social perspective Report No. 67

Emily Sharp
Allan Curtis

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Cotton Catchment Communities CRC National Centre for Groundwater Research and Training

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Emily Sharp and Allan Curtis

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List of acronyms

ABARE – Australian Bureau of Agricultural and Resource Economics
ABARES – Australian Bureau of Agricultural and Resource Economics and Sciences
ABS – Australian Bureau of Statistics
AC beliefs – awareness of consequences beliefs
ANU – Australian National University
ASR – aquifer storage and recovery
BRS – Bureau of Rural Sciences
CMA – Catchment Management Authority (e.g. Namoi CMA)
Cotton CRC – Cotton Catchment Communities Cooperative Research Centre
CSIRO – Commonwealth Scientific and Industrial Research Organisation
CSU – Charles Sturt University
MDBA – Murray-Darling Basin Authority
NCGRT – National Centre for Groundwater Research and Training
NLWRA – National Land and Water Resources Audit
NoW – New South Wales Office of Water
NRM – natural resource management
NWC – National Water Commission
SDLs – sustainable diversion limits
VBN theory – Value-belief-norm theory
WAL – water access licence
WSP – water sharing plan

Executive Summary

The Cotton Catchment Communities CRC and the National Centre for Groundwater Research and Training (NCGRT) commissioned research to assess the environmental, economic and social impacts of changes in water availability in the Namoi catchment. As part of this larger integrated project, the social researchers at Charles Sturt University undertook a survey to better understand landholder views about groundwater management issues and how landholders are adapting their farming practices in response to reduced water availability. Quantitative data were collected through a questionnaire mailed to all farming properties associated with a groundwater licence in the Namoi catchment (n=447), with the exception of the Peel River sub-catchment. This census of licence-holders achieved a 54% response rate (210 completed surveys). The key findings from the survey are summarised below using survey topics.

Social and property characteristics

Most respondents identified themselves as farmers (84%) who owned (94%) and lived on (85%) their property. Most respondents were male (89%), and the majority of respondents were members of a local industry group (67%) and had completed a short course relevant to property management in the past five years (68%). One-third of respondents had used financial support provided by Federal or State government natural resource management programs for on-property work.

The median hours of farming-related on-property work per week for all respondents over the past 12 months was 55 hours. Considerable time was also spent on off-property work with 39% of respondents indicating that they had worked off-property in the past year, spending a median 100 days working off-property each year.

Respondents from the Lower Namoi management zone had significantly longer periods of time that they had managed their properties (median 30 yrs) and longer lengths of family ownership (median 39.5 yrs) than respondents in the Upper management zones (Zones 1-12 combined, management median 20 yrs; family ownership median 28 yrs).

The median property size for all respondents was 902 hectares. Respondents from the Lower Namoi management zone had significantly larger properties than the Upper management zones. Lower zone respondents also had significantly larger areas cultivated and laid out to irrigation.

Responses showed that there had not been much change in land use at the catchment scale from 2005-2006 to 2010-2011 or projected for 2015-2016. The median total area cultivated and irrigated also remained fairly stable over time. The key exception was that the proportion of respondents growing dryland cotton increased from 4% to 19% between 2005-2006 and 2010-2011.

Views on current water policy issues

Guide to the Murray-Darling Basin Plan (2010)

Most respondents did not agree that the science used to calculate sustainable diversion limits in the Guide to the Murray-Darling Basin Plan released in October 2010 was sound (only 5% agreed compared to 63% disagreed). Most respondents did not agree that they could adapt their enterprises to further groundwater entitlement reductions (78%) or surface water entitlement reductions (62%). There were significant differences between responses in the Lower management zone and the Upper management zones in perceived ability to adapt to reductions. Fifteen percent of respondents in the Upper zones agreed that they could adapt to groundwater entitlement reductions, but only 6% in the Lower zone agreed. Upper zone respondents were also more likely to agree (29%) that they could adapt to surface water entitlement reductions than Lower zone respondents where only 2% agreed that they could adapt.

Only 13% of all respondents would be willing to sell part of their groundwater entitlements to the government if buybacks were offered as part of the sustainable diversion limits set under the Murray-Darling Basin Plan.

Groundwater management issues

Just over half (51%) of all respondents agreed that groundwater zones in the Namoi catchment are appropriate. Overall, slightly less than one-third (30%) of respondents agreed that over-allocation of groundwater was a problem in their management zone. However, there were significant differences across the different management zones regarding over-allocation. For example, only 14% of respondents in Zones 2 and 9 (Cox's Creek sub-catchment) said that over-allocation was a problem in their zone. However, respondents in the Mooki Valley were more likely to agree that groundwater over-allocation was a problem with 50% of respondents in Zone 8 and 35% of respondents in Zone 3 agreeing to this statement.

Water sharing plan process

More than a third of respondents (41%) disagreed that input from local farmers shaped the current water sharing plan (WSP) and 45% disagreed that there were meaningful opportunities to participate in the development of the WSP. Only 16% of all respondents thought the decision-making process for the WSP was fair. Respondents who were more likely to trust the NSW Office of Water, express environmental and altruistic values and beliefs and support a stewardship ethic were more likely to be supportive of the water sharing plan process undertaken in the period 2000-2006.

Duty of care, stewardship ethic and property rights

There appears to be a strong base of support for a duty of care for biodiversity in that most (67%) agreed that it is fair that the wider community asks landholders to manage their ways that will not cause foreseeable environmental harm. However, there was less evidence of a landholder stewardship ethic with only (39%) of respondents agreeing that short-term reductions in farm production are justified when there are long-term environmental benefits. A small percentage of

respondents agreed (12%) that landholders should have the right to use groundwater underlying their properties, even if that action impacted others, but most (81%) respondents disagreed. Respondents who expressed support for a stewardship ethic and a duty of care were also more likely to express altruistic and environmental values and agree that they can adapt to groundwater and surface water entitlement reductions.

Collective management of groundwater

Responses showed general support for collective management of groundwater. Sixty-nine percent of respondents agreed that collective management of groundwater at the local scale would ensure operating rules are appropriate to local conditions and environmental circumstances. Respondents also seemed to support the Government playing an 'umpire' role in collective management, with 61% of respondents indicating that it would be desirable to have Government oversee operating rules developed with landholder input. The findings suggest that respondents with pro-conservation values and beliefs, and altruistic (i.e. looking after others, the greater good or the community) values and beliefs are more likely to support collective governance arrangements while older licence-holders are less likely to express support. The findings also suggest that implementation of collective management will be more acceptable to licence-holders if it has the strong support of practitioners on-the-ground with whom licence-holders find more trustworthy than the agency itself.

Groundwater licence compliance

Respondents generally agreed that they, and others in their management zone, did their best to comply with the conditions of their water licences. For example, nearly all respondents (87%) agreed that it was important to comply with licence conditions and that they did their best to comply with the maximum allowable volume of water they can pump under their licence conditions (94%).

Nearly two-thirds (67%) of respondents thought that other licence-holders in their zone complied with reporting requirements. There was a significant difference between responses in the Upper Namoi management zones (Zones 1-12 combined) and the Lower management zone. Whereas 80% of respondents in the Lower management zone agreed that licence-holders in their zone complied with reporting requirements, 63% of respondents in the Upper zones agreed with this statement.

Aquifer storage and recovery

Research suggests that it may be possible to lift groundwater levels and reconnect surface water and groundwater flows, while also providing additional groundwater for irrigators, through a process called aquifer storage and recovery (ASR). One section of the questionnaire gauged respondents' interest in this technology based on its use with large flood events. Sixty-five percent of respondents agreed that aquifer storage and recovery based on intercepting large flood events was a good idea. However, some respondents were uncertain about the use of ASR and, in an open-ended section, expressed concerns about water quality, environmental impacts and implications for groundwater entitlements.

Personal values

The values section of the questionnaire asked respondents how much importance they placed on a range of environmental, altruistic and egoistic (or economic) values. All but one of the values was rated by most respondents as being of at least some importance in their lives. The value items with the highest ratings all measured environmental values. Older respondents and respondents who had participated in government NRM programs were more likely to place greater importance on altruistic values such as *'fostering equal opportunities for all community members'*. Respondents who worked greater hours on-property, were not Landcare members and who had larger property sizes, larger areas cultivated and larger total dam capacities were more likely to place greater importance on economic values, such as *'creating wealth and striving for a financially profitable business'*. The environmental values showed significant relationships with the environmental norms and beliefs in other sections of the survey providing support for Stern et al.'s (1998) value-belief-norm theory.

Norms for groundwater protection and carbon emissions

At least three quarters of survey respondents said they feel a personal obligation to act either as an individual or part of a group to protect the district's groundwater resource. There was a much lower level of personal commitment to act either as an individual (49%) or part of a group (34%) to reduce carbon emissions. Respondents who expressed pro-conservation values and beliefs were significantly more likely to express personal norms for both groundwater protection and carbon emission reductions at individual, group and community levels. Respondents who had a greater business focus and who were more likely to express economic values and beliefs were significantly less likely to express norms for carbon emission reductions but did feel a personal obligation to protect groundwater resources as part of a group.

Beliefs about the Namoi catchment

The beliefs section of the survey measured respondents' beliefs about a range of environmental, altruistic and economic issues in the Namoi catchment. The findings showed conflicting interests among respondents. For example, a large majority of respondents believe that water reform will have substantial personal impacts (81%) and that a healthy river contributes to human well-being (71%). Although half the respondents believe environmental flows are essential to maintaining river health (56%), very few believe that returning water to the environment is the best way to improve in-stream habitat (22%). While a large majority believe groundwater is an important resource for future generations (80%), only a third of respondents believe current pumping can harm other users.

Respondents who were more likely to agree that water reform will have substantial personal impacts were also less likely to say that they could adapt to further reductions in groundwater and surface entitlement, less likely to believe the science used to calculate sustainable diversion limits was sound and less likely to agree that they would be willing to sell their groundwater entitlements. Those respondents who supported a duty of care and stewardship ethic were also more likely to agree with the environmental and altruistic belief statements.

Views about climate change

Climate change beliefs

Respondents were more likely to express views consistent with a belief in climate change (41%) than to deny the existence of climate change, but substantial proportions were either unsure (33%) or appeared to deny (26%) that climate change existed. Most respondents seemed to be optimistic about human ability to adapt to climate change, with 73% agreeing that humans will always adapt to their environment; only 12% disagreed with the statement that it was not too late to take action to address climate change; and 43% disagreed with the statement that if we do nothing, climate change will have dire consequences. Respondents who believed in climate change and that it was influenced by human activities and would have dire consequences if nothing is done, were more likely to have pro-conservation beliefs and to be supportive of government processes and science used in plans for groundwater management. Conversely, climate change sceptics, or those respondents who were more likely to agree with the statements, ‘*There is no such thing as climate change*’ and ‘*Humans will always adapt to their environment*’ were more likely to express economic-focused beliefs and less likely to show support for government processes and science used in groundwater management.

Perception of climate change likelihood

Around one-quarter to one-third of respondents who completed this survey section rated the likelihood of impact as ‘Likely’ or ‘Highly Likely’ for: personal health and well-being (25%); property water supply (36%); and, property production (38%).

Perceived impact of climate change and ability to adapt

Respondents who completed this survey section were more likely to think there would be a negative rather than a positive impact on production, water supply and personal well-being and health. Most respondents indicated they could adapt to the impacts of climate change. Respondents with larger property sizes and larger areas cultivated in 2010-11 were significantly more likely to say that they could adapt property production and water supply to climate change. Conversely, older farmers were significantly less likely to think that they could adapt property production and water supply.

Trust in the NSW Office of Water

One section of the questionnaire covered respondents’ interactions with the NSW Office of Water (NoW). These item statements measured the trustworthiness of the agency and its staff and the willingness of respondents to rely on NoW. Respondents generally disagreed that:

- NoW, as an organisation, keeps water licence-holders’ interests in mind when making decisions about groundwater management (42% disagreed compared to 15% agreed).
- Sound principles seem to guide NoW organisational decisions about groundwater management (41% disagreed compared to 13% agreed).
- NoW shows good judgement when making decisions about groundwater management (52% disagreed compared to 6% agreed).

Forty percent of respondents disagreed with the statement, *“I can rely on NoW, as an organisation to manage groundwater in a sustainable manner”* while only 10% agreed. Similarly, only 8% agreed that they could rely on NoW to manage groundwater in a way that was fair to all users compared to 47% who disagreed.

It is important to note that many respondents did not have a strong opinion about items in this section with more than 40% of respondents answering “Unsure”. This may suggest that some respondents have not had many interactions with NoW which would allow them to develop opinions about these items.

Land use change and innovative practices being undertaken now and in the past five years

Licence-holders are faced with the task of finding ways to adapt their enterprises to many changing conditions, including changes in water policy, technology and climate. The top ten management actions taken in the past five years included: *‘changed tillage technique’*, *‘changed crop types in rotation’*, *‘changed crop rotation frequencies’*, *‘invested in new planting machinery’*, *‘modified flood irrigation approach’*, *‘deepened dam’*, *‘decreased cropping area’*, *‘changed to spray irrigation’*, *‘sought additional off-property work’*, and *‘changed drainage method’*.

Some of the 10 most frequently implemented management actions are directly related to water use efficiency, such as modify flood irrigation (40%), deepen dam (25%), decrease cropping area (40%), change to spray irrigation (28%) and change drainage method (26%). However, these actions were not undertaken by the majority of respondents. Larger dam capacities were significantly associated with uptake of several water use efficiency measures, including: deepen dam, divide dam into cells, measure evaporation losses and implement soil moisture mapping. This suggests landholders who store greater amounts of water are more interested in adopting water use efficiency measures.

Land use changes and innovative practices being undertaken in the next five years

Management actions being considered in the next five years were very similar to those taken in the previous 5 years. However, the top 10 actions being considered did not include: *‘Change drainage method’*; *‘Seek off-property work’*; or, *‘Decrease cropping area’*. These three items were replaced in the top ten actions being considered by: *‘Routinely test water quality’*; *‘Implement soil moisture mapping’*; and, *‘Measure dam evaporation losses’*.

Data analysis indicated that more than half of the respondents who had undertaken the following property management actions in the past five years were definitely planning on taking the same action in the next five years: change to spray irrigation (74%); purchase/lease more land (55%); utilise spray polymers (75%); implement soil moisture mapping (51%); and, routinely test water quality (51%). However, encouraging uptake of water use efficiency and conservation actions by licence-holders who have not already commenced doing so may be challenging. Very few of these respondents (less than 10%) indicated that they were planning on taking many of the 26 management actions if they hadn’t already done so in the past five years. The exceptions to this included the following actions in which more than 10% of the respondents who had NOT undertaken the following property management actions in the past five years were definitely planning on taking that action in the next five years: invest in planting machinery (17%); change to spray irrigation (17%); modify flood irrigation approach (15%); purchase/ lease more land (34%); and, deepen dam (17%).

Key drivers influencing adoption of innovative practices and land use change

The questionnaire included a large number of items exploring factors which may influence adaptive behaviours. Preliminary data analyses suggest that there are at least two key licence-holder types, including those *More committed to farm business viability (MCFB)* and those *More committed to environmental sustainability (MCES)*, based on a respondent's level of personal commitment to economic objectives (including values, personal norms and beliefs), the scale of the farming operation, and the types of adaptive actions being implemented (or planned). Compared to the *MCES*, the *MCFB* have larger properties, larger areas cultivated and irrigated, larger total dam capacities, and are working longer hours on-property and are less likely to seek off-property work. The *MCFB* licence-holders are also more likely than the *MCES* to take actions which allow them to maintain or expand production, such as buying more water on the temporary and permanent water markets and investing in water use efficiency measures. The *MCES* are more likely than the *MCFB* to trust the NSW Office of Water and the science used in the MDB Plan, have pro-conservation and altruistic values and beliefs, believe in human-induced climate change, rate its nature of impact as negative and are less optimistic about their capacity to adapt to climate change impacts.

The survey findings, including the differences between the *MCFB* and *MCES* groups of licence-holders, have important implications for practitioners wishing to engage licence-holders in dialogue about climate change and the implementation of new land uses or technologies. There is some survey evidence suggesting that a lack of knowledge or understanding underpins beliefs or attitudes that are inconsistent with contemporary NRM policy and management objectives. However, our assessment of survey evidence is that much of the difficulty of engaging licence-holders in dialogue about water reform or climate change is more likely to revolve around a clash of values, beliefs and risk perceptions and the distrust of government agencies by some licence-holders. Survey findings also suggest that engagement processes for water reform have mostly attracted participants who already trust government water agencies and share the values and goals they express/ represent.

These findings and risk communication theory suggest that a more effective approach to engaging groundwater licence-holders in water reform and climate change dialogues should focus on a set of common concerns and values. In the Namoi, these include community norms about protecting the groundwater resource and a widespread commitment to community well-being and the economic and social benefits of a healthy Namoi river. These common values and personal norms could be used as the basis for engaging licence-holders with dialogue focused on the long-term benefits of environmental sustainability in irrigation districts. Given evidence that agencies attempting to engage rural landholders in complex and contentious issues should do so through locally respected platforms, we suggest the use of industry groups as a credible platform for engaging licence-holders in the Namoi. Industry groups may be more effective than using Landcare because the former reaches a larger audience and is more likely to include a mix of the *MCFB* and *MCES* groups. We also suggest that, if using local platforms for dialogue, opportunities for collective management should be considered because the findings show support for this form of governance. We also suggest that agency communication about water reform, climate change or the adoption of innovative practices, be tailored to emphasise the different interests of the *MCFB* and *MCES* groups. Finally, the findings suggest effective engagement with licence-holders should involve building positive perceptions of trustworthiness in local agency staff, and in the Office of Water itself, by demonstrating how the agency and its staff are competent, share the community's norms and values, and act in the community's best interests.

1. Introduction

1.1 Research context

Surface and groundwater resources are stretched, leading to considerable trade-offs and the potential for environmental, economic and social impacts to occur as water is shared between productive and environmental uses. The *Cotton Catchment Communities Cooperative Research Centre* (Cotton CRC) and the *National Centre for Groundwater Research and Training* (NCGRT) funded research to assess the environmental, economic and social impacts of changes in water availability in the Namoi catchment. The research team includes scientists from Charles Sturt University, Australian National University and the University of Western Australia. The project, comprised of hydrological, ecological, social, economic, legal and governance teams, is using an integrated model to identify and explore trade-offs between environmental, economic and social outcomes for a selected set of climate and policy scenarios.

As part of the larger project, the social researchers undertook a mail survey to better understand landholder views about groundwater management issues and how landholders are adapting their farming practices in response to reduced water availability. Data was also gathered for each of the other project teams to assist with their input into the integrated model. For example, data assessing licence-holder views about licence compliance were collected for the legal team. Information about land use, total dam capacities and irrigation timing was collected for the economic and hydrology teams.

The aim of this report is to provide a comprehensive summary of data gathered for all survey topics. There is also a more detailed explanation of the results exploring trust and trustworthiness between agencies and communities, which was a key focus for the social research team. Subsequent reports and papers will draw on the survey data to provide a more detailed discussion of the findings and their implications.

1.2 Research questions

The key research questions for the social component of the integrated project included:

- 1) What innovative practices are landholders adopting now and who plans to do so in the future?
- 2) What are the key drivers influencing landholder adoption of innovative practices and/or changes in land use in the Namoi catchment?

Summaries of data relevant to these research questions are provided in report Sections 4.1-4.8. A more detailed discussion of these topics will be provided in a subsequent report where Bayesian Decision Network analysis is used to explore landholder adoption of innovative practices. Dr Jennifer Ticehurst (ANU) will lead that research component.

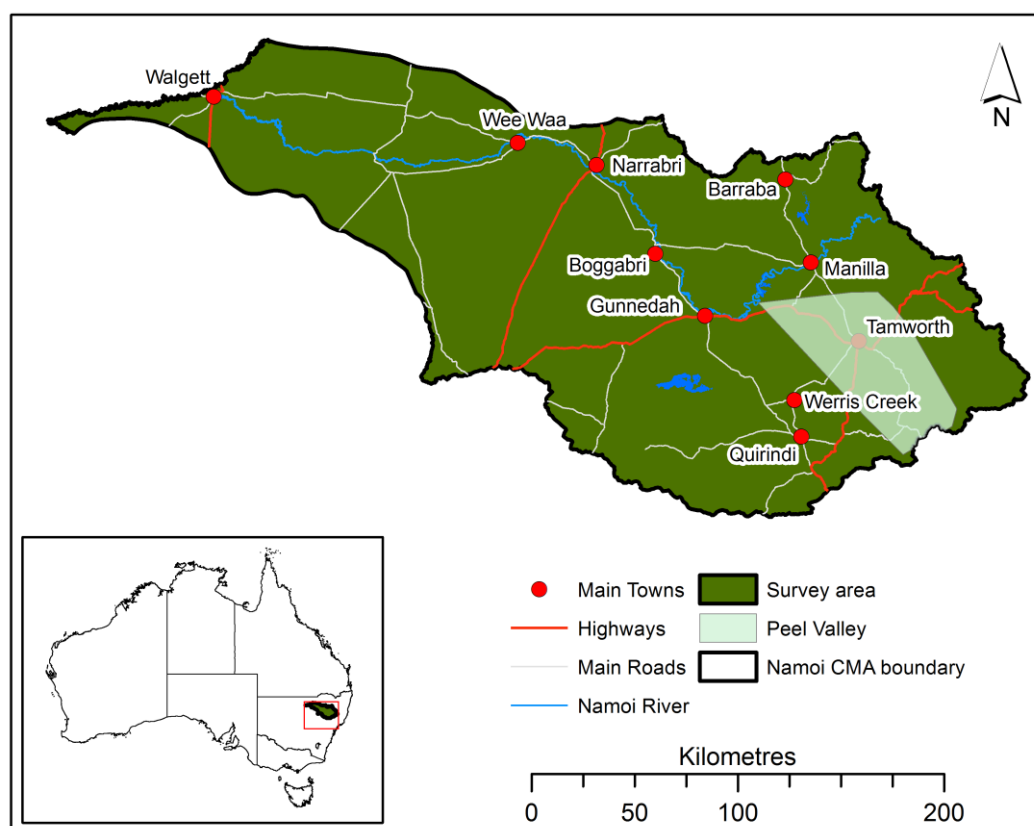
The social research team also sought to extend their work on trust between community members and natural resource management agencies. To address a gap in the literature, one section of the questionnaire was used to quantitatively measure licence-holder trust in the New South Wales Office of Water (NoW) and perceptions of agency and staff member trustworthiness. The research questions used to address this research gap are as follows:

- 1) How trustworthy do licence-holders rate NoW and their staff?
- 2) How does the trustworthiness of agency staff influence perceptions of agency trustworthiness and licence-holders' willingness to rely on NoW?

The background to the research problem, the methodology, findings and discussion for these trust questions are detailed in Section 4.9 of the report.

1.3 The Namoi catchment – the study area

The Namoi catchment, in northern New South Wales, covers approximately 42,000 square kilometres, and is based around the Namoi, Manilla and Peel Rivers (Figure 1). The catchment is bounded by Mount Kaputar and the Nandewar Ranges in the north, the Great Dividing Range in the east, and the Liverpool Ranges and Warrumbungles to the south (Namoi CMA, 2012). The Namoi is home to around 100,000 people. Tamworth is a large regional centre and irrigated agriculture provides an economic base for other major towns, including Boggabri, Burren Junction, Gunnedah, Narrabri, Quirindi, Walgett and Wee Waa.



*Figure 1: Location of Namoi catchment and survey area
Map supplied by SPAN, CSU*

1.3.1 Physical characteristics

The catchment comprises tablelands, slopes and plains which each have distinctive soils, patterns of drainage, vegetation and land use (Searle & Day, 2008). Rain generally occurs during the summer but is highly variable between years and seasons. Rainfall may reach 1100 mm/year over the Great Dividing Range in the eastern part of the catchment but only 470 mm/year on the western plains. Potential evaporation exceeds rainfall, generally (NLWRA, 2002). A range of land and water management issues affect the Namoi catchment including water quality decline, soil and land degradation, dryland salinity, and loss of native vegetation and decline in biodiversity (NLWRA, 2002).

1.3.2 Agricultural activity

Annual regional output is estimated at over \$1 billion, with agriculture representing approximately half of this amount (Namoi CMA, 2012). This output comprises around 11% of New South Wales' on-farm production from 6.25% of the state's area (Namoi CMA, 2012). The alluvial plains have been extensively developed for both grazing and dryland and irrigated cropping (cereals, cotton, pulses and oilseeds). Cotton is the main irrigated crop, accounting for 60% of irrigated area and 76% of water used in the catchment (ABS, ABARE, BRS, 2010). Cotton is most often grown using furrow and bed irrigation in large-scale layouts. Water-use efficiency in irrigated Australian cotton has increased by three to four percent per year or 20% in the last decade (Roth, 2010), and Australia now boasts some of the highest yields per hectare in the world (2.5 times the world average) (NLWRA, 2008). The 2010-11 season resulted in a record \$2.5 billion cotton crop thanks to high global prices, a world-wide cotton shortage and plentiful water supplies (Schliebs, 2011). Cotton area harvested in the 2010-11 season was 590,000 hectares Australia-wide, more than double the 208,000 hectares harvested in 2009-10 (ABARES, 2011).

1.3.3 Water sources and use

Irrigation in the Namoi catchment utilises both surface and groundwater. The region uses 2.6% of the surface water diverted for irrigation in the Murray–Darling Basin (CSIRO, 2007). Keepit (storage capacity 423,000 ML) and Split Rock (storage capacity 397,000 ML) are publicly owned storages that account for more than half of the total water storage in the Namoi Valley. According to the CSIRO Murray-Darling Basin Sustainable Yields Project (2007), current average surface water availability is 965 GL/year with 37% of that water being used.

Groundwater use increased rapidly in the late 1970s when less than 15,000 hectares was irrigated by groundwater to 1988 when 35,000 hectares was irrigated by groundwater (Turrall & Fullager, 2007). By 2001, licensed allocations had far exceeded the estimated recharge of aquifers (Pigram, 2006). Groundwater resources in the region are now the most intensively developed in New South Wales (CSIRO, 2007) with 2004/05 groundwater extraction of 255 GL. This represents almost half of the water used for irrigation in the catchment. The Namoi also accounts for about 40% of New South Wales total groundwater use and 15.2% of the MDB total (MDBA, 2010).

2. Background

Rural landholders in the Namoi catchment are faced with the task of finding ways to adapt their enterprises to reduced water availability. The following section first provides a background to changes in water policy and climate. Then, a conceptual framework for the research is described which outlines the factors that may influence landholder adaptations, including their on-property management decisions.

2.1 Adapting to reduced water availability

2.1.1 Water policy changes

A series of water reforms have been implemented at state and federal level over the past 20 years in response to concerns about environmental degradation and increasing water scarcity. The reforms have changed how both surface and groundwater are regulated and managed. At the federal level, the National Water Initiative was agreed upon by states and federal government in 2004 with the intention of achieving 'a nationally compatible, market, regulatory and planning-based system of managing surface water and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes' (NWC, 2009, p. 2). The Initiative is intended to lead to productivity gains and provide greater certainty for water users.

More recently, the Commonwealth Parliament passed the *Water Act 2007* and in July 2008 the Commonwealth and the Basin states signed the intergovernmental agreement on Murray-Darling Basin Reform that referred certain constitutional powers from the States to the Commonwealth for water management. A key element of the Water Act is the requirement that the Murray-Darling Basin Authority prepare a Basin Plan that provides for integrated and sustainable management of water resources in the Basin. Part of the Basin Plan involves setting enforceable sustainable diversion limits (SDLs) which are defined as the level at which water can be taken from a water resource without compromising key environmental assets, ecosystem functions, environmental outcomes and the productive bases (MDBA, 2009). The SDLs are likely to lead to further reductions in water entitlements in many parts of the Namoi catchment.

At the state level, New South Wales implemented the *Water Management Act 2000*. The Act recognises the need to provide water for the environmental health of surface and groundwater systems while also providing licence-holders with more secure access to water and greater opportunities to trade water. The Act legislated the use of water sharing plans (WSP) to set out the rules for the sharing of water between water users and the environment in a particular water source. WSPs also set the rules for water trading and have been progressively implemented across the state.

At the local level, the *Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources* was one of the first WSPs to commence development in 2000, but was not implemented until 2006. Disagreement about the definition of sustainable extraction and the method of entitlement reduction delayed this process. The current WSP for groundwater divides the Upper Namoi into 12 groundwater sources, or zones, based on geology and hydrogeology (Figure 2). The Lower Namoi, downstream and westward from Narrabri, is managed as a single groundwater source. The WSP reduced water entitlements to the estimated average annual recharge of the aquifers. In some zones, this has led to a reduction in aquifer access of greater than 87%. Supplementary licences

were issued to water users with a history of high water use to provide a 10-year adjustment period to help adaptation to a reduction in the volume of water previously extracted. These supplementary licences are not tradeable and cannot be carried over into subsequent years.

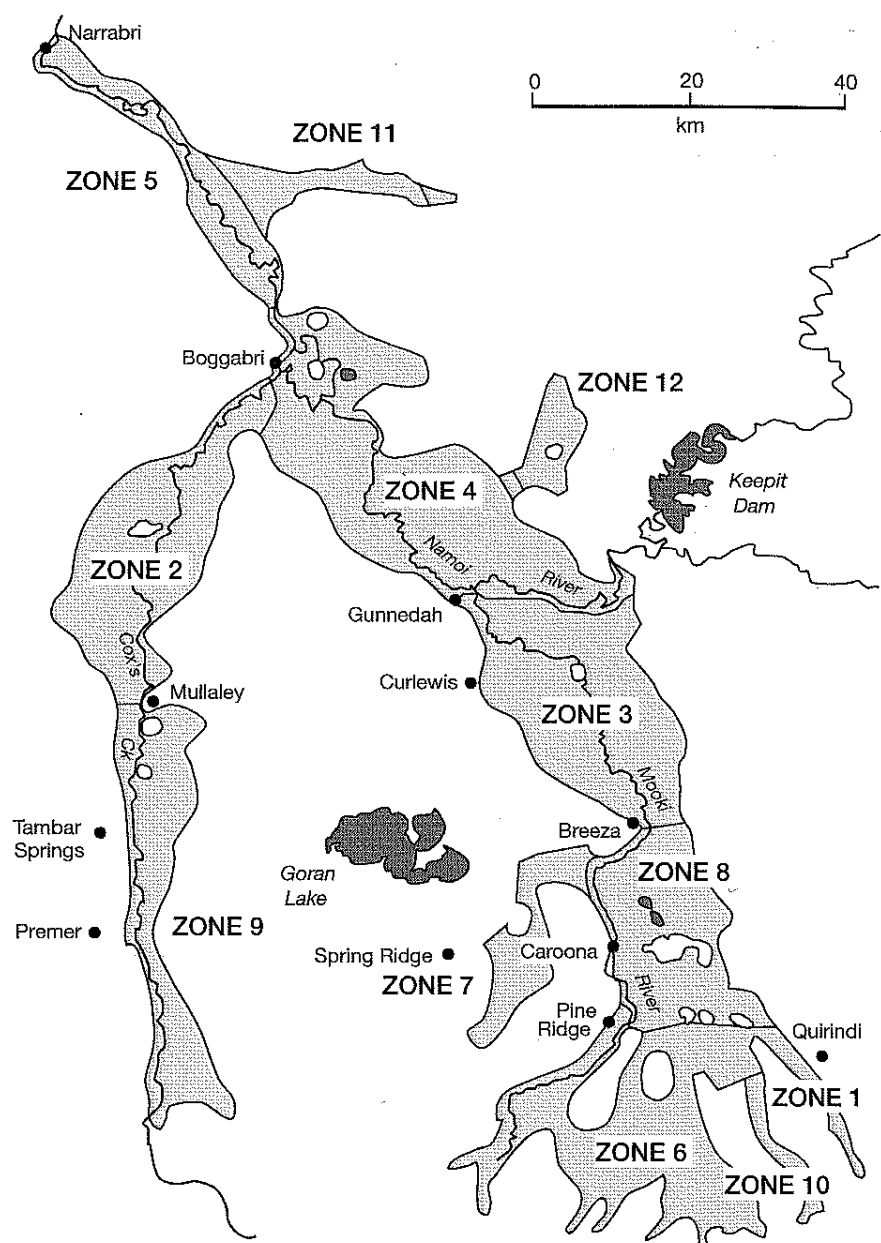


Figure 2: Twelve management zone areas in the Upper Namoi
Source: Pigram, J. (2006)

Water reforms at the state and federal level have the potential to negatively impact on landholders and local townships. Many irrigation-dependent communities and landholders have faced, or will face, large reductions in water availability as a result of efforts to address over-allocation and return surface and groundwater systems to more sustainable levels of extraction. As a result of reduced water entitlements, individuals may face increased uncertainty and management challenges related to production decisions, reduced profitability, and higher operating costs (Stubbs, Storer, Lux & Storer, 2010). In turn, rural communities may experience reduced populations, employment opportunities, consumer spending and support for service industries.

2.1.2 Climate change

Climate change is projected to increase temperatures and lead to a small decrease in run-off in the Namoi catchment. Under the best estimate 2030 climate scenario, CSIRO (2007) modelling suggests increased summer rainfall but reduced rainfall in other seasons, leading to a five percent reduction in water availability and a one percent reduction in surface water diversions overall. The CSIRO modelling also indicates that climate change will have minimal impacts on surface-groundwater exchanges in the Lower Namoi and there would be little additional increase in the average period between flooding of the Namoi River wetlands and billabongs. On the other hand, the wet extreme 2030 climate scenario predicts an increase of 38% average water availability while the dry extreme 2030 scenario predicts a decrease of 30% in average water availability.

It is predicted that climate change will have both positive and negative effects on cotton, the dominant irrigated crop in the Namoi catchment. Increased carbon dioxide may increase yield in well-watered crops, and higher temperatures will extend the length of the growing season (Bange, 2007). However, higher temperatures may also cause significant fruit loss, lower yields and reduced water use efficiencies (Bange & Constable, 2008). Additionally, declining overall water availability will increase competition for water resources between cotton production, other crops and environmental uses (Bange, McRae & Roth, 2008).

There is a wealth of literature exploring how agricultural industries, and the rural communities dependent on them, will manage climate change impacts. The terms resilience, vulnerability, adaptation, adaptive capacity or adaptability, are frequently used in dialogues about climate change adaptation (Engle, 2011; Wolfenden et al., 2007). In a summary of the climate change literature, Rogers, Curtis, Mazur and Thwaites (2010, p.17) defines and differentiates the terms as follows:

- Vulnerability is something that occurs when we are exposed to a hazard, resulting in an increased likelihood of succumbing to a negative impact. The severity of that impact will be moderated by the level of 'resilience' and/or 'adaptive capacity' available.
- Resilience refers to the ability to recover from or resist damage after exposure to a hazard.
- Adaptive capacity is defined as the potential or actual ability to modify or change characteristics or behaviour so as to improve the situation. It emphasizes a potential or actual ability to change.
- Adaptations are the particular adjustments or practices made or used in response to current and potential climate change impacts. Adaptation decisions are informed by adaptive capacity.

Adaptations may be tactical and occur in the short-term or may involve longer-term strategic planning (Montagu et al., 2006; Nelson et al., 2010; Semenza et al., 2008). Adaptations may occur at many different scales, including farm-level, community and institutional levels (Reidsma et al., 2010). Some potential adaptive actions being implemented by landholders in response to climate change include: land and resource management practices (e.g. adjusting planting dates; changing crop varieties); financial management strategies (e.g. use of insurance; industry exit); climate forecasting; and capacity building (e.g. participation in networks) (see Hogan et al., 2011; Holman & Trawick, 2011; Leith, 2006; Marshall, 2010; Milne, Stenekes & Russell, 2008; Pittman, Wittrock, Kushreshtha & Wheaton, 2011).

There are many factors which may influence the types of adaptations landholders may undertake in response to climate change. Economic (e.g. cash-poor farmers), institutional (e.g. emphasis on top-down administrative structures) and physical constraints (e.g. lack of predictability of timing, volume and reliability of water supply) may constrain adaptation (see Faures, Bernardi & Gommès, 2010; Hogan et al., 2011; Lundqvist & Falkenmark, 2010; Urwin & Jordan, 2008). However, Adger et al. (2009) argue adaptation is not limited by exogenous forces outside of our control but by values, perceptions and power structures in society. Adger et al. suggest that adaptation decisions depend on perceptions of risk which may act as a limiting factor if society (or a landholder) does not believe the risk is great enough to justify action.

'Risk' is socially constructed, that is, all people, irrespective of their backgrounds and position in society use speculative frameworks to make sense of the world and use selective judgements in their response to risk (Slovic, 1999). Since risk is socially constructed, it is possible to identify similarities and differences in the way people perceive and respond to risk generally and to climate change, specifically (Rogers et al., 2010). Several socio-cognitive factors, such as values, beliefs and motivations, are considered to be important influences in perceptions of risk and the resulting adaptations landholders may undertake. Such factors may include: social and moral identities/sense of responsibility (Hogan et al., 2011); interactions with other individuals, groups and institutions (Dietz, Fitzgerald & Shwom, 2007; Langford, 2002; Lieserowitz, 2005); trust in government and science providers (Lorenzoni et al., 2006); confusion about climate change and its nature, causes and consequences (Lorenzoni et al., 2006; Moser & Dilling, 2004) and/ or discrepancies between scientific and lay knowledge of climate change (Brace & Geoghegan, 2010).

2.2 Conceptual framework for the research

Landholders may adapt to reduced water availability through a number of property management actions. For example, landholders may reduce the area under production, seek more off-farm employment or adopt new technologies which increase water use efficiency. The adoption of new technologies by rural landholders is often a complex process. In a widely cited synthesis paper, Pannell et al. (2006) concluded that landholders readily adopt practices that are consistent with them achieving their goals/objectives. They also noted that a large number of factors can influence adoption and that these factors vary from one technology to another, from one person to another, from one social context to another and over time. Pannell et al. (2006) proposed a framework for exploring adoption that has four broad sets of factors. This framework and examples of specific factors are as follows:

- 1) The personal characteristics of the landholder and their immediate family (e.g. goals, values, attitudes, motivation, attitude towards risk, introversion or extroversion, world views, commitment to place, personal norms, knowledge, occupation, experience, age/ stage in life and succession).
- 2) The wider social context of the landholder, including prevailing social norms, the presence of local organisations, trust and experience with extension agents and information flows through networks.
- 3) The nature of the practice or attributes of the behaviour, including the feasibility of the practice, benefits (relative advantage of the practice over existing practices), ease of use or complexity, the extent it fits in with existing systems, the ability to trial the practice to learn and reduce

uncertainty, the ability to observe the benefits of the practice, extent of re-skilling required, opportunity costs, time lags, how it has been designed and disseminated.

4) Landholder access to resources (e.g. income, group membership, labour, farm equipment).

A number of Australian researchers, including Pannell et al. (2006), have attempted to develop holistic conceptual frameworks that enable researchers to identify influences on adoption of practices that managing agencies can “pull” or influence, and those they need to know about if they are to effectively engage landholders. Drawing on the work of Pannell et al. (2006), Mazur, Curtis, Thwaites and Race (2008) developed a conceptual framework of the factors affecting adoption, and this framework is represented in Figure 3. This conceptual framework illustrates the key points of overlap in the web of factors that can shape landholder decision-making.

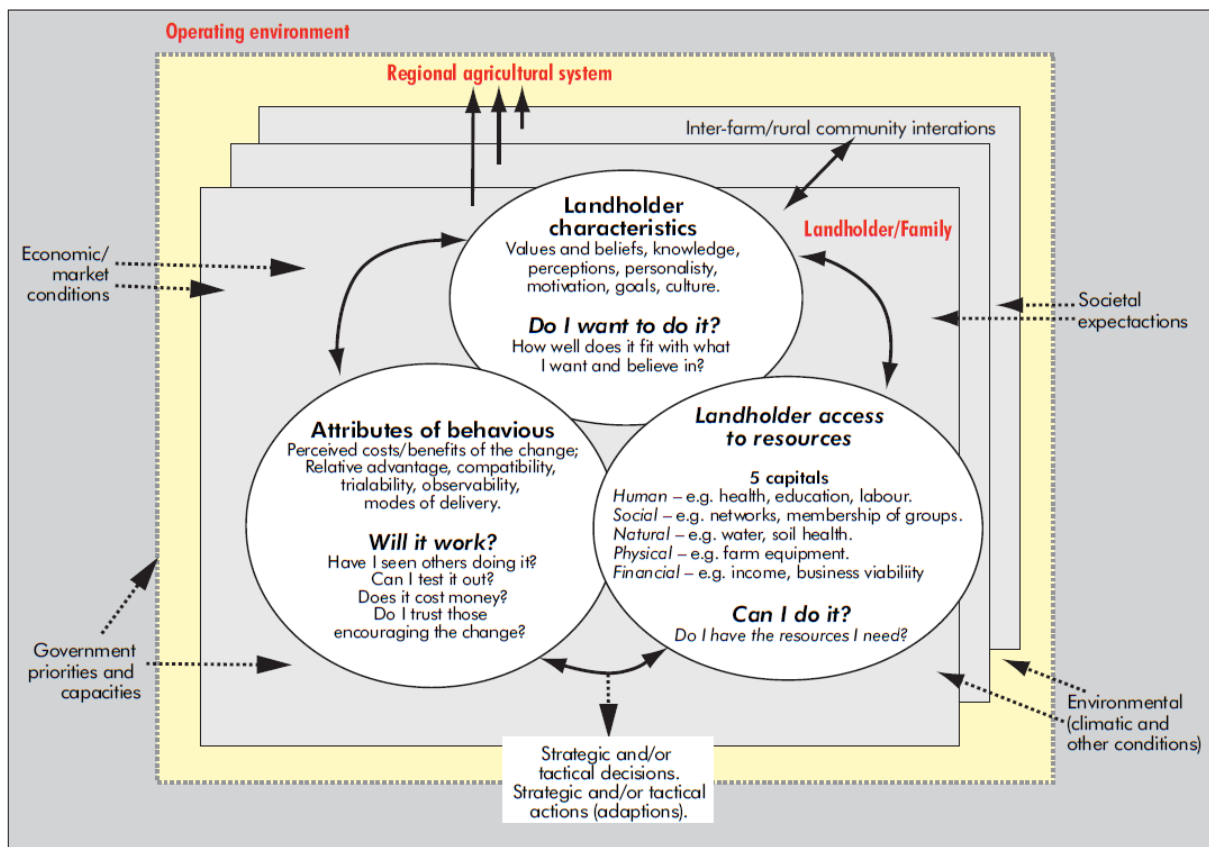


Figure 3: Conceptual framework for understanding landholder decision-making
(Source: Mazur et al., 2008, p.8)

A number of theories provide specific models and variable measures as a useful way of examining various aspects within the framework in more detail. These theories, such as the Theory of Planned Behaviour (Ajzen, 1985), the Cognitive Hierarchy Theory (Fulton, Manfredo & Lipscombe, 1986) and Value-Belief-Norm Theory (Stern, Guagnano & Dietz, 1998), attempt to explain the relationships among individuals' values, beliefs, norms, attitudes and conservation behaviours.

We adapted scales (i.e. a series of items that, when measured together, explore different dimensions of a theoretical concept) from Stern et al.'s (1998) Value-Belief-Norm theory. Value-belief-norm (VBN) theory is a model used to explain an individual's motivation for environmental behaviour and is based on a chain of elements where one component influences the next. The elements of VBN theory include values, beliefs (awareness of consequences, ascribed

responsibility beliefs and general environmental concern), personal norms and behaviour (Stern, 2000). VBN focuses on values and beliefs about environmental consequences based on three broad value orientations: environmental (concerns about the environment), altruistic (concern for others) and egoistic (concern for self). Further, VBN hypothesises that pro-environmental behaviour is more likely if the individual feels there may be adverse consequences for something that they value (Stern, Dietz & Kalof, 1993). To fully answer our research questions, we also adapted scales from Rogers et al.'s (2010) study of landholder adaptations to climate change and other studies of landholder adoption of conservation behaviour conducted by members of the research team (Curtis, Race & Sample, 2009; Curtis, Sample, McDonald & Mazur, 2010).

3. Methodology

3.1 Introduction

The survey was designed to measure the property management actions being undertaken by landholders and a number of potential influences on those actions. The survey was also designed to gather information for the other project teams' input into the integrated model being developed as part of the larger Cotton CRC/ NCGRT project.

3.2 Groundwater licence-holder mail survey

In February 2011, the New South Wales Office of Water (NoW) provided the research team with a list of all groundwater licence-holders in the Namoi catchment drawn from the NoW database. This raw list contained 1596 entries. To derive the mailing list and ensure only one survey was sent to each farming property regardless of the number of licences associated with it, the following procedure was used:

- All entries associated with the Peel River were removed (486 entries). This area of the catchment was excluded from the survey because it is administered under a different water sharing plan.
- Supplementary licence entries (approx. 325) were removed from the list unless the supplementary licence-holder did not also have a groundwater aquifer licence entry. In these 'supplementary only' cases, the supplementary entry was retained (4 entries).
- Entries comprising town water supplies, commercial (e.g. bowling clubs, mining operators), domestic (i.e. licence-holders with entitlements less than 15 ML), and government (e.g. schools) entities were deleted (approx. 40).
- Many licence-holders had more than one licence and many properties were associated with more than one licence. Approximately 300 entries were removed by deleting entries where more than one licence was associated with the same property/address. In these cases, the first entry on the list was retained and all others associated with the address deleted. Where a propriety limited company and a person's name were listed as separate entries for the same address, the propriety limited company entry was deleted.

The 2011 Namoi groundwater management survey therefore was a census of all 447 farming properties associated with a groundwater licence administered under the *Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources*.

3.2.1 The survey instrument

Drawing on consultations with Cotton CRC staff and NCGRT program partners, the experience of the research team, the Rogers et al. (2010) framework, the Stern et al. (1998) VBN theory, and the extensive literature on adoption studies in Australia (Barr & Cary 1992; Barr & Cary 2000; Cary, Webb & Barr, 2002; Vanclay, 1992), the research team identified a number of survey topics and prepared specific items to explore each topic. The topics included in the survey are listed below.

Topic 1: Your views on current water policy issues (includes items about: 1a - the Guide to the Murray-Darling Basin Plan; 1b - groundwater management issues and risks; 1c - water sharing plan development process; 1d - property rights and duty of care; 1e – collective management; 1f – licence compliance)

Topic 2: Your views on aquifer storage and recovery

Topic 3: Your interactions with NSW Office of Water (includes items about perceived trustworthiness of agency and agency staff)

Topic 4: Your views about water availability and climate (includes items about influences on property management decisions, and climate change beliefs)

Topic 5: Climate change risks (includes items about perceived likelihood of climate change, nature of impact and ability to adapt to climate change)

Topic 6: Your views about the Namoi catchment (includes items about personal beliefs and personal and social norms related to groundwater and climate)

Topic 7: Things of value in your life (includes items about personal values)

Topic 8: Property management

Topic 9: Background information (includes social and property variables)

Topic 10: Your property (includes items about current, past and future cropping, water storage and irrigation methods and sources)

3.2.2 Survey pre-test

Feedback for the draft survey was sought through meetings with Cotton CRC staff and the CEO of Namoi Water, as well as a workshop with five local landholders. A week before the workshop, the landholders were sent a copy of the survey and a list of questions to keep in mind while looking through the survey (e.g. were the instructions clear, which sections/items did you find difficult to fill out, etc). General feedback about overall impressions of the survey and detailed feedback about individual sections and items were sought. Revisions to the survey were made based on this feedback and in consultation with project team members. Revisions included: rewording the survey title and introduction, changing the sequence of sections within the survey, changing the design of the Climate Change Risks section to make it easier to respond, removing the Knowledge section to make the survey shorter, removing a water usage table and rewording or deletion of some items in different survey sections.

3.2.3 The survey process

The survey design and the mail-out process employed a modified Dillman (2007) approach. The survey was presented as a distinctive booklet and was mailed with an appealing cover letter. Several reminder and thank you notices were posted to respondents and non-respondents. After three reminder notices, all non-respondents were sent a new mail package which was followed by one reminder notice.

The mail-out process was closed with 210 useable surveys returned and a 54% response rate (Table 1). Fifty-five surveys were either: “returned to sender” (8); respondents said they owned multiple properties and received multiple surveys (3); property was only recently purchased (1) or owned by agencies (1); respondent felt a conflict of interest in completing the survey (1); the listed licence-holder was incapacitated by illness (1); property or water entitlement had been sold (4); respondent refused to complete the survey (6); or, the survey was returned blank (30). These respondents were all removed prior to calculation of the survey response rate. Survey response rates were also calculated by management zone (Table 1).

Table 1: Survey response rate. Namoi groundwater management survey, 2011 (N=210).

Management Zone	Initial mail-out	Surveys returned useable	Return to sender	Returned blank, excused	Response rate (%)
Lower Namoi	121	55	2	11	50.93%
Zone 1	15	4	0	2	30.77%
Zone 2	22	11	1	5	68.75%
Zone 3	35	20	0	2	60.61%
Zone 4	90	39	1	14	52.00%
Zone 5	34	14	1	7	53.85%
Zone 6	23	13	0	0	56.52%
Zone 7	9	3	1	0	37.50%
Zone 8	41	25	0	2	64.10%
Zone 9	22	10	0	1	47.62%
Zone 10	4	1	0	1	33.33%
Zone 11	19	9	2	1	56.25%
Zone 12	12	6	0	1	54.55%
Overall	447	210	8	47	54%

There are 12 management zones in the Upper Namoi (see Figure 2). The Lower Namoi comprises a single zone. Zones with sample sizes less than 20 respondents were combined so that statistical comparisons could be made. Zones 1 (n=4), 6 (n=13), 7 (n=3) and 10 (n=1) were combined because they are all tributaries of the Mooki River and had similar social and property characteristics. Zones 2 (n=11) and 9 (n=10) were combined because they represent the Upper and Lower sections of Cox’s Creek. Zones 5 (n=14) and 11 (n=9) were combined because they had similar social and property characteristics, adjacent geographical locations in the catchment and overlapping hydrological boundaries. Zone 12 has been excluded from further analyses by zone because of insufficient sample size. However, responses from licence-holders in this zone are considered in catchment-wide analyses.

The mail survey achieved an overall response rate of 54%, close to the 60% target which the research team believes is an acceptable response rate for surveys mailed to rural landholders in south eastern Australia. There may be differences between respondents and non-respondents to mail surveys. However, our experience is that with close to a 60% response rate that the non-respondents would need to be very different to the respondents for findings to be significantly

different. However, the median groundwater entitlement between respondents (*Med*=217 ML) and non-respondents (*Med*=187 ML) was not statistically different and the survey involved a census of all groundwater licence-holders, increasing our confidence that the data gathered is representative. Statistical comparisons of the property and social background data of respondents to catchment scale Australian Bureau of Statistics (ABS) landholder data could not be made because the area covered by ABS statistics does not match the survey area. Such comparisons may not be analogous anyway, because social and property data for licence-holders, as a group, may be significantly different from the general landholder population.

3.2.4 Data analysis

Survey data analysis included in this report consists of descriptive statistics, cross-tabulations, correlations, chi-square tests, Mann-Whitney and Kruskal Wallis tests, and stepwise multiple linear modelling. Descriptive statistics such as frequencies, means, medians and percentages were used to summarise the responses to survey items. Correlations, linear models, chi-square tests, Mann-Whitney tests and Kruskal Wallis tests were used in pairwise analysis to see if the relationships or differences observed by the summary statistics were significant.

- Relationship: Spearman's rho was used for correlation analysis to identify if there were significant relationships between pairs of continuous variables (e.g. age and area laid out to irrigation). Spearman's rho provides an r-value, or coefficient, which indicates the strength of the relationship between the variables. The size of the coefficient is affected by sample size. It is easier to obtain a high coefficient with a small sample size. In social science data where outcomes have many influences, no two variables are likely to be strongly related and a correlation of 0.30 might be regarded as relatively strong (de Vaus, 2002). However, de Vaus (2002) provides the following rule of thumb for interpreting the strength of relationship coefficients (r-values):
 - r-values from 0.01 to 0.09 show a trivial relationship
 - r-values from 0.10 to 0.29 show a low to moderate relationship
 - r-values from 0.30 to 0.49 show a moderate to strong relationship
 - r-values from 0.50 to 0.69 show a strong to very strong relationship
 - r-values from 0.70 to 0.89 show a very strong relationship
 - r-values from 0.90+ show a near-perfect relationship.
- Difference: Mann-Whitney and Kruskal Wallis tests were used to see if there were any significant differences on a continuous variable based on a grouping variable (e.g. area laid out to irrigation based on industry group membership). Mann Whitney tests were used when the grouping variable had two categories (e.g. Yes or No); Kruskal Wallis tests were used when the grouping variable had three or more categories (e.g. Upper Namoi management zones).
- Dependence: The chi-square test was used to test for a relationship when comparing two categorical variables. This test looks for dependence in the grouping (e.g. Landcare member/ non-Landcare member compared to industry group member/ non-industry group member).

The statistical tools identified above were used to explore relationships between variables (independent variables) thought to influence the property management actions (dependent variables), such as the link between total dam storage capacity and the measurement of dam evaporation losses. If the values were significant, then those variables were considered as possible predictors of each property management action. Each of these possible predictors were then scrutinised for a response rate above 80% to ensure modelling integrity. The final list of predictors was then used in a stepwise modelling process that used Akaike's information criterion as the step criteria and multi-collinearity issues were dealt with at each step. The modelling process was used to see which variables contributed collectively to implementation of the property management actions.

The stepwise modelling for the property management actions was performed in the package S-Plus. All other data analysis was performed in SPSS.

4. Findings

In this section we discuss the findings from the groundwater licence survey. Our discussion is based on the topics presented in the survey but do not necessarily follow the order found in the survey.

4.1 Social and property characteristics

4.1.1 Social characteristics

Most respondents identified themselves as farmers (84%) who owned (94%) and lived on (85%) their property (Table 2). Most respondents were male (89%) and the majority of respondents were members of a local industry group (67%) and had completed a short course relevant to property management in the past five years (68%). One-third of respondents had used financial support provided by Federal or State government natural resource management programs for on-property work in the past five years.

*Table 2: Property and social information for all respondents
2011 Namoi groundwater management survey (N=210)*

Property Data	n	% or median
Property size	178	902 ha
Property is the principal place of residence	203	85%
Respondents who are owner-operators of property	203	94%
Time property owned or managed by respondent	201	21 yrs
Time property has been in their family	198	32 yrs
Family members interested in taking over the property in the future	204	44%
Social Data	n	% or median
Age	205	57 yrs
Respondents who are male	206	89%
Hours per week worked on farming/ property related activities over the past 12 months	203	55 hrs
Respondents who worked (paid) off-property in the past 12 months	193	39%
Days that respondents worked (paid) off-property in the past 12 months	76	100 days
Member of a local Landcare group	203	28%
Member of a local industry group	206	67%
Number of different volunteer groups for which respondents attended meetings in last 12 months	107	2 groups
Used financial support provided by Federal or State government natural resource management programs for on-property work in past 5 years	206	33%
Completed a short course relevant to property management in past 5 years	203	68%
Occupation:	203	
Farmer		84%
Other [Including: Professional (5%), Retired (6%), Trades (3%), Other (2%)]		16%

The median weekly hours of farming-related on-property work over the past 12 months for all respondents was 55 hours. Considerable time was also spent on off-property work with 39% of respondents indicating that they had worked off-property in the past year, spending a median 100 days working off-property. Respondents from the Lower Namoi management zone had significantly longer periods of time that they had managed their properties (median 30 yrs) and longer lengths of family ownership (median 39.5 yrs) than respondents in the Upper management zones (management median 20 yrs; family ownership median 28 yrs).

4.1.2 Property characteristics

The median property size was 902 hectares. Respondents from the Lower Namoi management zone had significantly larger properties than the Upper management zones. Lower zone respondents also had significantly larger areas cultivated and laid out to irrigation.

Responses showed not much change in land use at the catchment scale between 2005/06, 2010/11 and 2015/16 (projected) with median total area cultivated and irrigated remaining fairly stable (Table 3). Median area of property cultivated for selected crops also stayed fairly stable across the time period. However, the proportion of respondents growing dryland cotton increased from 4% to 19% between 2005/06 and 2010/11 (Figure 4).

Table 3: Land use information for all respondents
2011 Namoi groundwater management survey (N=210)

Land use area	5 years ago (2005-06)		Current water year (2010-11)		5 years from now (2015-16)	
Median total area of property laid out to irrigation (ha)	n=189	145 ha	n=191	130 ha	n=178	148 ha
Median total area of property cultivated (ha)	n=188	400 ha	n=189	410 ha	n=177	410 ha

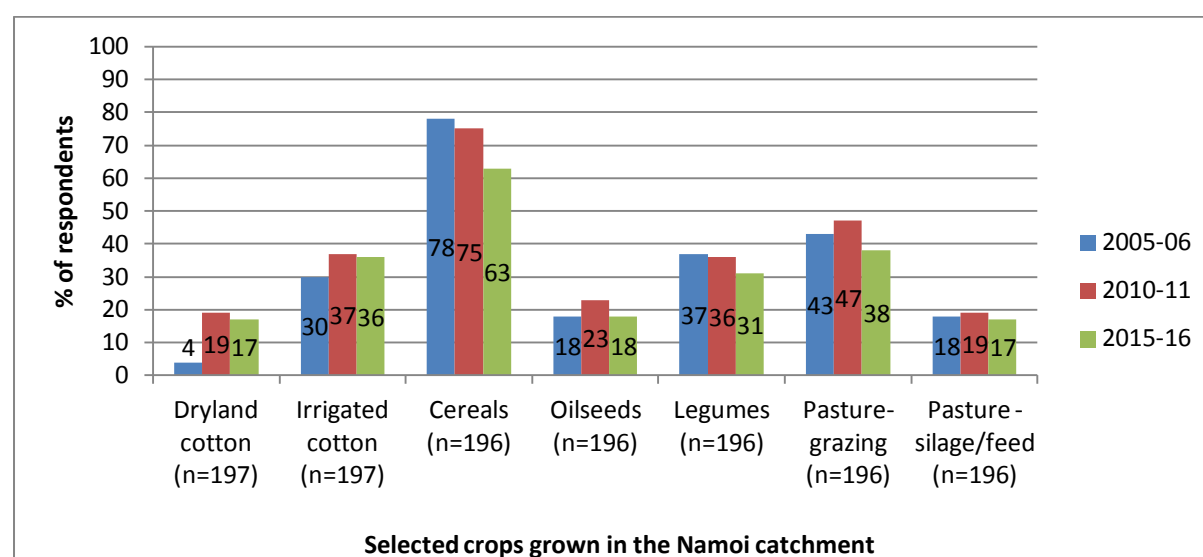


Figure 4: Proportion of respondents growing selected crop types in water years 2005-06, 2010-11, 2015-16

4.1.3 Relationships between social and property variables

The following sub-sections detail the significant relationships found between the social and property variables.

Age

Younger farmers:

- Spent more time working on-farm than older farmers.
- Were more likely than older farmers to have taken a short course related to farm management and used government financial assistance for on-property work in the past five years.

Older farmers:

- Had managed their property for longer periods and were associated with properties which had been in family ownership for longer periods.
- Were more likely than younger farmers to say a family member was interested in taking over the property.

Age had no significant relationships with: property size, irrigation area, cultivation area, total dam capacity, entitlement amount or supplementary entitlement amount.

On-farm work hours

Respondents who worked longer on-property hours per week in the past 12 months:

- Spent fewer days working off-property in the past 12 months.
- Had larger properties, larger areas of their properties cultivated and irrigated and larger groundwater entitlements and supplementary entitlements.
- Were more likely to have family members interested in taking over the property.
- Were more likely to have undertaken a short course related to property management in the past five years.

Days working off-property

Respondents who worked more days off-property in the past 12 months:

- Were more likely to have properties with shorter periods of family ownership.
- Were less likely to have undertaken a short course related to property management or used government financial assistance for on-property work in the past five years.
- Were more likely to have smaller properties and groundwater entitlements.

There was not a significant relationship between days worked off-property in the past 12 months and area cultivated or laid out to irrigation in 2010-11.

The number of days respondents had worked off-property was not significantly related to membership in Landcare or Industry groups, nor the length of time a respondent had managed the property.

Group membership

Landcare members were more likely than non-members to have:

- Used government financial assistance for on-property work in the past five years.
- Less property laid out to irrigation, smaller dam capacities and smaller supplementary entitlements.

Industry group members were more likely than non-members to have:

- Larger property sizes, more area cultivated and laid out to irrigation, greater dam capacity and larger groundwater and supplementary entitlements.

Membership in a Landcare or Industry group was not significantly related to the respondent's length of property management, the length of time the property had been in family management, or whether a family member was interested in taking over the property.

There was no significant relationship between Landcare and Industry group membership. Cross-tabulation shows that only 30 percent of Industry group members were also Landcare members.

There was no significant relationship between Landcare and Industry group membership and whether respondents had undertaken a property management short course in the past five years.

Length of management

Respondents with longer lengths of property management:

- Were associated with properties with longer periods of family ownership.
- Were more likely to have someone interested in taking over the property.

Length of management had no significant relationships with property size, irrigation area, cultivation area, total dam capacity, entitlement amount or supplementary title amount.

Short courses and financial support

Respondents who had completed a short course related to property management in the past five years:

- Had larger properties, more area cultivated and larger area laid out to irrigation in 2010-11, larger entitlements and larger supplementary entitlements.
- Were more likely to have used government financial support for on-property work in the past five years. (Of those respondents who had government financial assistance for on-property work in the past five years, 85% had also completed a short course. Of those respondents who had no government financial assistance, only 51% had completed a short course.)

- Were more likely to have a family member interested in taking over the property. (Of those respondents who had someone interested in taking over the property in the future, 78% had completed a short course in the past five years. Sixty-five percent of respondents who were unsure of family member management in the future had completed a short course, while 53% of those respondents with no one interested in taking over the property had completed a property management short-course in the past five years.)

Respondents who had used financial support from government natural resource management programs in the past five years:

- Had larger properties and more area laid out to irrigation.
- Had larger entitlements and larger supplementary entitlements.

4.2 Views on current water policy issues

This section of the survey sought licence-holder views on current water policy and management issues in the catchment that could potentially influence property management actions and land use. On a scale of 1-5, licence-holders were asked to score their level of agreement, ranging from *Strongly Disagree* to *Strongly Agree*, along with a *Not Applicable* option. The findings are summarised in tables (Tables 4-16) in each subsection below.

4.2.1 Murray-Darling Basin Plan

The *Water Act 2007* legislates that water resources in the Murray-Darling Basin be managed in the national interest. Part of the Water Act requires that a Basin Plan be prepared to provide for integrated and sustainable management of water resources in the Basin. To do this, the Basin Plan is required to set forth enforceable limits on the quantities of surface water and groundwater that can be taken from Basin resources. The limits, termed 'sustainable diversion limits' (SDLs), must be set at a level determined to be environmentally sustainable. The Guide to the Basin Plan, released in October 2010, summarised the proposed SDLs and the reductions in current diversion limits required to meet the proposed SDLs. The Guide released in 2010 instigated widespread protests in irrigation communities and a new draft Basin Plan was released in November 2011 as a response. The questions in the Namoi groundwater management survey referred to the Guide document released in 2010 as it was the applicable document at the time of survey implementation. The questions that asked respondents if they thought they could readily adapt their properties to reductions in surface and groundwater entitlements used average reductions for the Namoi catchment outlined in the Guide.

As shown in Table 4, the majority of respondents did not agree that they could adapt their enterprises to further groundwater entitlement reductions (78%) or surface water entitlement reductions (62%). There were significant differences between responses in the Lower management zone and the Upper management zone. Fifteen percent of respondents in the Upper zones agreed that they could adapt to groundwater entitlement reductions, but only 6% in the Lower zone agreed. However, only 5% of respondents in Zone 3 in the Upper zone area agreed that they could adapt to groundwater reductions, the lowest proportion of agreement in any zone.

Upper zone respondents were also more likely to agree (29%) that they could adapt to surface water entitlement reductions than Lower zone respondents (2% agreed). Respondents with larger areas of their properties laid out to irrigation in 2010-11 were significantly less likely to agree that they could adapt to changed groundwater and surface water entitlements, or agree that the science used to set sustainable diversion limits was sound. These respondents were also significantly less likely to be willing to sell part of their groundwater entitlements than respondents with smaller areas laid out to irrigation. These results suggest that respondents with larger areas laid out to irrigation may be more dependent on irrigated agriculture for their income and may also be more likely to be operating close to the limit of their existing entitlements.

Table 4: Views on the Guide to the Murray Darling Basin Plan (2010)
2011 Namoi groundwater management survey (N=210)

Topic: Views about the Murray-Darling Basin Plan (i.e. 2010)	n	Disagree	Unsure	Agree	N/A	Mean score*
If the revised Guide to the MDB Plan includes surface water entitlement reductions around 15%, I think I could readily adapt my property enterprise(s) to those reductions.	209	63%	31%	6%	1%	2.14
I believe the science used to develop sustainable diversion limits in the Guide to the MDB Plan released in October 2010 was sound.	207	63%	31%	5%	1%	2.13
I would be willing to sell part of my groundwater entitlement to the government if it offered me a buyback as part of the sustainable diversion limits set under the MDB Plan.	208	76%	9%	13%	1%	1.78
If the revised Guide to the Murray Darling Basin (MDB) Plan includes groundwater entitlement reductions around 20%, I think I could readily adapt my property enterprise(s) to those reductions.	209	78%	8%	12%	2%	1.74

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

The proportion of respondents willing to sell part of their groundwater entitlements if buybacks were offered as part of the sustainable diversion limits set under the Basin Plan was around 10% in most zones (13% agreement at catchment level). However, the combined Zone 1,6,7,10 (tributaries of the Mooki Valley) was a notable exception with 45% of respondents indicating they would be willing to sell.

4.2.2 Groundwater issues

A range of issues related to groundwater management may influence licence-holders' decision-making. Respondents were asked to rate how much they agreed with each statement using a 1-5 scale ranging from *Strongly Disagree* to *Strongly Agree* with *Not Applicable* listed as a separate response option (Table 5).

Most respondents agreed that coal mining presents a substantial risk to aquifer integrity (74%) and that their decision-making would be improved if they had access to information about groundwater levels and quality (75%). A small majority (54%) agreed that it is possible to calculate a sustainable yield for groundwater. Interestingly, those who had used financial support from NRM programs in the past five years were more likely to agree that it is possible to calculate a sustainable yield for groundwater.

Table 5: Views on groundwater management issues
2011 Namoi groundwater management survey (N=210)

Topic: Groundwater Issues	n	Strongly disagree	Disagree	Unsure	Agree	Strongly agree	N/A	Mean score*
Coal mining presents a substantial risk to aquifer integrity in my zone.	209	4%	4%	15%	17%	57%	3%	4.23
My decision-making would be improved if I had ready access to accurate information about groundwater levels and quality in my zone.	208	4%	6%	13%	52%	23%	2%	3.87
It is possible to calculate a sustainable yield for groundwater which can be taken without affecting the integrity of the resource.	209	7%	9%	30%	40%	14%	0.5%	3.45
Groundwater zone boundaries in the Namoi catchment are appropriate.	208	8%	14%	27%	48%	3%	0.5%	3.26
Over-allocation of groundwater is a problem in my management zone.	209	36%	24%	10%	20%	10%	0.5%	2.44

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

Just over half (51%) of respondents agreed that groundwater zones in the Namoi catchment are appropriate (Figure 5). Overall, slightly less than one-third (30%) of respondents agreed that over-allocation of groundwater was a problem in their management zone. However, there were significant differences among responses from different management zones regarding over-allocation. For example, only 14% of respondents in Zones 2 and 9 (Cox's Creek sub-catchment) said that over-allocation was a problem in their zone. However, respondents in the Mooki Valley were more likely to agree that groundwater over-allocation was a problem with 50% of respondents in Zone 8 and 35% of respondents in Zone 3 agreeing to this statement. There were also significant differences in responses to concern about over-allocation of groundwater based on several social and property variables. Older licence-holders, those with longer periods of management and longer periods of family ownership were more likely to agree that over-allocation of groundwater was a problem in their zone. Additionally, respondents who had used financial support from government natural resource programs in the past five years were less likely to think over-allocation of groundwater was a problem in their zone.

As shown in Table 6, about half of all respondents (52%) think that there will be a similar amount of surface water available in the next 25 years and 39% think there will be less. Those respondents who thought there would be less water available also seemed to have greater environmental awareness or concerns. For example, respondents who thought there would be less water available in future were significantly more likely to agree that groundwater pumping on their property can harm other users of the resource; environmental flows are essential to maintaining a healthy river; some flora and fauna species associated with the Namoi river are likely to become extinct; and returning water is the best way to improve habitat for in-stream life.

Table 6: Views about surface water availability and groundwater carry-over periods
2011 Namoi groundwater management survey (N=210)

Topic: Surface water availability	n	A lot less	A little less	About the same	A little more	A lot more	Mean score*
Do you think there will be more or less surface water available in the next 25 years?	193	22%	17%	52%	7%	2%	2.50
Topic: Groundwater carry-over periods	n	Way too small	A little too small	Just about right	A little too large	Way too large	Mean score**
Do you think the carry-over amount allowed for groundwater is too small or too large?	193	22%	25%	46%	5%	3%	2.41

*Responses were rated on a scale from 1, 'A lot less' to 5, 'A lot more'.

** Responses were rated on a scale from 1, 'Way too small' to 5, 'Way too large'..

Opinions appear evenly divided about the appropriateness of existing carry-over water in that nearly half of all respondents think the current carry-over amount allowed for groundwater is just about right (46%) while 47% think the amount is too small. Those more committed to irrigated agriculture in terms of having larger areas laid out to irrigation in 2010-11 and working longer hours on-property were significantly more likely to think groundwater carry-over amounts were too small. This assessment is reinforced by the finding that respondents who thought the carry-over amounts were too small were also significantly more likely to agree that further reductions of water entitlements will threaten their economic viability. Those who said carry-over amounts were too small were also more likely to agree that regulations created to protect the Namoi River are likely to limit choices.

It seems that those who thought that groundwater carry-over amounts were too large were also more concerned about the environment, or aware of their impact on the environment. These respondents were significantly more likely to: score higher on an item assessing the extent of a stewardship ethic (that short term reductions in production are justified when there are long-term environmental benefits); agree that groundwater pumping on their properties can harm other resource users; believe that environmental flows are essential to maintaining a healthy river; and, support returning water to the environment as the way to improve in-stream habitat. Those indicating that carry-over amounts were too large also expressed more positive views about the water sharing plan process in terms of the process providing meaningful opportunities for participation, using local input from farmers, and being fair. These respondents were also significantly more likely to agree that conservation of groundwater will provide a resource for future generations.

4.2.3 Water sharing plan process

Water sharing plans for groundwater and surface water resources in the Namoi catchment were developed by the NSW government in the 2000s. Water sharing plans establish rules for sharing water between the environmental needs of the river or aquifer and water users, as well as between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation. The development of a water sharing plan (WSP) for groundwater in the Namoi catchment began in 2000 and was implemented in 2006. The implementation was delayed due to considerable concern about the method used to determine water entitlement reductions and the perceived inclusiveness of the public participation process. This section of the survey asked respondents whether they thought the WSP development process included meaningful opportunities for

participation, used local input and was fair. Respondents were asked to rate how much they agreed with each statement using a 1-5 scale ranging from *Strongly Disagree* to *Strongly Agree* with *Not Applicable* listed as a separate response option (Table 7).

More than a third of respondents (41%) disagreed that input from local farmers shaped the current water sharing plan (WSP) and 45% disagreed that there were meaningful opportunities to participate in the development of the WSP. Only 16% of all respondents thought the decision-making process for the WSP was fair (Table 7).

*Table 7: Views about the water sharing plan process
2011 Namoi groundwater management survey (N=210)*

Topic: Water sharing plan development process	n	Strongly disagree	Disagree	Unsure	Agree	Strongly Agree	N/A	Mean score*
I believe input from local farmers helped shape the current water sharing plan in my area.	209	18%	23%	22%	30%	8%	0.5%	2.86
There were meaningful opportunities for me to participate in the development of the water sharing plan(s) in my area (between 2001-2006).	209	19%	26%	17%	27%	6%	5%	2.73
The decision-making process for the water sharing plan in my area was fair.	209	34%	28%	23%	12%	4%	0.5%	2.25

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

There were significant differences in responses across the management zones regarding the use of local input and the fairness of decision-making in the development of the WSP. Those in Zone 3 and Zone 8 in the Mooki Valley were more likely to agree that local input from farmers helped shape the WSP (Zone 3 agreement 65%; Zone 8 agreement 54%) than those in other zones (Table 8). As noted above, respondents from Zone 3 and 8 were also the most likely to agree that over-allocation was a problem in their zones. However, as shown in Table 8, there were significant differences in how these adjacent zones in the Mooki Valley perceived the fairness of the WSP process. Zone 3 respondents were the most likely to agree that the decision-making process for the WSP was fair (45%) and Zone 8 respondents were the least likely to agree (8%).

*Table 8: Significant differences across management zones for allocation and WSP items:
% respondents rating statement 'agree' and 'strongly agree' in each zone*

Items showing significant differences		Zone LOWER	Zone 1,6,7,10	Zone 2,9	Zone 3	Zone 4	Zone 5,11	Zone 8
I believe input from local farmers helped shape the current water sharing plan in my area.	n	55	21	21	20	39	22	24
	(%) agree	31%	19%	24%	65%	41%	41%	54%
The decision-making process for the water sharing plan in my area was fair.	n	55	21	21	20	39	22	24
	(%) agree	15%	10%	29%	45%	10%	10%	8%
Over-allocation of groundwater is a problem in my management zone.	n	55	21	21	20	39	22	24
	(%) agree	24%	33%	14%	35%	28%	23%	50%

Respondents who were more likely to rate '*working for the welfare of others*' and '*caring for the weak and correcting social injustice*' as 'important' or 'very important' personal values were significantly more likely to agree that there were meaningful opportunities to participate in water sharing plan development. These respondents were also significantly more likely to think the WSP decision-making process was fair. Similarly, respondents who agreed that local input had been used to develop the WSP were significantly more likely to agree with the three items measuring environmental personal beliefs and three items measuring altruistic personal beliefs. Respondents who agreed that the WSP decision-making process was fair were also significantly more likely to disagree that further reductions of water entitlements will threaten economic viability and that regulations created to protect the Namoi River will limit choices. It may be that those respondents who valued looking after the environment and others in the community (i.e. altruistic and environmental values) also support the water sharing process plan because sharing and concern for others are commensurate principles for these respondents. This has implications for practitioners wishing to engage licence-holders in public participation processes because it may indicate that the process is only attracting the 'converted' and is missing participation by stakeholders whose views are otherwise not represented.

As shown in Table 9, there were significant relationships between the three WSP items and items regarding over-allocation concerns, ability to calculate sustainable yield and the appropriateness of groundwater zone boundaries.

*Table 9: Significant relationships between water sharing plan and groundwater issue items
2011 Namoi groundwater management survey (N=210)*

	Over-allocation of groundwater is a problem in my management zone.	It is possible to calculate a sustainable yield for groundwater which can be taken without affecting the integrity of the resource.	Groundwater zone boundaries in the Namoi catchment are appropriate.
Water sharing plan issues			
I believe input from local farmers helped shape the current water sharing plan in my area.	POS	NS	POS
There were meaningful opportunities for me to participate in the development of the water sharing plan(s) in my area (between 2001-2006).	POS	POS	POS
The decision-making process for the water sharing plan in my area was fair.	NS	POS	NS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

POS = positive relationship. NEG = negative relationship. NS = not significant.

Respondents who were more likely to agree that BOTH the WSP decision-making process was fair and that local input was used were also significantly more likely to agree that it is fair that the wider community asks landholders to manage their land in ways that will cause no foreseeable harm to the environment and that short-term reductions in farm production are justified when there are long-term benefits to the environment. These findings suggest that respondents who possess a stewardship ethic and support a duty of care may be more likely to have values and attitudes that lead to their participation in public participation processes or which lead to their agreement with participation outcomes. It may be that those who are more likely to get involved in public

participation processes are more likely to think about issues in a positive manner rather than those respondents who think about the same issues in a negative manner.

Data analysis also showed that responses to the three WSP items were related to respondents' intention to trust the NSW Office of Water (NoW). The questionnaire included two items measuring respondents' intention to trust NoW to manage groundwater in a sustainable manner and in a way that was fair to all users (see Section 4.9 below). All three WSP items showed small to moderate positive relationships (i.e. significant r-values ranging from .255 to .421) with these trust items, suggesting that those respondents who agreed that the WSP process was fair, provided participation opportunities and used local input were more likely to trust the Office of Water to manage groundwater in a sustainable and fair manner. These findings may suggest that the respondents who trusted NoW and regarded the WSP process as positive share similar pro-environmental values and goals as the organisation. Previous work supports this notion that members of differing rural groups, such as environmental groups and natural resource management professionals, may share similar values and that these may differ from other groups such as landholders and rural residents (Seymour et al., 2011).

4.2.4 Duty of care, stewardship ethic and property rights

Three survey items explored respondent attitudes about the responsibilities of landholders in the management of their properties and underlying groundwater (Table 10). All three items had been used in previous landholder surveys implemented by the research team. Respondents were asked to rate how much they agreed with each statement based on a 1-5 scale from *Strongly Disagree* to *Strongly Agree*, with *Not Applicable* a separate response option.

One item, *It is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable harm to the environment*, measured respondents' attitude toward a **duty of care** for biodiversity. The second item, *Short-term reductions in farm production are justified when there are long-term benefits to the environment*, measured respondent attitudes toward a **stewardship ethic**. The third item, *Landholders should have the right to use groundwater underlying their properties, even if that action impacts on others* measured respondent attitudes toward **property rights**. According to Earle et al. (2010, p. 687-688), 'duty of care has a moral basis but is usually enshrined in legislation. It is externally imposed and obligatory, but it reflects a standard that is widely held by society, in effect a social norm, or one that governments seek to embed in society. It is usually articulated and/or supported by codes or guidelines, and is specific to particular entities. Stewardship also has a moral basis, but is clearly a personal ethic, internally driven and reflecting an individual, voluntary standard. Stewardship is never translated into legislation. In contrast to duty of care, it tends to be more worldly and holistic, and often has a spiritual foundation'.

There appears to be a strong base of support for a duty of care for biodiversity in that most respondents (67%) agreed that it is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable environmental harm. This finding is similar to the results from a 2011 survey of rural landholders in the Wimmera catchment, Victoria, a 2009 survey of river-frontage owners in the Loddon catchment, Victoria and a 2008 survey of rural Tasmanian river-frontage landholders in which 50%, 61% and 51% of respondents agreed to this statement, respectively. However, there was less support for a stewardship ethic with only (39%) of Namoi

respondents agreeing that short-term reductions in farm production are justified when there are long-term environmental benefits. By comparison, in the recent Victorian surveys, 64% (Loddon) and 52% (Wimmera) of respondents agreed with this statement. Finally, a small percentage of respondents agreed (12%) that landholders should have the right to use groundwater underlying their properties, even if that action impacted others, but most (81%) respondents disagreed.

*Table 10: Views about duty of care, stewardship and property rights
2011 Namoi groundwater management survey (N=210)*

Topic: Duty of care, stewardship and property rights	n	Strongly disagree	Disagree	Unsure	Agree	Strongly Agree	N/A	Mean score*
It is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable harm to the environment.	208	6%	15%	11%	57%	10%	1%	3.49
Short-term reductions in farm production are justified when there are long-term benefits to the environment.	208	10%	28%	22%	35%	4%	1%	2.95
Landholders should have the right to use groundwater underlying their properties, even if that action impacts on others.	209	20%	61%	7%	7%	5%	1%	2.15

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

Respondents in the Upper zones were significantly more likely to agree (44% agreed) than Lower zone respondents (25% agreed) that short-term reductions in farm production are justified where there are long-term benefits to the environment. Respondents with shorter periods of property management were also significantly more likely to agree that landholders should have the right to use groundwater underlying their properties, even if that action impacts on others.

The duty of care and stewardship statements also had small to moderate, significant relationships with statements regarding the Guide to the Murray-Darling Basin Plan (Table 11). The data suggest that those respondents who exhibited a stronger stewardship ethic and more support for a duty of care for biodiversity are more likely to agree that they can adapt to groundwater and surface water entitlement reductions and that the science used to develop sustainable diversion limits was sound. While these findings are not surprising, they do suggest that negative responses to the Basin Plan are underpinned by a combination of personal values and attitudes and not simply an argument about the science underpinning the Plan. This finding is consistent with contemporary theory about risk communication (Garvin, 2001; Slovic, 1999) that suggests that providing additional scientific evidence/ proof is unlikely to persuade opponents of the merits of a policy initiative when the basis for opposition is a different perception of risk and distrust in science or the lead agency.

Respondents who agreed with the duty of care statements were also significantly more likely to rate one of the altruistic values and all of the environmental values as 'important' or 'very important' personal values (Table 12).

Table 11: Significant relationships between duty of care and stewardship items and Guide to the MDB Plan items

Duty of care and stewardship issues	I believe the science used to develop sustainable diversion limits in the Guide to the MDB Plan released in October 2010 was sound.	If the revised Guide to the MDB Plan includes groundwater entitlement reductions around 20%, I think I could readily adapt my property enterprises to those reductions.	If the revised Guide to the MDB Plan includes surface water entitlement reductions around 15 %, I think I could readily adapt my property enterprises to those reductions.
It is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable harm to the environment.	POS	POS	POS
Short-term reductions in farm production are justified when there are long-term benefits to the environment.	POS	POS	POS

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

Orange-shaded cells show correlations between 4.0 and 4.99.

POS = positive relationship. NEG = negative relationship.

Table 12: Significant relationships between duty of care, stewardship and property rights items and personal environmental values

Duty of care, stewardship and property rights issues	Personal value: Protecting the environment and preserving nature	Personal value: Respecting the earth and living in harmony with other species	Personal value: Preventing pollution and protecting natural resources	Personal value: Fostering equal opportunities for all community members
It is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable harm to the environment.	POS	POS	POS	NS
Short-term reductions in farm production are justified when there are long-term benefits to the environment.	POS	POS	POS	POS
Landholders should have the right to use groundwater underlying their properties, even if that action impacts on others.	NEG	NEG	NEG	NS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

POS = positive relationship. NEG = negative relationship. NS = not significant.

4.2.5 Collective management of groundwater

Collective management of groundwater, which may also be termed local or community-based or participatory management, refers to management of groundwater resources by water users. Exploring the potential to implement collective management as an alternative form of governance

has become popular given the trend to devolve responsibility away from centralised authorities and the difficulties agencies face in regulating groundwater and preventing over-extraction (Mitchell, Curtis, Sharp & Mendham, 2011). Two survey items were included to better understand licence-holder's beliefs about two features of collective management (Table 13). Respondents were asked to rate how much they agreed with the statements on a scale of 1-5 from *Strongly Disagree* to *Strongly Agree*. *Not Applicable* was a separate response option.

Responses showed general support for collective management of groundwater (Table 13). Sixty-nine percent of respondents agreed that collective management of groundwater at the local scale would ensure operating rules are appropriate to local conditions and environmental circumstances. Respondents also seemed to support the Government playing an 'umpire' role in collective management, with 61% of respondents indicating that it would be desirable to have Government oversee operating rules developed with landholder input.

*Table 13: Views about collective management of groundwater
2011 Namoi groundwater management survey (N=210)*

Topic: Collective management of groundwater	n	Strongly disagree	Disagree	Unsure	Agree	Strongly agree	N/A	Mean score*
If governments and water users agreed to the collective management of groundwater at the local scale, that would ensure operating rules are appropriate to local conditions and environmental circumstances.	206	2%	5%	24%	51%	18%	0%	3.76
As part of collective management at a local scale, it would be desirable to have Government oversee operating rules developed with landholder input.	207	5%	12%	23%	51%	10%	0%	3.48

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

Respondents who placed higher importance on the value of '*fostering equal opportunities for all community members*' and '*preventing pollution and protecting natural resources*' were more likely to agree that local scale collective management would ensure operating rules are appropriate. However, older respondents, and those who had longer periods of management, were less likely to agree collective management at the local scale would ensure operating rules were appropriate.

Respondents who favoured having the Government oversee operating rules were more likely to agree that: 1) they could adapt to groundwater and surface water entitlement reductions proposed under the Basin Plan; 2) it is fair that the wider community asks landholders to manage their land in ways that cause no foreseeable harm to the environment; and, 3) short-term reductions in farm production are justified when there are long-term environmental benefits.

Interestingly, respondents who agreed that it would be desirable to have Government oversee operating rules were more likely to agree that NoW staff were trustworthy (i.e. three items measuring ability, benevolence and integrity). However, there were no significant relationships with trustworthiness of the agency itself or respondents' intention to trust NoW.

These findings suggest that respondents with pro-conservation values and beliefs, and altruistic (i.e. looking after others, the greater good or the community) values and beliefs, are more likely to support collective governance arrangements for groundwater. However, older respondents who

have owned their properties longer may be satisfied with the status quo and do not favour 'mucking' with the current system to which they are accustomed. Further, the trust findings suggest that implementation of collective management will be more acceptable to licence-holders if it has the strong support of practitioners on-the-ground with whom licence-holders find more trustworthy than the agency itself.

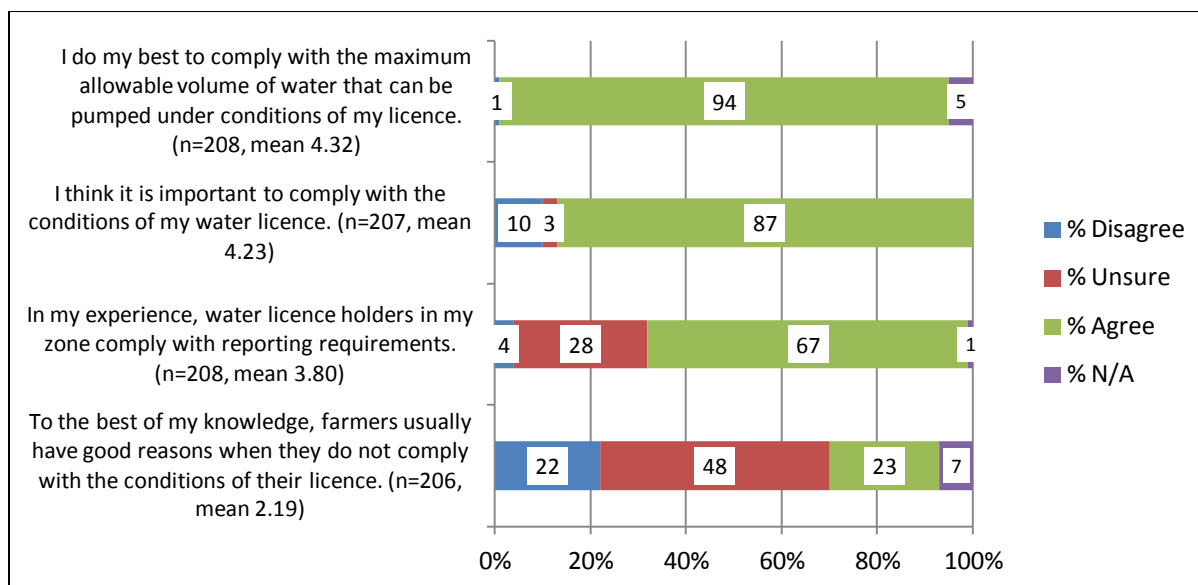
4.2.6 Groundwater licence compliance

A water access licence (WAL) or other approval from the Office of Water (NoW) is required to extract water from rivers or aquifers for commercial purposes. A WAL entitles licence-holders to specified shares in available water (share component) and to take water at specified times, rates or circumstances from specified areas or locations (extraction component). NoW has the responsibility of regulating access to water across NSW and ensuring compliance with legislation so that water resources are shared fairly and sustainably. Some users, however, may illegally pump or divert water without a licence or act in ways that are not compliant with their licence conditions. This section of the survey measured licence-holders' beliefs about compliance and procedures used to address non-compliance (Table 14). Respondents were asked to rate how much they agreed with each statement on a 1-5 scale from *Strongly Disagree* to *Strongly Agree*. *Not Applicable* was a separate response option.

Respondents generally agreed that they, and others in their management zone, did their best to comply with the conditions of their water licences (Figure 5). Nearly all respondents agreed that it was important (87%) to comply with licence conditions and that they did their best to comply with the maximum allowable volume of water they can pump under their licence conditions (94%).

Respondents who agreed that landholders should have the right to use groundwater underlying their properties, even if it impacts on others, were significantly less likely to agree that it was important to comply with water licence conditions and that they did their best to comply with the maximum volume of water they were allowed to pump. Respondents who worked longer hours off-property were more likely to agree that they did their best to comply with licence conditions. It is possible that those working more hours off-property are less dependent on irrigated agriculture for their livelihood and are therefore more inclined to do their best to comply with licence conditions.

Nearly half of all respondents (48%) were unsure whether those not complying with licence requirements had good reasons for doing so. However, there were significant relationships between the social variables of age, on-property work hours and length of management and this statement. Younger farmers, those with shorter lengths of property management and those who worked longer hours on-property were more likely to agree that farmers usually have good reasons when they do not comply with their licence conditions. These respondents may be working hard to establish or grow their enterprises and find government regulations an obstacle to achieving the goals they have for their properties. They may also simply be more naive, perhaps because they are young, or less aware of what is happening around them.



*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

Figure 5: Views about licence compliance in the Namoi catchment
2011 Namoi groundwater management survey (N=210)

In some cases, licence-holders may wish to take legal action when other licence-holders are not complying with conditions of their licence. Responses showed that around half of all respondents (56%) agreed that only regulatory agencies should be able to take legal action to prosecute or restrain non-compliance (Table 14). However, 33% of respondents said that farmers should be able to take legal action to challenge non-compliance. A similar proportion of respondents (29%) agreed that such legal action should only be used when a consequential reduced water access can be shown.

Table 14: Views about legal procedures regarding licence compliance
2011 Namoi groundwater management survey (N=210)

Topic: Licence compliance issues	n	Strongly disagree	Disagree	Unsure	Agree	Strongly agree	N/A	Mean score*
Only regulatory agencies should be able to take legal proceedings to prosecute or restrain non-compliance with water licences.	206	2%	20%	21%	43%	13%	1%	3.44
Farmers should be able to take legal action against other farmers to challenge non-compliance with licence conditions.	207	9%	25%	29%	28%	5%	4%	2.96
Farmers should <u>only</u> be able to take legal action against other farmers for non-compliance with licence conditions when the plaintiff farmer can show a consequential reduced water access.	205	8%	21%	38%	26%	3%	4%	2.96
I would like to be able to access compliance information provided by other farmers in my zone .	204	5%	20%	24%	39%	8%	4%	3.27

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

Licence-holders on larger properties seemed to support legal action being taken by regulatory agencies only. For example, there was a significant negative relationship between property size and agreement with the statement that farmers should be able to take legal action against other farmers and a significant positive relationship between property size and agreement with the statement that only regulatory agencies should be able to take legal action. Respondents favouring only regulatory agencies taking legal action against farmers were also significantly less likely to think the science used to develop sustainable diversion limits for the Basin Plan were sound and that they could adapt to groundwater reduction entitlements proposed in the Guide to the Basin Plan. Conversely, respondents who placed more importance on altruistic and environmental values were more likely to agree that farmers should be able to take legal action against other farmers to challenge non-compliance (Table 15). These respondents were also more likely to agree that they did their best to comply with their licence conditions regarding maximum allowable pumping volumes. These relationships are consistent with the idea that those licence-holders with strong beliefs about property rights are less likely to comply with regulations or support legal actions that limit those rights.

Table 15: Significant relationships between licence compliance items and personal altruistic and environmental values

Licence compliance issues	Personal value: Protecting the environment and preserving nature	Personal value: Respecting the earth and living in harmony with other species	Personal value: Preventing pollution and protecting natural resources	Personal value: Working for the welfare of others.	Personal value: Caring for the weak and correcting social injustice.	Personal value: Fostering equal opportunities for all community members
I do my best to comply with the maximum allowable volume of water that can be pumped under the conditions of my licence.	POS	POS	POS	NS	POS	POS
Farmers should be able to take legal action against other farmers to challenge non-compliance with licence conditions.	POS	POS	POS	POS	POS	POS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

POS = positive relationship. NEG = negative relationship. NS = not significant.

4.2.7 Aquifer storage and recovery

Research suggests that it may be possible to lift groundwater levels and reconnect surface water and groundwater flows, while also providing additional groundwater for irrigators, through a process called aquifer storage and recovery (ASR). One section of the questionnaire gauged respondents' interest in this technology based on its use with large flood events.

Sixty-five percent of respondents agreed that aquifer storage and recovery based on intercepting large flood events was a good idea (Figure 6). However, some respondents were uncertain about the use of ASR and, in an open-ended question section, expressed concerns about water quality, environmental impacts and implications for groundwater entitlements (Rawluk et al., submitted). As shown in Table 16, respondents were more supportive of personal investment in water-use

efficiency and ASR technology if public funds were used to develop ASR infrastructure (58% agreed) rather than development using landholders' private funds (27% agreed).

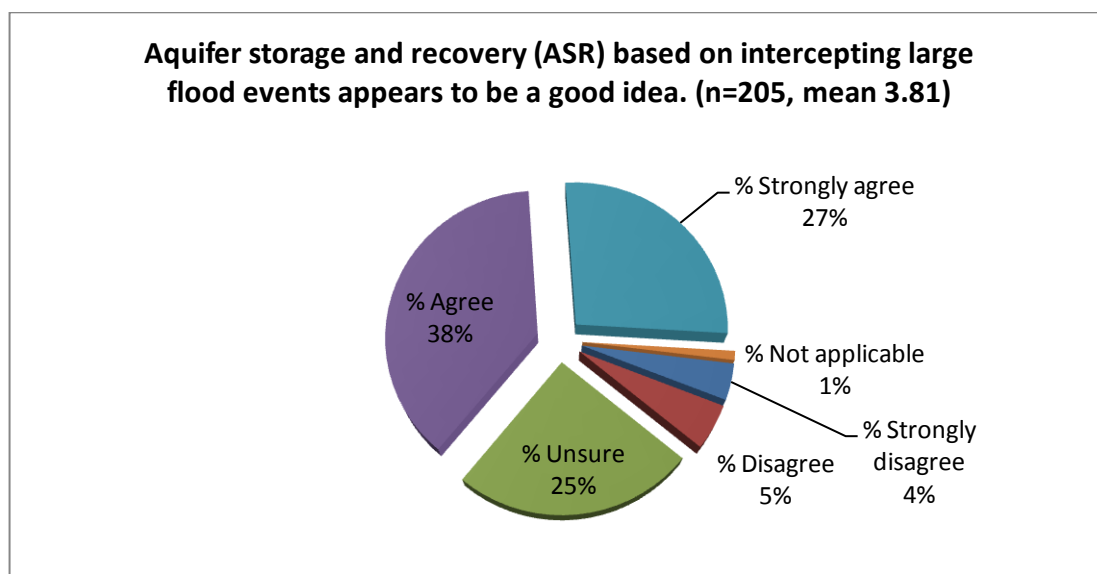


Figure 6: Social acceptability of aquifer storage and recovery in the Namoi catchment 2011 Namoi groundwater management survey (N=210)

Table 16: Views about aquifer storage and recovery in the Namoi catchment 2011 Namoi groundwater management survey (N=210)

Topic: Aquifer storage and recovery	n	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree	N/A	Mean score*
I am interested in learning more about the interception of large floods to implement ASR in my WSP area.	205	2%	5%	9%	55%	25%	4%	3.98
If public funds were used to develop the infrastructure for ASR based on intercepting large floods, I would be prepared to invest in technology to improve the water-use efficiency on my farm.	205	4%	8%	25%	41%	17%	5%	3.61
I would be prepared to invest, along with others, without public funding to develop ASR based on intercepting large floods in my water sharing plan (WSP) area.	204	9%	26%	35%	21%	6%	3%	2.89

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

Members of the research team, along with several project partners, have prepared a paper examining the potential benefits and costs of ASR using water from large floods and identifying future research needed to underpin a thorough assessment of that technology (Rawluk et al., submitted). In that paper the authors explore results from this section of the survey more fully and suggest that support for ASR is likely to be strongest among those groundwater licence-holders with a strong business focus, and the support of this group will largely depend on the strength of the ASR business case. Interestingly, while this group has a strong property rights focus, they are also likely to support collective approaches to groundwater governance. Opposition to ASR is likely to be strongest from licence-holders with strong conservation values who will need to be convinced that ASR will not lead to negative environmental impacts. This cohort is likely to include people with considerable influence in their communities.

4.3 Personal values

The value-belief-norm (VBN) theory used as part of the conceptual framework for this project focuses on values and beliefs about environmental consequences based on three broad value orientations: environmental (concerns about the environment), altruistic (concern for others) and egoistic (concern for self). Social researchers distinguish between the principles or *held* values that guide our behaviour (Brown 1984, McIntyre, Moore & Yuan, 2008) and those that we *assign* to particular things, physical goods, activities and services (Lockwood, 1999). Values also differ from norms and beliefs. Values reflect a personal ideal while personal norms are based on how individuals think they 'ought' to behave (refer to the next topic, below), and beliefs reflect what an individual thinks is true.

In accordance with VBN theory, the survey measured licence-holders' environmental, altruistic and egoistic held values. No assigned values were measured in this survey. The items were based on de Groot and Steg's (2007) adaptation of items from Schwartz's value typology (Schwartz, 1992; Schwartz, 1994). Three items were used to measure each value orientation and respondents were asked to rate the importance of each value to them on a 1-5 scale ranging from *Not Important* to *Very Important*. A *Don't Know/Not Applicable* option was offered as a separate response.

The value items with the highest rating all measured environmental values. At the same time, there were very high ratings (i.e. mean scores) for at least one of the altruistic value items and one egoistic value item (Table 17). The latter items relate to the importance of community service and building a viable business.

Table 17: Important guiding principles
2011 Namoi groundwater management survey (N=210)

Topic: Personal values	n	No or minimal importance	Some importance	Important	Very important	Don't know/ Not applicable	Mean score*
Altruistic values							
Working for the welfare of others.	208	3%	26%	48%	22%	1%	3.89
Caring for the weak and correcting social injustice.	208	11%	27%	43%	16%	2%	3.65
Fostering equal opportunities for all community members.	207	12%	34%	37%	16%	1%	3.56
Environmental values							
Preventing pollution and protecting natural resources.	208	1%	11%	53%	36%	0%	4.23
Respecting the earth and living in harmony with other species.	208	3%	20%	45%	32%	0%	4.05
Protecting the environment and preserving nature.	208	2%	17%	55%	26%	0%	4.04
Egoistic values							
Creating wealth and striving for a financially profitable business.	208	5%	17%	49%	28%	1%	4.01
Being influential and having an impact on other people and events.	208	28%	39%	26%	6%	1%	3.05
Having power and being able to lead others.	208	58%	25%	12%	3%	2%	2.36

*Responses were rated on a scale from 1, 'Not Important' to 5, 'Very Important'. 'Don't know/ Not applicable' was a separate response option.

Older respondents and those with longer periods of property management were significantly more likely to say that caring for the weak and correcting social injustice was important to them. Older

respondents were also significantly more likely to place more importance on fostering equal opportunities for all community members. This difference may reflect the extent that older respondents have had longer periods of time to become enmeshed in their community. It may also reflect their stage of life in which they are less engaged in rearing children and have more time to respond to the needs of others in the community.

Those respondents who had used government support for on-property works were also significantly more likely to place greater importance on all three altruistic values than respondents who had not used government support. It is likely that those who have more pro-conservation values are more likely to participate in government NRM programs.

A longer period of family ownership was positively associated with the egoistic value of having power and being able to lead others. The greater the number of voluntary groups to which a respondent belonged was positively associated with reporting more importance on being influential and having an impact on other people and events. Again, these findings are as might be expected.

Reporting more importance on creating wealth and striving for a financially profitable business was positively associated with a greater number of hours worked on-property, larger property sizes, larger areas cultivated and larger total dam capacities. Non-Landcare members were significantly more likely to place greater importance on this value, as well. This finding demonstrates that there is a consistency between values and behaviour reflecting a relatively stronger influence of conservation values among Landcare members.

None of the social/property variables showed statistically significant relationships or differences with the environmental variables, thereby providing little explanation about what type of respondents placed high importance on environmental values. However, the three environmental values showed significant positive relationships with many other survey variables as described in the report sections above. The most consistently strong relationships occurred between the three environmental values and survey items related to environmental and altruistic beliefs and carbon reduction and groundwater protection norms (Table 18). These findings support Stern et al.'s (1998) theory that values influence personal beliefs and norms. While our findings based on pairwise analysis cannot be used to infer causality among these constructs, the findings do suggest that there are consistent relationships among the constructs.

Table 18: Questionnaire items which show significant relationships with two or more of the three items measuring environmental values. Items shaded grey measure personal norms and environmental and altruistic beliefs adapted from Stern et al. (1998) scales.

Various survey topics	Protecting the environment and preserving nature	Respecting the earth and living in harmony with other species	Preventing pollution and protecting natural resources
If the revised Guide to the MDB Plan includes surface water entitlement reductions around 15%, I think I could readily adapt my property enterprise(s) to those reductions. (n=150)	POS	POS	POS
If the revised Guide to the MDB Plan includes groundwater entitlement reductions around 20%, I think I could readily adapt my property enterprise(s) to those reductions. (n=203)	POS	POS	NS
It is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable to the environment. (n=204)	POS	POS	POS
Short-term reductions in farm production are justified when there are long-term benefits to the environment. (n=204)	POS	POS	POS
Landholders should have the right to use groundwater underlying their properties, even if that action impacts on others. (n=205)	NEG	NEG	NEG
I do my best to comply with the maximum allowable volume of water that can be pumped under conditions of my licence. (n=197)	POS	POS	POS
Farmers should be able to take legal action against other farmers to challenge non-compliance with licence conditions. (n=198)	POS	POS	POS
Local NoW staff are very knowledgeable about groundwater management. (n=200)	POS	POS	NS
A healthy Namoi River enhances the enjoyment I get from the local landscape. (n=195)	POS	POS	POS
A healthy Namoi River contributes to the improved well-being of people in local townships and rural areas. (n=206)	POS	POS	POS
Conservation of groundwater in the catchment will provide a resource to future generations of people. (n=207)	POS	POS	POS
Environmental flows are essential to maintaining a healthy Namoi River. (n=201)	POS	POS	POS
In the next few decades, a number of flora and fauna species associated with the Namoi River will become extinct. (n=203)	POS	POS	POS
Returning water to the environment is the best way to improve habitat for in-stream life in the Namoi River. (n=201)	POS	POS	POS
I feel it is important that people throughout the community play a part in protecting the district's groundwater resource. (n=207)	POS	POS	POS
I feel a personal obligation to act as part of a group to protect the district's groundwater resource. (n=206)	POS	POS	POS
I feel a personal obligation to do whatever I can to protect the district's groundwater resource. (n=205)	POS	POS	POS
I feel a personal obligation to do whatever I can to reduce my carbon emissions. (n=203)	POS	POS	POS
I feel it is important that people throughout the community play a part in reducing carbon emissions. (n=203)	POS	POS	POS
I feel a personal obligation to act as part of a group to reduce carbon emissions. (n=203)	POS	POS	POS
Human activities are influencing changes in climate. (n=205)	POS	POS	NS
Climate change likelihood impacts on personal health and well-being. (n=138)	POS	NS	POS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

POS = positive relationship. NEG = negative relationship. NS = not significant.

Given the consistently strong relationships between the environmental value statements and the environmental norms and environmental and altruistic belief statements shown above, we decided to further investigate the relationships between the value statements and the other items in the survey shown to have consistent relationships with the environmental values. We used Chronbach's alpha to test whether the egoistic, environmental and altruistic sub-scales, and the value scale as a whole, were reliable. Values above 0.7 are considered statistically acceptable. The Chronbach's alpha scores were: altruistic sub-scale, 0.797; environmental sub-scale, 0.857; and, egoistic sub-scale 0.690. Chronbach's alpha for the whole scale was 0.804. The egoistic sub-scale was on the margin for statistical acceptance but the research team considered it acceptable for use in analysis because the alpha value for the entire scale was good.

Analysis of the three sub-scales further demonstrated that the environmental and altruistic values, but not the economic (i.e. egoistic) values, had many significant relationships with the environmental and altruistic norms, beliefs and attitudes included in the survey (Table 19). These relationships are consistent with other findings from the survey which indicated that respondents with a stronger business focus (i.e. egoistic values) scored lower on items measuring environmental norms, beliefs and attitudes. These findings are also consistent with Stern's (2000) VBN theory which posits that values influence norms and beliefs.

Table 19: Questionnaire items showing significant relationships with the personal value sub-scales.
Items shaded grey measure personal norms and environmental and altruistic beliefs adapted from Stern et al. (1998) scales.

Various survey topics	Egoistic value sub-scale	Environmental value sub-scale	Altruistic value sub-scale
If the revised Guide to the MDB Plan includes surface water entitlement reductions around 15%, I think I could readily adapt my property enterprise(s) to those reductions. (n=150)	NS	POS	NS
If the revised Guide to the MDB Plan includes groundwater entitlement reductions around 20%, I think I could readily adapt my property enterprise(s) to those reductions. (n=203)	NS	NS	NS
It is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable to the environment. (n=204)	NS	POS	POS
Short-term reductions in farm production are justified when there are long-term benefits to the environment. (n=204)	NS	POS	NS
Landholders should have the right to use groundwater underlying their properties, even if that action impacts on others. (n=205)	NS	NEG	NS
I do my best to comply with the maximum allowable volume of water that can be pumped under conditions of my licence. (n=197)	NS	POS	POS
Farmers should be able to take legal action against other farmers to challenge non-compliance with licence conditions. (n=198)	NS	POS	POS
Local NoW staff are very knowledgeable about groundwater management. (n=200)	NS	POS	POS
A healthy Namoi River enhances the enjoyment I get from the local landscape. (n=195)	NS	POS	NS
A healthy Namoi River contributes to the improved well-being of people in local townships and rural areas. (n=206)	NS	POS	POS
Conservation of groundwater in the catchment will provide a resource to future generations of people. (n=207)	NS	POS	POS
Environmental flows are essential to maintaining a healthy Namoi River. (n=201)	NS	POS	NS
In the next few decades, a number of flora and fauna species associated with the Namoi River will become extinct. (n=203)	NS	POS	NS
Returning water to the environment is the best way to improve habitat for in-stream life in the Namoi River. (n=201)	NS	POS	NS
I feel it is important that people throughout the community play a part in protecting the district's groundwater resource. (n=207)	NS	POS	NS
I feel a personal obligation to act as part of a group to protect the district's groundwater resource. (n=206)	POS	POS	POS
I feel a personal obligation to do whatever I can to protect the district's groundwater resource. (n=205)	NS	POS	POS
I feel a personal obligation to do whatever I can to reduce my carbon emissions. (n=203)	NS	POS	POS
I feel it is important that people throughout the community play a part in reducing carbon emissions. (n=203)	NS	POS	POS
I feel a personal obligation to act as part of a group to reduce carbon emissions. (n=203)	NS	POS	POS
Human activities are influencing changes in climate. (n=205)	NS	POS	NS
Humans will always adapt to their environment. (n=204)	POS	NS	NS
Climate change likelihood impacts on personal health and well-being. (n=138)	NS	POS	NS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

POS = positive relationship. NEG = negative relationship. NS = not significant.

4.4 Groundwater protection and carbon emission norms

Norms are an important piece of the VBN framework. There are three types of norms: social, personal and moral norms. Social norms are established, and often enforced, by others (i.e. gender roles, dress codes, accepted behaviour at a meeting). Personal norms are not enforced by others but are internalised guiding principles. Moral norms are individuals' perceptions about moral correctness or incorrectness of performing a certain behaviour (Corbett, 2006). Norms are based on a feeling of 'ought' and differ from values and beliefs in that values reflect a personal ideal and beliefs reflect what an individual thinks is true.

Norms related to: 1) protection of the groundwater resource; and, 2) reduction of carbon emissions were measured using three items for each topic. The statements measured respondent's sense of personal responsibility for each topic at individual, group and community levels. These items followed the format used by Stern et al. (1999), Nordlund and Garvill (2002) and Seymour (2010). Respondents were asked to score their agreement with items on a 1-5 scale from *Strongly Disagree* to *Strongly Agree* with a separate *Not Applicable* option.

At least three quarters of survey respondents said they feel a personal obligation to act either as an individual or part of a group to protect the district's groundwater resource. There was a much lower level of personal commitment to act either as an individual or part of a group to reduce carbon emissions (Table 20).

Table 20: Groundwater protection and carbon emission reduction norms
2011 Namoi groundwater management survey (N=210)

Topic: Personal Norms						
Groundwater protection norms	n	Disagree	Unsure	Agree	N/A	Mean Score*
I feel it is important that people throughout the community play a part in protecting the district's groundwater resource.	209	13%	10%	77%	0%	3.80
I feel a personal obligation to act as part of a group to protect the district's groundwater resource.	208	9%	15%	75%	0%	3.81
I feel a personal obligation to do whatever I can to protect the district's groundwater resource.	208	6%	11%	82%	1%	3.92
Carbon emission reduction norms						
I feel a personal obligation to do whatever I can to reduce my carbon emissions.	207	28%	21%	49%	1%	3.18
I feel it is important that people throughout the community play a part in reducing carbon emissions.	207	26%	19%	56%	1%	3.34
I feel a personal obligation to act as part of a group to reduce carbon emissions.	207	35%	30%	34%	1%	2.94

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

The findings showed that respondents who had larger areas laid out to irrigation and worked longer hours on-property felt a personal obligation to work as part of group to protect groundwater but did not feel such obligation to reduce carbon emissions. However, respondents who placed a high importance on altruistic and environmental values, who supported a duty of care and a stewardship ethic or agreed with statements about groundwater concerns were significantly more likely to agree that they felt an obligation at community, individual or group levels to BOTH protect the groundwater

resource and reduce carbon emissions (Table 21). Additionally, the carbon emission reduction statements were associated with respondents who were more likely to agree that they could adapt to water entitlement reductions in the MDB Plan and who thought that the science used to develop SDLs was sound. These findings suggest that respondents who are more committed to their agricultural enterprises feel some obligation to protect groundwater but do not feel the same obligation to reduce carbon emissions. It may be that protection of groundwater has direct, immediate or visible impacts on these respondents' businesses and/ or at the local scale, but carbon emissions do not, thereby inducing an obligation to protect groundwater but not reduce emissions. However, further confirming the relationships posited in Stern et al.'s (1999) VBN theory, respondents with strong environmental and altruistic values and beliefs were more likely to feel an obligation to both protect groundwater and reduce carbon emissions at multiple levels.

Table 21: Significant relationships between groundwater norm items and MDB Plan and groundwater management issues
2011 Namoi groundwater management survey (N=210)

Topic: Personal Norms							
	I believe the science used to develop sustainable diversion limits...was sound.	If the revised Guide to the MDB Plan includes groundwater entitlement reductions around 20%, I could...adapt my property....	If the revised Guide to the MDB Plan includes surface water entitlement reductions around 15%, I could...adapt my property....	I would be willing to sell part of my groundwater entitlement....	Over-allocation of groundwater is a problem in my management zone.	Coal mining presents a substantial risk to aquifer integrity in my zone.	My decision-making would be improved if I had ready access to accurate information about groundwater levels and quality in my zone.
Groundwater protection norms							
I feel it is important that people throughout the community play a part in protecting the district's groundwater resource.	POS	POS	POS	POS	POS	POS	NS
I feel a personal obligation to act as part of a group to protect the district's groundwater resource.	NEG	NEG	NS	NS	NS	POS	POS
I feel a personal obligation to do whatever I can to protect the district's groundwater resource.	NS	NS	NS	NS	NS	POS	POS
Carbon emission reduction norms							
I feel a personal obligation to do whatever I can to reduce my carbon emissions.	POS	NS	POS	NS	NS	NS	POS
I feel it is important that people throughout the community play a part in reducing carbon emissions.	POS	NS	POS	NS	NS	NS	POS
I feel a personal obligation to act as part of a group to reduce carbon emissions.	POS	NS	POS	NS	NS	POS	POS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

Orange-shaded cells show correlations between 4.0 and 4.99.

POS = positive relationship. NEG = negative relationship. NS = not significant.

4.5 Beliefs about the Namoi catchment

Value-belief-norm (VBN) theory suggests that pro-environmental behaviours (e.g. adaptive property management actions) are more likely if the individual feels there may be adverse consequences for something that they value (Stern et al., 1993). VBN theory proposes that beliefs about environmental consequences are based on three broad value orientations: environmental (concerns about the environment), altruistic (concern for others) and egoistic (concern for self). Beliefs may be defined as what people think is true about something (Bengston & Fan, 1999). The survey items in this section explored respondents' beliefs about potential consequences of environmental change in the Namoi catchment. The survey items were adaptations of several of the Stern et al. (1993) 'awareness of consequences (AC) beliefs' items used and tested by Seymour (2010). Nine items were used to explore AC beliefs with three items for each value orientation (Table 22). Respondents were asked to score their agreement with items on a 1-5 scale from *Strongly Disagree* to *Strongly Agree* with a separate *Not Applicable* option.

Respondents showed considerable concern about maintaining the health of the Namoi River and the impacts of water entitlements and regulations. The majority of respondents agreed that further reductions of water entitlements would threaten economic viability for farmers (81%). Just over half of respondents (52%) agreed that regulations created to protect the Namoi River were likely to limit their choices. Most respondents also agreed that a healthy Namoi River enhances the enjoyment they get from the local landscape (71%) and contributes to the improved well-being of people in local townships and rural areas (82%). However, respondents were less certain about how to improve in-stream habitat and the status of river flora and fauna. While over half (56%) of the respondents agreed that environmental flows are essential to maintaining a healthy river, 42% of respondents were unsure whether returning water to the environment is the best way to improve river habitat and whether flora and fauna associated with the river are in danger of becoming extinct (52%). While a large majority of respondents believed that groundwater is an important resource for future generations (80%), only about one-third (34%) believe current pumping can harm other users.

These findings suggest that practitioners seeking to engage groundwater users in dialogue about improved groundwater management can build upon the widespread commitment to economic and social benefits of a healthy Namoi River but will need to address apparent gaps in knowledge about: the extent of groundwater depletion and the future implications of continued pumping at current rates; the current condition of key flora and fauna; and, the links between the future health of these species and environmental flows. Given the extent of distrust in science and concern about the economic impacts of water reform, efforts to engage landholders will need to be through a credible local platform. Use of industry groups rather than Landcare may be more effective because the former reaches a larger audience and includes many of those with an economic focus.

Mann-Whitney tests showed significant differences in responses for some social and property variables which highlight the differences in environment-focused and economic-focused respondents. The findings showed that Landcare members were significantly more likely to agree with the environmental beliefs. Conversely, respondents who worked longer hours on property, had larger properties, had larger areas cultivated and laid out to irrigation,

and were members in an industry group were significantly more likely to agree with egoistic beliefs about economic concerns and significantly less likely to agree with environmental beliefs.

While many respondents were concerned that further reductions of water entitlements would threaten economic viability, there were significant differences in responses between the Upper and Lower zones. Lower zone respondents were significantly more likely to agree that entitlement reductions would threaten economic viability (95% agreed) than Upper zone respondents (78% agreed). These findings may reflect the greater amount of off-property work undertaken in the Upper zones. Upper zone respondents may feel less concern about the economic consequences of entitlement reductions if they are less reliant on their properties for income. Similarly, respondents in the Upper zones were significantly more likely to agree that environmental flows are essential to maintaining a healthy river (62% agreed) than Lower zone respondents (40% agreed). Upper zone respondents were also significantly more likely to agree that returning water to the environment is the best way to improve in-stream habitat (29% agreed) than Lower zone respondents (6% agreed).

*Table 22: Awareness of consequence beliefs about the Namoi catchment
2011 Namoi groundwater management survey (N=210)*

Topic: Beliefs about the Namoi catchment	n	Disagree	Unsure	Agree	N/A	Mean score*
<i>Egoistic beliefs</i>						
Further reductions of water entitlements will threaten economic viability for people like me.	208	12%	5%	81%	2%	4.28
Regulations created to protect the Namoi River are likely to limit my choices.	207	10%	26%	52%	13%	3.61
A healthy Namoi River enhances the enjoyment I get from the local landscape.	209	8%	15%	71%	7%	3.83
<i>Altruistic beliefs</i>						
Groundwater pumping here can ham other users of the resource.	207	44%	22%	34%	1%	2.86
A healthy Namoi River contributes to the improved well-being of people in local townships and rural areas.	209	8%	10%	82%	1%	3.91
Conservation of groundwater in the catchment will provide a resource to future generations of people.	209	10%	11%	80%	0%	3.89
<i>Environmental beliefs</i>						
Environmental flows are essential to maintaining a healthy Namoi river.	205	18%	25%	56%	1%	3.47
In the next few decades, a number of flora and fauna species associated with the Namoi River will become extinct.	207	38%	52%	10%	1%	2.64
Returning water to the environment is the best way to improve habitat for in-stream life in the Namoi River.	206	35%	42%	22%	1%	2.82

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

There were significant relationships between the personal beliefs and items related to the Basin Plan and to over-allocation of groundwater (Table 23). For example, respondents who were more likely to agree with the environmental belief statements (i.e. have pro-environmental beliefs) were also significantly **more** likely to agree that the science used to

calculate sustainable diversion limits was sound, that they could adapt to groundwater and surface water reductions, and that they would be willing to sell part of their groundwater entitlement if the Government offered buy-backs. Conversely, respondents who were more likely to believe that further entitlement reductions would threaten economic viability were **less** likely to believe that the science used to calculate sustainable diversion limits was sound, that they could adapt to groundwater and surface water reductions, that over-allocation was a problem and that they would be willing to sell part of their groundwater entitlement if the Government offered buy-backs. These findings have important ramifications for scientists and agencies attempting to engage groundwater users in dialogue about groundwater management. For example, they are likely to have most success in engaging those who already support policy changes and who agree with, or understand, the scientific basis for those changes.

There were also consistent and significant relationships between the personal belief statements and statements related to duty of care and a stewardship ethic. Spearman's rho correlations suggested that those respondents who supported a duty of care and expressed a stewardship ethic were more likely to agree with the environmental and altruistic belief statements and less likely to agree with the egoistic belief statements. These findings support other findings throughout this report which suggest that respondents who are more business-focused are more likely to place importance on economic values and are less likely to show pro-conservation values and beliefs.

Table 23: Significant relationships between AC beliefs about the Namoi and MDB Plan and over-allocation items.

Beliefs about the Namoi catchment	I believe the science used to develop sustainable diversion limits...was sound.	If the revised Guide to the MDB Plan includes groundwater entitlement reductions around 20%, I could...adapt my property....	If the revised Guide to the MDB Plan includes surface water entitlement reductions around 15%, I could...adapt my property....	I would be willing to sell part of my groundwater entitlement....	Over-allocation of groundwater is a problem in my management zone.
<i>Egoistic beliefs</i>					
Further reductions of water entitlements will threaten economic viability for people like me.	NEG	NEG	NEG	NEG	NEG
Regulations created to protect the Namoi River are likely to limit my choices.	NS	NEG	NEG	NEG	NS
A healthy Namoi River enhances the enjoyment I get from the local landscape.	POS	NS	POS	POS	NS
<i>Altruistic beliefs</i>					
Groundwater pumping here can harm other users of the resource.	POS	POS	POS	NS	POS
A healthy Namoi River contributes to the improved well-being of people in local townships and rural areas.	NS	NS	POS	NS	NS
Conservation of groundwater in the catchment will provide a resource to future generations of people.	POS	NS	NS	NS	POS
<i>Environmental beliefs</i>					
Environmental flows are essential to maintaining a healthy Namoi river.	POS	POS	POS	POS	POS
In the next few decades, a number of flora and fauna species associated with the Namoi River will become extinct.	POS	POS	POS	POS	POS
Returning water to the environment is the best way to improve habitat for in-stream life in the Namoi River.	POS	POS	POS	POS	POS

Blue-shaded cells show correlations between 1.00 and 1.99. Red-shaded = correlations between 2.00 and 2.99. Green-shaded cells show correlations between 3.0 and 3.99. Orange-shaded = correlations between 4.0 and 4.99. POS = positive relationship. NEG = negative relationship. NS = not significant.

4.6 Views about climate change

The mail survey sought to understand licence-holders' beliefs about climate change, their perceptions of climate change risks and their beliefs about their ability to adapt to climate change (Tables 24-34).

4.6.1 Climate change beliefs

Leiserowitz (2005) suggest that there are five reasons people doubt the reality of climate change, including flat denials that there is a problem, belief that climate change is a natural phenomenon, belief that the problem is overblown or part of a conspiracy theory, and belief that the science supporting climate change is false or unsound. Drawing upon the work of Milne et al. (2008) and Leiserowitz (2005), Rogers et al. (2010) suggest that it is important to not only establish whether people believe in climate change but also explore beliefs about

the cause (i.e. natural or anthropogenic) of change. Given this suggestion, the Namoi questionnaire measured beliefs about the existence of climate change, its potential causes and potential influences (Table 24). The six items in the questionnaire were adapted from Rogers et al. (2010) based on the reliability and validity of the items in that study. Respondents were asked to rate how much they agreed with each statement using a scale ranging from *Strongly Disagree* to *Strongly Agree*. *Not Applicable* was provided as a separate response option.

Respondents were more likely to express views consistent with a belief in climate change than to deny the existence of climate change, but substantial proportions were either unsure or appeared to deny that climate change existed. For example, 41% agreed with the statement that human activities are influencing changes in climate while 27% disagreed; and 46% disagreed that there is no such thing as climate change (25% agreed) (Table 24). Most respondents seemed to be optimistic about human ability to adapt to climate change, with 73% agreeing that humans will always adapt to their environment; only 12% disagreed with the statement that it was not too late to take action to address climate change; and 43% disagreed with the statement that if we do nothing, climate change will have dire consequences.

Table 24: Beliefs about climate change
2011 Namoi groundwater management survey (N=210)

Topic: Beliefs about climate change	n	Strongly Disagree/ Disagree	Unsure	Agree/ Strongly agree	N/A	Mean score*
Humans will always adapt to their environment.	208	9%	18%	73%	0%	3.73
It is not too late to take action to address climate change.	203	12%	35%	42%	11%	3.35
Human activities are influencing changes in climate.	206	27%	33%	41%	0%	3.12
Climate change is out of our control.	208	38%	28%	33%	0%	3.00
There is no such thing as climate change.	206	46%	28%	25%	2%	2.78
If we do nothing, climate change will have dire consequences for all living things, including humans.	207	43%	31%	25%	1%	2.71

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

The same questionnaire items about climate change beliefs were included in a survey of landholders in Northeast Victoria in 2009. Compared to the Namoi, Northeast Victoria is a very different climatic zone (e.g. winter compared to summer rainfall) and is likely to experience more severe reductions in rainfall and runoff under existing climate change scenarios. The survey in Victoria was implemented during the ten-year drought period while the Namoi survey was implemented after the drought had ended. Another important difference is that the Namoi survey was completed by groundwater licence-holders while in Northeast Victoria, the sample was drawn from the population of all rural property owners. Given that the two cases provide data for the northern and southern parts of the MDB, we have included a table comparing results for the two regions (Table 25).

Table 25: Comparison of climate change belief items between Northeast Victoria and Namoi catchment respondents. Namoi responses are shaded grey.

Topic: Beliefs about climate change	n	Strongly Disagree/ Disagree	Unsure	Agree/ Strongly agree	N/A	Mean score*
Humans will always adapt to their environment.	208	9%	18%	73%	0%	3.73
Humans will always adapt to their environment.	90	20%	26%	52%	2%	3.39
It is not too late to take action to address climate change.	203	12%	35%	42%	11%	3.35
It is not too late to take action to address climate change.	90	9%	27%	60%	4%	3.64
Human activities are influencing changes in climate.	206	27%	33%	41%	0%	3.12
Human activities are influencing changes in climate.	90	11%	20%	68%	1%	3.83
Climate change is out of our control.	208	38%	28%	33%	0%	3.00
Climate change is out of our control.	90	42%	39%	19%	0%	2.73
There is no such thing as climate change.	206	46%	28%	25%	2%	2.78
There is no such thing as climate change.	90	79%	14%	6%	1%	1.84
If we do nothing, climate change will have dire consequences for all living things, including humans.	207	43%	31%	25%	1%	2.71
If we do nothing, climate change will have dire consequences for all living things, including humans.	90	16%	34%	48%	2%	3.53

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

Comparison of the statements between respondents from the Namoi catchment and Northeast Victoria show that there is a greater proportion of climate change sceptics in the Namoi. For example, 25% of Namoi respondents agreed that there is no such thing as climate change compared to only 6% of Northeast respondents. Namoi respondents were also less likely to agree that human activities are influencing climate change (41% agreed) compared to Northeast Victoria respondents (68%). However, Namoi respondents were more optimistic about being able to adapt to their environment (73% agreed) compared to just over half of Victorian respondents (52%). These findings may reflect differences in the nature of property enterprises in the two regions; prevailing seasonal weather conditions at the time of the respective surveys; or even in the extent of non-farming occupations in the two regions. Northeast Victoria is an area of mostly dryland farming while the Namoi catchment has more irrigated properties. Only a small proportion of the Victorian respondents were irrigators while all of the Namoi respondents were irrigators. Irrigation may act as a buffer to climate change impacts (Bange, McRae & Roth, 2008), so respondents from regions with a greater proportion of irrigators, such as the Namoi may be more optimistic about climate change. Non-farmers generally have more pro-conservation values than farmers (Curtis & Mendham, 2010). A substantial proportion of the Victorian respondents were non-farmers while very few of the Namoi respondents were non-farmers. Given the ten-year drought had broken at the time of the Namoi survey, it is also not surprising that more of the Namoi respondents were likely to believe that human activities were influencing changes in climate.

In the Namoi survey, respondents who believed in climate change and that it was influenced by human activities and would have dire consequences if nothing is done, were more likely to have pro-conservation beliefs and to be supportive of government processes and science used in plans for groundwater management. For example, these respondents were more likely to be members of Landcare and volunteer groups, express a stewardship ethic, support a duty of care for the environment, believe in the science used to create SDL in the Basin Plan, believe that the WSP for their area used local input, was fair and provided meaningful opportunities for participation (Table 26). Conversely, climate change sceptics, or those respondents who were more likely to agree with the statements ‘*There is no such thing as climate change*’ and ‘*Humans will always adapt to their environment*’ were more likely to work longer hours on-property, show less support for government processes and science used to create groundwater management plans and were less likely to believe short-term reductions in farm production are justified when there are long-term environmental benefits.

Table 26: Significant relationships between climate change belief items and respondent characteristics and groundwater issues items

Social characteristics and ‘your view’ items	There is no such thing as climate change.	Human activities are influencing changes in climate.	Humans will always adapt to their environment.	It is not too late to take action to address climate change.	Climate change is out of our control.	If we do nothing, climate change will have dire consequences for all living things, including humans.
Hours worked on-property in past year	NS	NEG	NS	NS	NS	NEG
Member of a volunteer group	NS	NS	NO	NS	NS	NS
Landcare member	NS	NS	NO	NS	NS	NS
Used government NRM program financial support for on-property work	NS	NS	NO	NS	NS	NS
I believe the science used to develop sustainable diversion limits in the Guide to the MDB Plan was sound.	NS	POS	NEG	POS	NS	POS
If the revised Guide to the MDB Plan includes surface water entitlement reductions around 15%, I think I could readily adapt my property enterprise to those reductions.	NS	POS	NEG	NS	NS	POS
I believe input from local farmers helped shape the current water sharing plan in my area.	NEG	POS	NS	POS	NS	POS
There were meaningful opportunities for me to participate in the water sharing plan for my area.	NS	NS	NS	NS	NS	POS
The decision-making process for the water sharing plan in my area was fair.	NS	NS	NS	NS	NS	POS
Short-term reductions in farm production are justified when there are long-term benefits to the environment.	NS	POS	NEG	NS	NEG	POS
It is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable harm to the environment.	NS	NS	NS	NS	NS	POS

Blue-shaded cells show significant relationships between 1.00 and 1.99.

Red-shaded cells show significant relationships between 2.00 and 2.99.

Green-shaded cells show significant relationships between 3.0 and 3.99.

POS = positive relationship. NEG = negative relationship. NS=relationship not significant.

As expected, there were significant relationships between each of the carbon emission reduction norms and each of the climate change belief statements, with the exception of the statement 'Climate change is out of our control' (Table 27). These significant relationships suggest that respondents who are more likely to feel that individuals, groups and community members should play a part in carbon emission reductions are also more likely believe in climate change, that human activities are influencing climate change and it will have dire consequences if nothing is done.

Table 27: Significant relationships between climate change belief and carbon emission norm statements

Climate change beliefs	I feel a personal obligation to do whatever I can to reduce my carbon emissions.	I feel a personal obligation to act as part of a group to reduce carbon emissions.	I feel it is important that people throughout the community play a part in reducing carbon emissions.
There is no such thing as climate change.	NEG	NEG	NEG
If we do nothing, climate change will have dire consequences for all living things, including humans.	POS	POS	POS
Human activities are influencing changes in climate.	POS	POS	POS
Climate change is out of our control.	NS	NS	NS
Humans will always adapt to their environment.	NEG	NEG	NEG
It is not too late to take action to address climate change.	POS	POS	POS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

POS = positive relationship. NEG = negative relationship. NS=relationship not significant.

Significant relationships between climate change beliefs and personal beliefs about the Namoi catchment suggest that climate change 'believers' were significantly more likely to agree with statements about the importance of environmental flows, the habitat benefits of returning water to the Namoi River and threats to flora and fauna. The 'believers' were also significantly more likely to agree that conservation of groundwater will provide a resource for future generations and significantly less likely to agree that further entitlement reductions will threaten economic viability. 'Non-believers' were more likely to place a high value on economic priorities (Table 28). These findings suggest that those with pro-conservation values are more likely to accept scientific explanation of climate change and the need for water reform and that those with a stronger economic focus are less likely to accept those arguments.

Table 28: Significant relationships between climate change beliefs and AC beliefs for the Namoi catchment

Beliefs about the Namoi catchment	Humans will always adapt to their environment.	It is not too late to take action to address climate change.	Human activities are influencing changes in climate.	Climate change is out of our control.	There is no such thing as climate change.	If we do nothing, climate change will have dire consequences for all living things, including humans.
<i>Egoistic beliefs</i>						
Further reductions of water entitlements will threaten economic viability for people like me.	POS	NS	NEG	NS	POS	NEG
Regulations created to protect the Namoi River are likely to limit my choices.	NS	NS	NS	NS	NS	NS
A healthy Namoi River enhances the enjoyment I get from the local landscape.	NEG	NS	POS	NS	NEG	POS
<i>Altruistic beliefs</i>						
Groundwater pumping here can harm other users of the resource.	NS	NS	NS	NS	NS	NS
A healthy Namoi River contributes to the improved well-being of people in local townships and rural areas.	NEG	NS	NS	NS	NEG	NS
Conservation of groundwater in the catchment will provide a resource to future generations of people.	NS	POS	POS	NS	NEG	POS
<i>Environmental beliefs</i>						
Environmental flows are essential to maintaining a healthy Namoi river.	NEG	POS	POS	NS	NS	POS
In the next few decades, a number of flora and fauna species associated with the Namoi River will become extinct.	NEG	NS	POS	NS	NS	POS
Returning water to the environment is the best way to improve habitat for in-stream life in the Namoi River.	NEG	NS	POS	NS	NS	POS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

POS = positive relationship. NEG = negative relationship. NS = relationship not significant.

4.6.2 Perception of climate change likelihood

The risk of climate change is one of many factors which may influence licence-holders' decision-making. Rogers et al. (2010) developed a list of twelve potential impacts of climate change to rural property holders and asked respondents to assess the likelihood of the impacts actually occurring and the expected nature or severity of impacts. This measurement was based on Grieving, Fleischhauer and Luckenkotter (2006) who stated that risk is expressed as a function of exposure (i.e. likelihood of impact), sensitivity (i.e. severity/nature of impact) and adaptability (i.e. capacity to avoid/resist loss).

For the Namoi mail survey, we reduced Roger et al.'s (2010) list of twelve impacts by classifying them into three categories: *Personal Well-being and Health*; *Water Supply for your Property*; and, *Production on your Property*. Part A of the Climate Change Risk section

asked respondents to rate the likelihood of the potential impacts of climate change on each category (i.e. personal well-being, water supply and production) using a scale from *Highly Unlikely* to *Highly Likely*. *Not Relevant* was a separate response option. Respondents were asked not to complete this section if they did not believe in human-induced climate change. The non-response 'n' was 32% which is a similar result to those who agreed that there is no such thing as climate change (25%) and who disagreed that human activities are influencing changes in climate (25%).

More respondents thought that climate change would impact on production on their property (38% likely) than the water supply on their property (36%) or personal well being and health (25). Regardless of the type of impact, most respondents though climate change was unlikely to have any impact or they were not sure if there would be any impact (Table 29).

*Table 29: Likelihood of climate change impact on property production, water supply and personal well-being
2011 Namoi groundwater management survey (N=210)*

Potential impacts of climate change	Likelihood of climate change impact						Mean Score*
	Item n	Highly Unlikely	Unlikely	Not sure	Likely	Highly Likely	
Personal well-being and health	141	16%	37%	21%	21%	4%	2.59
Water supply for your property	140	11%	29%	24%	31%	5%	2.91
Production on your property	141	9%	25%	37%	30%	8%	3.04

*Responses were rated on a scale from 1, 'Highly Unlikely' to 5, to 'Highly Likely'. 'Not relevant' was a separate response option.

4.6.3 Perceived impact of climate change and ability to adapt

Part B of this section asked respondents to rate the severity of climate change impacts on a scale ranging from *Large Negative Impact* to *Large Positive Impact* for each of the impact categories. Part C of this questionnaire section measured ability to adapt to climate change on a scale ranging from *Unable to Adapt* to *Highly Adaptable* for each of the impact categories. *Not relevant* was a separate option for each response.

About 10 percent of the respondents who completed Part B of this survey section (n=139) thought there would be a large negative impact on their production, water supply and personal well-being and health. About another third of the respondents thought there would be a small negative impact across production, water supply and well-being. A small majority thought the impacts would be positive or of no real consequence (Table 30).

The majority of respondents who completed this survey section indicated that they could adapt property production, water supply and personal well-being to the impacts of climate change (Table 31).

Respondents with larger property sizes and larger areas cultivated in 2010-11 were significantly more likely to say that they could adapt property production and water supply to climate change. Conversely, older farmers were significantly less likely to think that they could adapt property production and water supply.

Table 30: Nature of climate change impact on property production, water supply and personal well-being

Potential impacts of climate change	Nature of impact						
	Item n	Large Negative Impact	Small Negative Impact	No real impact	Small Positive Impact	Large Positive Impact	Mean Score*
Personal well-being and health	140	6%	27%	61%	5%	0%	2.64
Water supply for your property	139	10%	37%	44%	7%	1%	2.53
Production on your property	139	11%	36%	44%	8%	1%	2.53

*Responses were rated on a scale from 1, 'Large Negative Impact' to 5, 'Large positive impact'. 'Not relevant' was a separate response option.

Table 31: Ability to adapt property production, water supply and personal well-being to climate change impacts

Potential impacts of climate change	Ability to Adapt						
	Item n	Unable to Adapt	Limited Adaptability	Not Sure	Adaptable	Highly Adaptable	Mean Score*
Personal well-being and health	140	1	11	22	61	5	3.58
Water supply for your property	141	3	28	19	46	4	3.19
Production on your property	141	3	23	20	47	6	3.31

*Responses were rated on a scale from 1, 'Unable to Adapt' to 5, 'Highly Adaptable'. 'Not relevant' was a separate response option.

Comparing the Namoi results for these items with those for the Northeast Victoria climate change survey indicate that the Victorian respondents were more likely to think climate change would impact their properties in a negative way than Namoi respondents and that Namoi respondents were more likely to indicate that they could adapt to those impacts (Table 32). Given that these items were only completed by those who believed in climate change, these differences may reflect the widespread use of irrigation in the Namoi which should provide a buffer against climate change impacts on water supply, production and well-being. The findings may also reflect respondent's awareness of the climate change projections for each region. CSIRO (2007) projections for the Namoi catchment show that water availability is expected to decrease overall but rainfall is expected to increase in the summer season when irrigators do most of the cropping (e.g. cotton). In contrast, Northeast Victoria is projected to have reduced winter rainfall which typically underpins pasture and crop growth in the spring; more frequent and intense drought events, and hotter summers, with potentially more summer rainfall events. Overall, the region is expected to have significantly reduced run-off.

Table 32: Comparison of climate change risk perception and ability to adapt between Northeast Victoria and Namoi catchment respondents. Namoi responses are shaded grey.

Potential impacts of climate change	Proportion of respondents rating climate change impacts as:		Proportion of respondents rating ability to adapt as:
	Likely/ Highly likely	Impact Negative (large/small)	Adaptable/ Highly Adaptable
Personal well-being and health (n=141, 140, 140)	25%	33%	66%
Personal well-being and health (n=91)	44%	52%	63%
Water supply for your property (n=140, 139, 141)	36%	47%	50%
Water supply for pasture production (n=91)	74%	70%	35%
Production on your property (n=141, 139, 141)	38%	47%	53%
Pasture productivity (n=91)	71%	71%	42%

In the Namoi survey, there were significant relationships between the likelihood and nature of climate change impacts and each of the carbon emission norm statements (Table 33). These findings consistently showed that respondents who felt a personal obligation to reduce carbon emissions individually, as part of a group, or as a community also thought that climate change impacts were likely and would have a negative impact on their personal well-being, water supply and property production. However, feelings of personal obligation to act individually, as a group, or as a community did not have significant relationships with respondents' ability to adapt personal well-being, water supply and property production to climate change.

Table 33: Significant relationships between climate change risk perceptions and carbon emission norms

Climate change likelihood, nature of impact and ability to adapt	I feel a personal obligation to do whatever I can to reduce my carbon emissions.	I feel a personal obligation to act as part of a group to reduce carbon emissions.	I feel it is important that people throughout the community play a part in reducing carbon emissions.
Likelihood of impact: Personal health and well-being	POS	POS	POS
Likelihood of impact: Property water supply	POS	POS	POS
Likelihood of impact: Property production	POS	POS	POS
Nature of impact: Personal health and well-being	NEG	NEG	NEG
Nature of impact: Property water supply	NEG	NEG	NEG
Nature of impact: Property production	NEG	NEG	NEG
Ability to adapt: Personal health and well-being	NS	NS	NS
Ability to adapt: Property water supply	NS	NS	NS
Ability to adapt: Property production	NS	NS	NS

Blue-shaded cells = correlations between 1.00 and 1.99. Red-shaded cells = correlations between 2.00 and 2.99. Green-shaded cells = correlations between 3.0 and 3.99. Orange-shaded cells = correlations between 4.0 and 4.99. POS = positive relationship. NEG = negative relationship. NS=relationship not significant.

There were significant relationships between nearly all of the climate change belief statements and beliefs about the likelihood of climate change impacts on personal well-being, water supply and property production (Table 34). As might be expected, the findings showed that respondents who expressed stronger beliefs in climate change and its consequences were also likely to believe that climate change impacts on their properties and personal health would be negative.

Table 34: Significant relationships between climate change perceptions and climate change beliefs

Climate change likelihood, nature of impact and ability to adapt	There is no such thing as climate change.	If we do nothing, climate change will have dire consequences for all living beings, including humans.	Human activities are influencing changes in climate.	Climate change is out of our control.	Humans will always adapt to their environment.	It is not too late to address climate change.
Likelihood of impact: Personal health and well-being	NEG	POS	POS	NS	NEG	NS
Likelihood of impact: Property water supply	NEG	POS	POS	NS	NEG	POS
Likelihood of impact: Property production	NEG	POS	POS	NS	NEG	POS
Nature of impact: Personal health and well-being	NS	NEG	NEG	NS	NS	NEG
Nature of impact: Property water supply	NS	NEG	NEG	NS	POS	NEG
Nature of impact: Property production	NS	NEG	NEG	NS	POS	NEG
Ability to adapt: Personal health and well-being	NS	NS	NS	NS	NS	NS
Ability to adapt: Property water supply	NS	NEG	NEG	NEG	NS	NEG
Ability to adapt: Property production	NS	NEG	NEG	NS	NS	NS

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

Orange-shaded cells show correlations between 4.0 and 4.99.

Grey-shaded cells show correlations between 5.0 and 5.99.

POS = positive relationship. NEG = negative relationship. NS=relationship not significant.

4.7 Property management actions in the past five years

Licence-holders are faced with the task of finding ways to adapt their enterprises to many changing conditions, including changes in water policy, technology and climate/ seasonal conditions. In this section, respondents were asked to indicate whether or not they had undertaken 26 different property management actions in the past five years. The actions were developed from the researchers' knowledge of the literature and in consultation with local landholders, CRC staff and other members of the project team. Actions listed were considered strategies that landholders might undertake to adapt to changes in water

availability and climate. There are obvious limitations to the type and number of questions that can be included in a mail survey, so only a selection of the possible list of actions was included in the survey.

4.7.1 Property management actions

The top 10 actions in the past five years, by proportion of respondents indicating taking that action, are shown in Table 35. Data for all 26 items are provided in Appendix 1. The majority of respondents had changed tillage technique (74%), changed crop types in rotation (70%) and changed crop rotation frequencies (62%) in the past five years. Interestingly, 35% of respondents had sought additional off-property work.

*Table 35: Top 10 property management actions taken or considered in the past 5 years
2011 Namoi groundwater management licence-holder survey (N=210)*

Actions taken or considered in past 5 years	n	Not applicable	Didn't think about doing this	Gave serious consideration to doing this	Planned to do this, but did not do it	Did this	Mean score*
Changed tillage technique	197	9%	7%	7%	4%	74%	3.58
Changed crop types in rotation	199	12%	7%	8%	3%	70%	3.55
Changed crop rotation frequencies	197	14%	10%	8%	6%	62%	3.41
Invested in new planting machinery	198	14%	13%	12%	5%	57%	3.23
Modified flood irrigation approach	197	41%	11%	6%	3%	40%	3.22
Deepened dam	199	46%	17%	4%	8%	25%	2.79
Decreased cropping area	199	20%	33%	5%	2%	40%	2.61
Changed to spray irrigation	197	33%	20%	14%	5%	28%	2.61
Sought additional off-property work	198	26%	31%	6%	2%	35%	2.55
Changed drainage method	197	40%	26%	6%	3%	26%	2.48

*Responses were rated on a scale from 1, 'Didn't think about doing this' to 5, 'Did this'. 'Not applicable' was a separate response option.

Mann-Whitney tests revealed that respondents in the Lower management zone were significantly more likely than Upper zone respondents to have decreased crop area, divided dams into cells, measured dam evaporation losses, changed row widths and lengths of cotton, sold part or all of their property and bought water on the temporary market (Table 36). Respondents in the Upper management zones were significantly more likely to have changed to spray irrigation.

Table 36: Significant differences between Upper and Lower Zones in property management actions undertaken in past 5 years: % responding 'Did this'. Shaded items have medium to large effect sizes.

Property management action taken in past 5 years	n	Upper Zone (%)	Lower Zone (%)	p	Effect size r
Measured dam evaporation losses	103	24	38	.017	-.19
Changed to spray irrigation	132	52	14	.001	-.30
Decreased crop area	159	42	75	.000	-.31
Divided dam into cells	91	7	33	.001	-.36
Changed row widths of cotton	73	15	40	.008	-.31
Changed row lengths of cotton	70	2	16	.016	-.29
Sold part/ all of property	119	6	13	.05	-.18
Bought water on temporary market	138	18	26	.006	-.23

4.7.2 Property management actions and their relationships with social and property background variables

Respondents with longer average on-farm working hours per week were significantly more likely to have changed crop types in rotation, invested in new planting machinery and bought water on the temporary and permanent markets. These respondents were significantly less likely to have decreased cropping area and sold water on the temporary market.

As might be expected, respondents who worked more days off-property in the past year were significantly more likely to have leased part of their property. They were also significantly less likely to have changed crop rotation frequencies and routinely tested water quality.

Larger property, larger areas laid out to irrigation in 2010-11, larger areas cultivated in 2010-11 and larger total storage capacity in their dams were significantly associated with many property management actions (Table 37).

Completion of a short course related to property management in the past five years also had significant relationships with several property management actions. Respondents who had completed a short course were significantly more likely to have changed tillage technique, changed crop types in rotation, changed crop rotation frequencies, measured dam evaporation losses, implemented soil moisture mapping and bought water on the temporary market. These findings are consistent with other research the authors have undertaken (Curtis et al., 2009, Curtis et al., 2010).

Table 37: Significant relationships between property management actions taken in the past five years and property background variables

Property management action taken in past 5 years*	Property size	Area cultivated in 2010-11	Area laid out to irrigation 2010-11	Total storage capacity of dams
Changed tillage technique	POS	POS	POS	NS
Changed crop types in rotation	POS	POS	POS	NS
Changed crop rotation frequencies	POS	POS	NS	NS
Sought additional off-property work	NEG	NEG	NEG	NS
Invested in new planting machinery	POS	POS	POS	NS
Changed to drip irrigation	NEG	NEG	NS	NS
Modified flood irrigation approach	NS	NS	POS	NS
Sold water on the temporary market	NS	NS	NEG	NS
Deepened dam	NS	NS	NS	POS
Divided dam into cells	NS	NS	POS	POS
Utilised spray polymers on dams	NS	NS	POS	NS
Measured dam evaporation losses	NS	POS	POS	POS
Implemented soil moisture mapping	POS	POS	POS	POS
Routinely tested water quality	NS	NS	POS	NS
Changed row lengths of cotton	NS	NS	POS	NS
Leased part of the property	NS	NEG	NEG	NS
Bought water on the temporary market	NS	POS	POS	POS
Bought water on the permanent market	NS	POS	POS	NS

*Only property management actions with significant relationships to the property background variables are listed in the table.

Blue-shaded cells show correlations between 1.00 and 1.99.

Red-shaded cells show correlations between 2.00 and 2.99.

Green-shaded cells show correlations between 3.0 and 3.99.

Orange-shaded cells show correlations between 4.0 and 4.99.

Grey-shaded cells show correlations between 5.0 and 5.99.

POS = positive relationship. NEG = negative relationship. NS=relationship not significant

4.7.3 Key influences on property management actions taken in the past five years

All property management actions showed at least one significant relationship with questionnaire items measuring respondents' values, beliefs, and attitudes. The ten property management items which showed the greatest number of significant relationships with the other items in the survey included:

- 1) Bought water on temporary market (24 significant relationships)
- 2) Bought water on permanent market (18)
- 3) Sold water on temporary market (17)
- 4) Implemented soil moisture mapping (12)
- 5) Sold part/ all of my property (12)
- 6) Changed row widths of cotton (11)

- 7) Decreased cropping area (10)
- 8) Changed drainage method (10)
- 9) Purchased/leased more land (10)
- 10) Sold water on the permanent market (10)

It is interesting to note that there are few overlaps between the top ten management actions taken and those management actions which have the greatest number of significant relationships with items measuring respondent values, beliefs and attitudes.

A range of statistical approaches were employed to explore relationships between the property management actions taken by licence-holders and a wide range of influential factors. The first step was to use pairwise comparisons to identify statistically significant relationships between each of the 26 property management actions and the 148 potentially influential factors for which data were gathered in the survey.

The second step was to employ a multiple linear regression analysis to identify the influential factors most strongly correlated to the adaptive actions. The regression tested how well the model for each adaptive action was explained by the influential factors. The nine management actions highlighted in blue in Table 38 were considered 'not applicable' by too many respondents for inclusion in the modelling of influential factors. Eight management actions highlighted in green featured regression results which were not significant. Therefore, no model of influential factors was possible for these adaptations.

Table 38: Property management actions

1. Changed tillage technique	14. Deepened dam
2. Changed crop types in rotation	15. Divided dam into cells
3. Changed crop rotation frequencies	16. Utilised spray polymers on dams
4. Sought additional off-property work	17. Measured dam evaporation losses
4 Invested in new planting machinery	18. Implemented soil moisture mapping
5 Changed to spray irrigation	19. Routinely tested water quality
6 Changed to drip irrigation	20. Changed row widths of cotton
7 Changed drainage method	21. Changed row length of cotton
8 Modified flood irrigation approach	22. Increased dryland cotton cultivation area
9 Decreased cropping area	23. Leased part of the property
10 Purchased/leased more land	24. Sold part/all of my property
11 Sold water on the temporary market	25. Bought water on the temporary market
12 Sold water on the permanent market	26. Bought water on the permanent market

As explained in the Methodology section, it is possible that a statistically significant relationship between an independent variable and a dependent variable is the result of the independent variable being correlated with another independent variable. For example, it is possible that items measuring a risk perception and a belief about climate change are both significantly related to a specific management action and are also significantly correlated with each other. In this example, it is possible that a respondent's belief about climate change also shapes their perception of climate change risk. Regression modelling is one

way of addressing this issue of co-linearity between independent variables. Regression modelling assumes that when a number of independent variables are correlated, that only the variable that is most strongly correlated to the dependent variable should be retained. Using this approach, models for each dependent variable (property management action) are developed, identifying the mix of influential factors (independent variables) that provide the 'best' explanation of variance in the management action (dependent variable). The amount of variance explained by the model (R^2 value) provides a test of the extent that key independent variables have been included in the model.

Table 39 presents the results of the regression analysis for each property management action. Only the most significant relationships highlighted by the regression analysis are shown.

Table 39: Set of influential factors and their relationship to the property management actions

Report subsection	Multi R2	5%	17%	2%	15%	9%	12%	15%	9%	19%	10%	11%
	Actions taken >> Influential factors	Changed crop rotation frequencies	Sought additional off-property work	Invested in new planting machinery	Modified flood irrigation approach	Purchased/ leased more land	Sold water on the temporary market	Sold water on the permanent market	Implemented soil moisture mapping	Sold part/ all of property	Bought water on temp market	Bought water on perm market
4.2	I would be willing to sell part of my groundwater entitlement to the government if it offered me a buyback as part of the sustainable diversion limits set under the MDB Plan.				POS							
4.2	Groundwater zone boundaries in the Namoi catchment are appropriate.	POS	POS									
4.2	Over-allocation of groundwater is a problem in my zone.				POS		POS					
4.2	Coal mining presents a substantial risk to aquifer integrity.		POS									
4.2	There were meaningful opportunities for me to participate in the development of water sharing plans in my area.			POS				POS				POS
4.2	If governments and water users agreed to the collective management of groundwater at the local scale, that would ensure operating rules are appropriate to local conditions and environmental circumstances.							POS				
4.2	As part of collective management at a local scale, it would be desirable to have Government oversee operating rules developed with landholder input.										POS	
4.2	I would like to be able to access compliance information of other farmers.									POS		
4.2	Farmers should be able to take legal action against other farmers to challenge non-compliance with licence conditions.							POS				
4.2	Carry-over amounts allowed for groundwater are too large.					POS	POS					

	Property management actions taken and Influential factors (continued)	Changed crop rotation frequencies	Sought additional off-property work	Invested in new planting machinery	Modified flood irrigation approach	Purchased/leased more land	Sold water on the temporary market	Sold water on the permanent market	Implemented soil moisture mapping	Sold part/ all of property	Bought water on temp market	Bought water on perm market
4.3	Value: Having power and being able to lead others.	POS									POS	POS
4.3	Value: Creating wealth and striving for a financially profitable business				NEG							
4.3	Value: Being influential and having an impact on other people and events					POS				POS		
4.3	Value: Caring for the weak and correcting social injustice.									POS		
4.3	Value: Working for the welfare of others				NEG							
4.4	I feel a personal obligation to do whatever I can to help protect the groundwater resource.								POS	POS		
4.4	I feel a personal obligation to act as part of a group to protect the district's groundwater resource.				NEG							
4.5	Further reductions in groundwater entitlements will threaten economic viability for people like me.							NEG				NEG
4.5	Groundwater pumping here can harm other users of the resource.						POS	POS		POS		
4.5	Returning water to the environment is the best way to improve habitat for in-stream life in the Namoi River					POS		POS				
4.9	Local NoW staff are very knowledgeable about groundwater management.		POS									
4.1	Age					NEG	POS	POS	POS	POS	POS	POS
4.1	Landcare member				YES							
4.1	Taken short course in past five years related to property management								YES			
4.1	Years property managed								POS			
4.1	Owner of property		YES		YES		YES					
4.1	Number of days worked off-farm	NEG	POS									
4.1	Area planted to cereals 2005-06		POS									
4.1	Area proposed for pasture/silage 2015-16		POS									
4.1	Area cultivated for cereals 2005-06									POS		

POS=Positive relationship; NEG=Negative Relationship

YES/NO = Dichotomous variable

The statistically significant relationships found in the pairwise analyses between the property management actions and the other survey variables, which could not be analysed using multiple regression, are listed below to give some indication of the associations which exist. The bullet points describe respondent characteristics and their values, beliefs and attitudes which were significantly associated with the management action listed.

Changed tillage technique

- Have a larger property size, more property area cultivated in 2010-11 and more area laid out to irrigation in 2010-11.
- Believe groundwater zone boundaries in the Namoi catchment are appropriate.
- Would be prepared to invest in technology to improve on-farm water use efficiency if public funds were used to develop infrastructure for aquifer storage and recovery.
- Believe water licence-holders in their zone comply with reporting requirements.

Changed crop types in rotation

- Have a larger property size, more property area cultivated in 2010-11 and more area laid out to irrigation in 2010-11.
- Work longer hours on-farm per week
- Do not think they could readily adapt their property enterprises to further groundwater entitlement reductions proposed under the Guide to the Murray-Darling Basin Plan.
- Believe groundwater zone boundaries in the Namoi catchment are appropriate.
- A healthy Namoi river does not enhance the enjoyment they get from the local landscape.
- Variability in surface water is not an important influence on the types of cropping they undertake.

Changed to spray irrigation

- Have shorter periods of family ownership of the property.
- Do not think local NoW staff members follow through with what they say in relation to groundwater management.
- Believe a healthy Namoi River does NOT contribute to the improved well-being of people in local townships and rural areas.
- Variability in surface water supply is not an important influence on their decisions to enter the water market.
- Believe that farmers usually have good reasons when they don't comply with their licence.

Changed to drip irrigation

- Have smaller properties and area cultivated in the 2010-11 water year.
- Do not think there were meaningful opportunities for them to participate in the development of the water sharing plans in their area.

- Do not think NoW, as an organisation, or its staff members follow through with what they say they will do in relation to groundwater management.
- Believe they have no ability or limited ability to adapt personal health and well-being to climate change impacts.
- Variability in surface water supply and trends in weather and climate are important influence on the types of cropping they undertake.
- Trends in weather and climate are important influences on their decisions to enter the water market and about the methods and on-farm technologies they use.
- Would like to be able to access compliance information provided by other farmers in their zone.

Changed drainage method

- Believe further reductions in water entitlements will threaten economic viability for people like them.
- Feel a personal obligation to do all they can to protect the district's groundwater resource.
- Believe climate change impacts on their personal well-being and health are likely or highly likely.
- Variability in surface water supply and trends in weather and climate are important influences on the decisions about the methods or on-farm technologies they use.
- Believe that it is important to comply with the conditions of their water licence and do their best to comply with the maximum allowable volume of water that can be pumped under the conditions of their licence.
- Believe that water licence-holders in their zone comply with reporting requirements.

Decreased cropping area

- Are older.
- Work fewer hours on-property per week.
- Have longer periods of management.
- Do not think they could readily adapt their property enterprises to further surface and groundwater entitlement reductions proposed under the Guide to the Murray-Darling Basin Plan.
- Think that aquifer storage and recovery (ASR) is a good idea and would be prepared to invest in on-farm technology to improve water use efficiency if public funds were used to develop ASR infrastructure.
- Think that groundwater carry-over amounts are too small or way too small.
- Believe that in the next few decades a number of flora and fauna species associated with the Namoi River will become extinct.
- Variability in surface water supply is an important influence on their decisions about the types of cropping they undertake.

- Believe licence-holders in their zone comply with reporting requirements.

Deepened dam

- Have larger total capacities of dam storage.
- Would be prepared to invest in on-farm technology to improve water use efficiency if public funds were used to develop ASR infrastructure.
- Believe that climate change impacts will have a small or large positive impact on their personal well-being and health.
- Variability in surface water supply and trends in weather and climate are important influences on their decisions about the types of cropping they undertake, their decisions to enter the water market and the methods or on-farm technologies they use.

Divided dam into cells

- Have larger total dam storage capacities and larger areas laid out to irrigation in 2010-11.
- Are older.
- Think that the carry-over amount for groundwater is too large or way too large.
- Believe that they cannot adapt or have limited ability to adapt water supply and property production to the impacts of climate change.
- Variability in surface water supply is an important influence on their decisions about the types of cropping they undertake and the methods or on-farm technologies they use.
- Trends in weather and climate are an important influence on their decisions to enter the water market and about the methods or on-farm technologies they use.
- Protecting the environment and preserving nature are of less importance to them.
- Respecting the earth and living in harmony with other species are of less importance to them.

Utilised spray polymers on dams

- Have larger areas laid out to irrigation in 2010-11.
- Do not think they can readily adapt their property enterprises to further reductions in groundwater entitlements proposed under the Guide to the Murray-Darling Basin Plan.
- Would be prepared to invest in on-farm technology to improve water use efficiency if public funds were used to develop ASR infrastructure.
- Believe that regulations created to protect the Namoi River are likely to limit their choices.
- Trends in weather and climate are important influences on their decisions to enter the water market and about the methods or on-farm technologies they use.
- Protecting the environment and preserving nature are of less importance to them.
- Respecting the earth and living in harmony with other species are of less importance to them.

Measured dam evaporation losses

- Have larger areas cultivated and laid out to irrigation in 2010-11.
- Have larger total dam storage capacity.
- Do not think they can readily adapt their property enterprises to further reductions in groundwater entitlements proposed under the Guide to the Murray-Darling Basin Plan.
- Would be prepared to invest in on-farm technology to improve water use efficiency if public funds were used to develop ASR infrastructure.
- Believe their groundwater needs and concerns are very important to local NoW staff.
- Do not believe returning water to the environment is the best way to improve habitat for in-stream life in the Namoi River.
- Feel a personal obligation to do whatever they can and act as part of a group to protect the district's groundwater resource.

Routinely tested water quality

- Work less days off-farm per year.
- Have greater areas laid out to irrigation in 2010-11.
- Do not think they can readily adapt their property enterprises to further reductions in groundwater entitlements proposed under the Guide to the Murray Darling Basin Plan.
- Do not believe the science used to develop sustainable diversion limits in the Guide to the MDB Plan was sound.
- Believe groundwater zone boundaries in the Namoi catchment are appropriate.
- Believe the nature of climate change impacts on property water supply and production will have a small or large positive impact.
- Having power and being able to lead others is of less importance to them.
- Believe water licence-holders in their zone comply with reporting requirements.
- Believe only regulatory agencies should be allowed to take legal proceedings to prosecute or restrain non-compliance with licence conditions.

Changed row widths of cotton

- Do not think they can readily adapt their property enterprises to further reductions in surface water entitlements proposed under the Guide to the Murray-Darling Basin Plan.
- Do not believe the science used to develop sustainable diversion limits in the Guide to the MDB Plan was sound.
- Do not think there were meaningful opportunities for participation in the development of the water sharing plan for their area.
- Do not think the decision-making process for the water sharing plan was fair.

- Do not think sound principles seem to guide Office of Water decisions about groundwater management.
- Do not think Office of Water show good judgement when making groundwater management decisions.
- Do not think their needs and concerns are very important to Office of Water.
- Cannot rely on Office of Water to manage groundwater in a sustainable manner or in a way that is fair to all users.
- Think that it is important to have a good way to keep an eye on Office of Water decisions about groundwater management.
- Do not feel that it is important for people throughout the community to play a part in protecting the district's groundwater resource.
- Believe that farmers usually do not have good reasons when they do not comply with their licence.

Changed row length of cotton

- Have larger areas laid out to irrigation in 2010-11.
- Do not think they can readily adapt their property enterprises to further reductions in surface water entitlements proposed under the Guide to the Murray-Darling Basin Plan.
- Do not believe the science used to develop sustainable diversion limits in the Guide to the MDB Plan was sound.
- Do not think sound principles seem to guide Office of Water decisions about groundwater management.
- Do not think Office of Water show good judgement when making groundwater management decisions.
- Cannot rely on Office of Water to manage groundwater in a sustainable manner.
- Do not feel that it is important for people throughout the community to play a part in protecting the district's groundwater resource.
- Protecting the environment and preserving nature are of less importance to them.
- Respecting the earth and living in harmony with other species are of less importance to them.
- Fostering equal opportunities for all community members is of less importance to them.

Increased dryland cotton cultivation area

- Do not think they can readily adapt their property enterprises to further reductions in groundwater entitlements proposed under the Guide to the Murray-Darling Basin Plan.

- Believe that collective management at the local scale would ensure operating rules are appropriate to local conditions and environmental circumstances.
- Trends in weather and climate are an important influence on their decision to enter the water market.
- Respecting the earth and living in harmony with other species are of less importance to them.
- Believe that farmers usually have good reasons when they do not comply with their water licence.

Leased part of the property

- Work a greater number of days off-farm in the past year.
- Have smaller areas cultivated and laid out to irrigation in 2010-11.
- Working for welfare of others is of importance to them.
- Believe that farmers usually have good reasons when they do not comply with their water licence.
- Think that farmers in their zone do NOT comply with reporting requirements.

4.8 Property management actions in the next five years

In this section, respondents were asked to indicate whether or not they were considering or planning on undertaking the same 26 property management actions from Section 4.7 in the next 5 years. The response scale ranged from *Not interested at this time* to *Definitely intend to do this/ do more*.

Responses were similar between the top 10 actions taken in the past five years and actions being considered in the next five years in terms of the proportion of all respondents indicating a YES. However, the top 10 actions being considered in the next five years did not include: '*Change drainage method*'; '*Seek off-property work*'; or, '*Decrease cropping area*'. These three items were replaced in the top 10 actions being considered by: '*Routinely test water quality*'; '*Implement soil moisture mapping*'; and, '*Measure dam evaporation losses*'.

Table 40: Top 10 property management actions being planned or considered in the next 5 years
2011 Namoi groundwater management survey (N=210)

Actions being planned or considered in next 5 years	n	Not applicable	Not interested at this time	Will give serious consideration to doing this	Planning to do this/ do more	Definitely intend to do this, do more	Mean score*
Change crop types in rotation	199	13%	17%	26%	23%	22%	2.57
Change crop rotation frequencies	199	13%	18%	25%	23%	22%	2.55
Change tillage technique	198	13%	22%	19%	25%	21%	2.51
Routinely test water quality	199	19%	21%	25%	18%	18%	2.40
Modify flood irrigation approach	199	39%	20%	17%	12%	13%	2.28
Invest in new planting machinery	197	15%	30%	22%	18%	15%	2.21
Implement soil moisture mapping	198	25%	30%	19%	19%	11%	2.09
Deepen dam	198	45%	27%	10%	8%	10%	2.01
Measure dam evaporation losses	198	47%	25%	13%	9%	7%	1.94
Change to spray irrigation	199	37%	35%	10%	8%	11%	1.90

*Responses were rated on a scale from 1, 'Not interested at this time' to 5, 'Definitely intend to do this, do more'. 'Not applicable' was a separate response option.

There were significant relationships between actions taken in the past five years and actions being planned/ considered in the next five years for 17 of the property management actions. That is, those who were implementing these actions currently also planned to do more in the future. More than half of the respondents who had undertaken the following property management actions in the past five years were definitely planning on taking the same action in the next five years: change to spray irrigation (74%); purchase/lease more land (55%); utilise spray polymers (75%); implement soil moisture mapping (51%); and, routinely test water quality (51%). These findings suggest a continued interest in water use efficiency and conservation actions being undertaken by licence-holders.

Very few respondents (less than 10% for each action) were definitely planning on undertaking particular property management actions in the next five years if they had NOT already undertaken that action in the past five years. For example, of the respondents who had not changed tillage technique in the past five years, only nine percent definitely planned to implement this action in the next five years. However, there were some actions that showed a greater potential uptake among those who had not undertaken such actions in the past five years. More than 10% of the respondents who had NOT undertaken the following property management actions in the past five years were definitely planning on taking that action in the next five years: invest in planting machinery (17%); change to spray irrigation (17%); modify flood irrigation approach (15%); purchase/ lease more land (34%); and, deepen dam (17%).

Respondents in the Lower zone were significantly more likely than those in the Upper zones to deepen their dams, measure dam evaporation losses and buy water on the temporary market in the next five years (Table 41). Respondents in the Upper zones were significantly more likely to change to spray irrigation in the next five years.

Table 41: Significant differences between Upper and Lower Zones in property management actions being considered in the next 5 years: % responding 'Definitely intend to do this-do more'. Shaded items have medium to large effect sizes.

Property management action being considered in next 5 years	n	Upper Zone (%)	Lower Zone (%)	p	Effect size r
Change to spray irrigation	125	19	5	.002	-.28
Deepen dam	109	11	33	.001	-.33
Measure dam evaporation losses	106	9	18	.000	-.35
Buy water on temporary market	157	8	10	.001	-.25

4.9 Interactions with New South Wales Office of Water

This section of the survey explored licence-holder trust in the New South Wales Office of Water (NoW) and built upon previous research conducted by the research team in other natural resource management (NRM) contexts (Sharp, Thwaites, Curtis & Millar, 2009). One of the aims of including this section in the survey was to better understand how the trustworthiness of the agency and its staff influenced trust in the agency. The subsections below introduce the research problem, define trust and trustworthiness, describe the statistical models used to explore the research objectives and present and discuss the findings from this section.

4.9.1 Introduction to the research problem

Multiple benefits of building trust between communities and NRM agencies have been identified in the literature. For example, trust is considered a key factor in the social acceptability of policy and the effectiveness of public participation and collaborative processes (Beunen & de Vries, 2011; Cooke et al., 2011). Research also suggests that trust is relational (Lewicki, Tomlinson & Gillespie, 2006; Rousseau, Sitkin, Burt & Camerer, 1998) and that increased frequency of contact between relationship partners (e.g. government agencies and community members) leads to increased trust (Burt & Knez, 2006; Shapiro, Sheppard, & Cheraskin, 1992). NRM studies have recommended that increasing on-ground staff interaction with the public at the interpersonal level will lead to greater trust in management agencies (Olsen & Shindler, 2010; Toman, Shindler, Absher & McCaffrey, 2008). However, other research has found that trust in agency staff does not always translate into trust in the managing agency at an organisational level (Davenport, Leahy, Anderson & Jakes, 2007; Zaheer, McEvily & Perron, 1998). Therefore, the objectives of including this section in the Namoi survey were to:

- 1) measure trustworthiness at both interpersonal and organisational levels; and,
- 2) investigate how agency trustworthiness influences staff member trustworthiness and trust in the agency itself by testing two alternative models which may explicate the relationships among these constructs.

4.9.2 Defining trust and trustworthiness

Trust has been defined in many different ways in the NRM literature (e.g. Marshall & Jones, 2005; Toman, Stidham, Shindler & McCaffrey, 2011; Vogt, Winter & Fried, 2005) with no consensus

definition and a lack of clarity regarding conceptual distinctions between trust and trustworthiness. Several organisational management researchers have attempted to clarify the conceptual confusion surrounding trust by defining it in a way that differentiates trust and trustworthiness (Mayer, Davis & Schoorman, 1995; Rousseau et al., 1998). Rousseau et al. (1998) defined trust as “a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another” (p. 395). Mayer et al. (1995, p. 712) defined trust as “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other party will perform a particular action important to the trustor....” These definitions suggest trust has two main components. First, the willingness to accept vulnerability represents trusting intentions. Second, these trusting intentions are based on positive trusting beliefs or expectations (i.e. beliefs or expectations about another’s trustworthiness). Consequently, trust and trustworthiness are viewed as separate constructs. Trustworthiness is a quality of the trustee (i.e. person being trusted) while trusting is something that the trustor (i.e. person doing the trusting) does (Mayer et al. 1995).

Trust

Several authors have identified common components of trust found in conceptualisations in the literature (e.g. Rousseau et al., 1998; Hudson, 2004; Mollering, 2006). These authors suggest that most conceptualisations of trust involve dimensions of risk, vulnerability, uncertainty, expectations and interdependence, as explained below.

It is argued that for trust to arise, uncertainty and vulnerability are necessary conditions facing the trustor and trustee (Luhmann, 1979, Bigley & Pearce, 1998). **Uncertainty** relates to the limits of an individual ever having full knowledge of others, their motives and their responses to internal and external changes in situations (Gambetta, 1988, p. 218). In other words, the trustor can never be absolutely sure that the trustee will fulfil his or her obligations. Trusting under such conditions of uncertainty requires taking a “leap of faith” (Lewis & Weigert, 1985). This “leap of faith” is related to **risk**, that is, the potential that the trustor will experience negative outcomes (e.g. loss) if the trustee proves untrustworthy (Sitkin & Pablo, 1992). Rousseau et al. (1998) state that uncertainty is the source of risk, and risk creates the opportunity for trust.

Vulnerability (i.e. taking on risk) is related to **expectation** because it is presumed that a trustor is willing to assume vulnerability based on positive expectations that the trustee will fulfil his or her obligations within the relationship (Mayer et al., 1995; Rousseau et al., 1998). Relationship obligations could include such things as completion of a job or achievement of a shared goal. Finally, trusting relationships are assumed to require **interdependence**, a situation where the interests of at least one of the parties cannot be fulfilled without dependence on another party.

Trust therefore is a unique form of a relationship that entails vulnerability to and uncertainty about another party’s actions when one or both parties are dependent on the other to fulfil its interests. Further, trust is based on positive expectations that the other party will fulfil its obligations in the relationship. It is important to note that trust would not be necessary if the other party’s intentions could be ascertained with complete certainty or neither party had anything meaningful at stake (Kee & Knox, 1970; Bigley & Pearce, 1998). Trust is based on positive expectations, which involves perceptions of the other party’s trustworthiness. Trust should therefore be measured by the ‘willingness to be vulnerable’ and is often operationalised as reliance on the other party for certain actions that carry some sort of risk.

Trustworthiness

Mayer et al. (1995) suggest that trustworthiness, or expectations about another's intentions or behaviour, is comprised of three characteristics, including: ability (i.e. trustor perceptions of the trustee's knowledge, skills and competencies); benevolence (i.e. the extent to which a trustor believes that a trustee will act in the best interest of the trustor); and, integrity (i.e. the extent to which the trustor perceives the trustee as acting in accord with a set of values and norms shared with or acceptable to the trustor).

4.9.3 Measures

Agency trustworthiness was measured in the survey using five items which covered the three characteristics of trustworthiness (i.e. ability, benevolence and integrity) identified by Mayer et al. (1995) (Table 42). Agency staff trustworthiness was measured using one item for each trustworthy characteristic. Intention to trust NoW was measured using three items which captured respondents' willingness to rely on the agency. All items were adapted from Mayer et al. (1995), McKnight, Choudhury and Kacmar (2002) and Sharp (2010). Respondents were asked to rate their agreement with each statement on a 1-5 scale ranging from *Strongly Disagree* to *Strongly Agree*. *Not Applicable* was a separate response option.

Table 42: Items used to measure intention to trust and agency and staff trustworthiness
2011 Namoi groundwater management survey (N=210)

Items used to measure trust and trustworthiness	Item level	Trustworthy characteristic measured
The NoW, as an organisation , keeps water licence-holders' interests in mind when making decisions about groundwater management.	Agency (organisational)	Benevolence
My needs and concerns are very important to NoW (organisation) in its decision-making.	Agency (organisational)	Benevolence
Sound principles seem to guide NoW organisational decisions about groundwater management.	Agency (organisational)	Integrity
NoW (organisation) follows through with what it says it will do in relation to groundwater management.	Agency (organisational)	Integrity
NoW (organisation) shows good judgement when making decisions about groundwater management.	Agency (organisational)	Ability
Local NoW staff members follow through with what they say in relation to groundwater management.	Staff (interpersonal)	Integrity
Local NoW staff are very knowledgeable about groundwater management.	Staff (interpersonal)	Ability
My groundwater management needs and concerns are very important to local NoW staff .	Staff (interpersonal)	Benevolence
I can rely on NoW, as an organisation , to manage groundwater in a sustainable manner.	Agency (organisational)	TRUST
I can rely on NoW, as an organisation , to manage groundwater in a way that is fair to all users.	Agency (organisational)	TRUST
It is important for me to have a good way to keep an eye on NoW (organisation) decisions about groundwater management. (reverse scored)	Agency (organisational)	TRUST

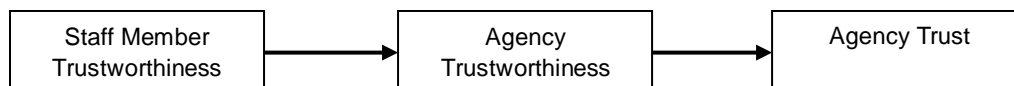
The Chronbach's Alpha test was used to identify the best combination of explanatory items for each scale (i.e. Agency trustworthiness, Staff trustworthiness and Intention to trust). The three Staff trustworthiness items showed a statistically acceptable alpha of 0.780 (alpha's greater than 0.7 are considered acceptable). The best combination for the Agency trustworthiness items (alpha 0.736) included one item from each of the trustworthy characteristics. No acceptable Chronbach's Alpha combinations for the set of Intention to rust items could be found. So, in the subsequent mediation/moderation analyses, Intention to trust was included as the single item, '*I can rely on NoW to manage groundwater in a sustainable manner*'.

4.9.4 Mediation and moderation models

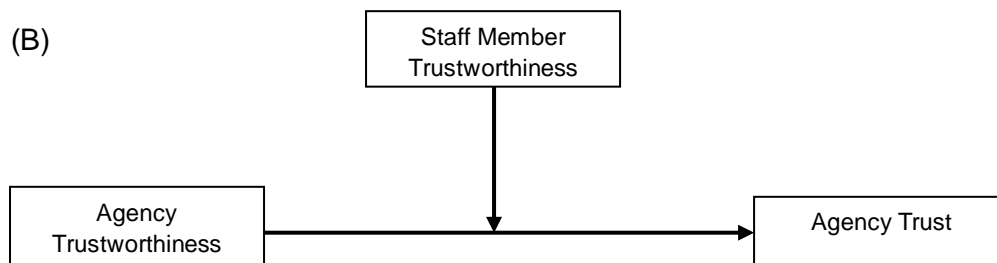
One of our research objectives was to investigate how staff trustworthiness influences agency trustworthiness and trust in the agency itself. To do this, we tested two simple regression models which reflected the findings in previous literature. The first model was a mediation model (Figure 7A). The second model was a moderation model (Figure 7B).

Figure 7: (A) Schematic diagram of the mediating role of agency trustworthiness.
(B) Schematic diagram of the moderating role of staff member trustworthiness.

(A)



(B)



The first model, the mediator model (Fig. 7A), answers the question of 'why' and specifies how a given effect occurs (Holmbeck, 1997). Mediation models explain 'process'. To this end, the hypothesis in the first model was that agency trustworthiness would mediate the relationship between staff member trustworthiness and agency trust. In other words, staff member trustworthiness influences agency trustworthiness which, in turn, influences agency trust. This model tests whether staff member trustworthiness: 1) has a significant influence on agency trustworthiness and/ or agency trust; and, 2) directly influences agency trust.

The second model tested was a moderator model (Fig. 7B). Moderation models explain 'when', or under what conditions, a relationship exists. The moderating variable affects the strength of the relationship between the first, or predictor variable (i.e. agency trustworthiness) and the dependent variable (i.e. agency trust). For example, in this model, agency trustworthiness may only influence agency trust when levels of staff trustworthiness are high. The moderating effect is typically

expressed as an interaction between the predictor and criterion variables (Baron & Kenny, 1986). The hypothesis in the second model was that staff member trustworthiness would moderate the relationship between agency trustworthiness and agency trust. In other words, staff member trustworthiness would interact with agency trustworthiness to modify the level of agency trust. Because pairwise analysis showed that both staff member and organisational trustworthiness are associated with agency trust, we expected organisational trustworthiness to be most strongly related to agency trust when staff member trustworthiness was high.

4.9.5 Trust and trustworthiness findings

Research objective 1

Our first research objective was to measure trustworthiness at the agency (i.e. organisational) and staff (i.e. interpersonal) levels. As shown in Table 43, the findings showed that respondents generally disagreed that:

- NoW, as an organisation, keeps water licence-holders' interests in mind when making decisions about groundwater management (42% disagreed compared to 15% agreed).
- Sound principles seem to guide NoW organisational decisions about groundwater management (41% disagreed compared to 13% agreed).
- NoW shows good judgement when making decisions about groundwater management (52% disagreed compared to 6% agreed).

Agency staff were generally viewed to be slightly more trustworthy than the agency itself but these differences were not statistically significant. It is important to note that some respondents did not have a strong opinion about items in this section with more than 40% of respondents answering "Unsure". This may suggest that some respondents have not had many interactions with NoW which would allow them to develop opinions about these items.

Only 10% of respondents agreed with the statement, '*I can rely on NoW, as an organisation to manage groundwater in a sustainable manner*' while 40% disagreed. Similarly, only 8% agreed that they could rely on NoW to manage groundwater in a way that was fair to all users compared to 47% who disagreed.

There were no significant differences in how respondents answered the trust and trustworthiness questions based on management zone which suggests that respondents across the catchment have had similar experiences with the Office of Water.

Table 43: Views about staff and agency trustworthiness and respondent intention to trust
2011 Namoi groundwater management survey (N=210)

Topic: Interactions with NSW Office of Water	n	Strongly Disagree/ Disagree	Unsure	Agree/ Strongly Agree	N/A	Mean score*
The NoW, as an organisation , keeps water licence-holders' interests in mind when making decisions about groundwater management.	205	42%	42%	15%	2%	2.57
My needs and concerns are very important to NoW (organisation) in its decision-making.	206	39%	35%	23%	2%	2.75
Sound principles seem to guide NoW organisational decisions about groundwater management.	206	41%	44%	13%	2%	2.56
NoW (organisation) follows through with what it says it will do in relation to groundwater management.	206	31%	50%	18%	2%	2.73
NoW (organisation) shows good judgement when making decisions about groundwater management.	206	52%	41%	6%	2%	2.35
Local NoW staff members follow through with what they say in relation to groundwater management.	205	23%	48%	28%	2%	3.01
Local NoW staff are very knowledgeable about groundwater management.	206	31%	45%	24%	2%	2.83
My groundwater management needs and concerns are very important to local NoW staff .	206	33%	40%	24%	3%	2.85
I can rely on NoW, as an organisation , to manage groundwater in a sustainable manner.	206	40%	50%	10%	2%	2.55
I can rely on NoW, as an organisation , to manage groundwater in a way that is fair to all users.	206	47%	44%	8%	2%	2.41
It is important for me to have a good way to keep an eye on NoW (organisation) decisions about groundwater management.	206	3%	10%	87%	2%	4.15

*Responses were rated on a scale from 1, 'Strongly Disagree' to 5, 'Strongly Agree'. 'Not applicable' was a separate response option.

Research objective 2

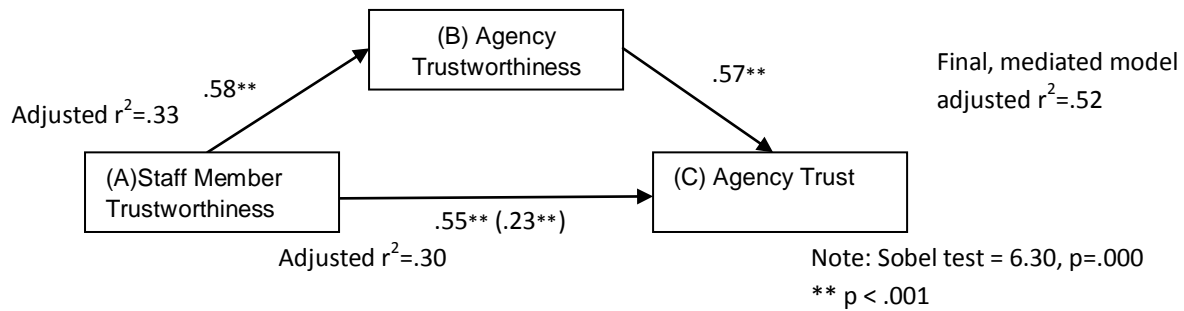
Our second research objective was to investigate how staff trustworthiness influenced agency trustworthiness and agency trust. We tested a mediation model and a moderation model through multiple regression analysis to address this objective.

MODEL 1 - MEDIATION

For the first model, four conditions must be met through three multiple regressions to show mediation. Using our model as an example, the following conditions must be met (Figure 8):

- 1) (A) must be significantly associated with (C)
- 2) (A) significantly associated with (B)
- 3) (B) significantly associated with (C) – after controlling for (A)
- 4) Impact of (A) on (C) significantly less after controlling for (B)

Figure 8: Model 1 - The trust and trustworthiness mediation model



As shown by Figure 8, the model supports partial mediation. Condition 1 is satisfied through a significant beta (i.e. β) between (A) and (C) of 0.55, $p < .001$. Condition 2 is satisfied through a significant beta between (A) and (B) of 0.58, $p < .001$. Condition 3 is satisfied through a significant beta between (B) and (C) of 0.57, $p < .001$ after controlling for A. Finally, Condition 4 is satisfied because the beta between (A) and (C) drops from 0.55 to 0.23, which a Sobel test indicates is a significant change. The model does not support full mediation of the relationship between staff trustworthiness and agency trust by agency trustworthiness because the final beta value between (A) and (C) is reduced but still significant.

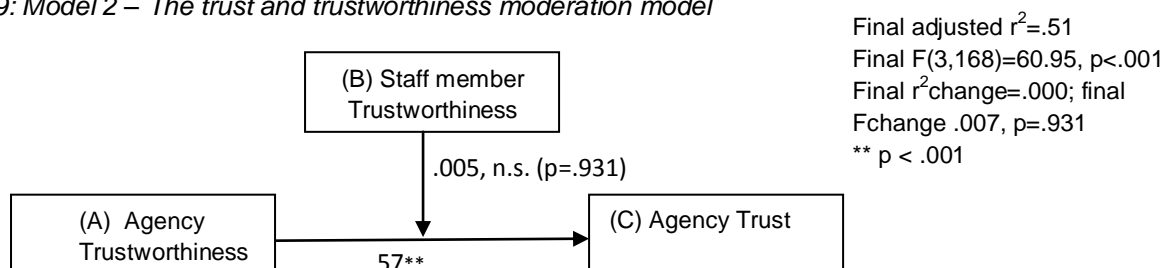
Therefore, the model suggests that agency trust is influenced by both staff and agency trustworthiness. Staff trustworthiness directly and indirectly, through agency trustworthiness, influences agency trust. The r^2 value for this model, which shows how much variance is explained by the model, is acceptable at 0.52, $p < .001$. This finding indicates that a little more than half of the variance in the model is explained by the included variables. Previous research by the project team in other NRM contexts suggests that including variables related to communication and community engagement would likely increase the r^2 value for the model. The model suggests that it is important to focus on perceptions of agency trustworthiness at both interpersonal and organisational level because both influence intention to trust the agency.

MODEL 2 – MODERATION

For the second model, there are two steps to test for moderation. Using our model as an example (Figure 9):

- 1) Enter (A) and (B) simultaneously as main effects in a multiple regression model.
- 2) Enter an interaction effect as the product of (A) and (B).

Figure 9: Model 2 – The trust and trustworthiness moderation model



If moderation is found, there will be a significant beta value for the interaction effect. As can be seen in Figure 9, moderation is not supported because the interaction value ($\beta=.005$, $p=.931$) is not significant. The model suggests the significant, main effect from (A) to (C) does most of the explanation in the model. In other words, high or low levels of staff trustworthiness do not significantly influence the relationship between agency trustworthiness and agency trust. These findings also suggest that the mediation model (Model 1) does a better job of explaining the relationships between the constructs. This is as expected, statistically, because analysis of moderators is easiest when they have no significant linear relationship with either of the other constructs.

4.9.6 Trust and trustworthiness discussion

Trust is an important part of decision-making processes in NRM, but there are conflicting findings in the literature in regard to the relationships between trust and trustworthiness at interpersonal and organisational levels. In this study, we examined perceptions of agency and staff trustworthiness and the relationships among staff member trustworthiness, agency trustworthiness and agency trust through a mediation model and a moderation model.

Previous studies conducted by the research team in Victoria suggests that the high proportion of respondents (more than one-third) who were 'Unsure' about items in this section is likely to stem from the respondents not having many interactions with the agency or its staff. High unsure responses have been found in other NRM studies when asking questions about agency actions (Olsen & Shindler, 2010; Sharp, 2010). While other studies may have been surveying the general public, this result is particularly interesting because this research is a study of licence-holders who would likely have interactions with the agency in regard to bore monitoring and checks of compliance with regulations. However, this high proportion of unsure respondents is not as negative as it may seem. It suggests that there is an opportunity for NoW to engage these unsure respondents which, if done well, could lead to positive perceptions of agency trust and trustworthiness.

Conducting both a mediator and a moderator analysis allowed us to test two different models that reflected the findings from qualitative NRM research. Initial analysis showed significant relationships among the three constructs being tested. While this is an important condition for a mediation model, significant relationships between moderating variables and either of the other model constructs may confound interpretation of a moderation model (Hair, Black, Babin & Anderson, 2010). However, we conducted both analyses so that we could reflect the previous findings and confirm that the mediation model was a more appropriate representation of the variables tested. The models showed that in this study that staff member trustworthiness influences agency trustworthiness, as well as influencing agency trust both directly and indirectly. However, the interaction effects in the moderation model were not significant, suggesting that when trust in the staff member is high, it does not necessarily influence the relationship between agency trustworthiness and trust in the agency. Therefore, the models suggest that staff member trustworthiness influences the 'how' and the not 'when' of the relationships among constructs. Our findings supports the work of Davenport et al. (2007) which says that trust in the agency can arise from interpersonal interactions but does not always do so (consistent with our mediation model) and that some members of the public can express high levels of interpersonal trust but this does not influence their perceptions of agency trustworthiness or trust in the agency itself (consistent with our moderation model).

The findings suggest that focusing community engagement resources solely at the interpersonal level ignores the important role that perceptions of trustworthiness at the organisational level play in influencing trust in the managing agency. While community members' willingness to rely on the agency is directly influenced by whether a staff member exhibits knowledge, care, concern and integrity, it is also influenced by whether the organisation itself exhibits these same characteristics. This emphasises the importance of communicating agency 'culture' to community members in a way that demonstrates that the agency, through its policies, strategies and actions, is knowledgeable, shares community values and norms and acts in the community's best interest. Previous research shows communication efforts instigated at agency level are a good way to do this (Bushnell & Cottrell, 2007; Ryan & Hamin, 2006) because it communicates agency policy and allows community members to see how the agency shares values for management (Earle & Cvetkovich, 1995; McCaffrey, 2006). While face-to-face community engagement may build some trust in the agency, engagement resources targeted at the organisational level may complement interpersonal efforts, resulting in greater community trust in the agency than resources focused on interpersonal interactions alone.

5. Conclusions

The aim of the mail survey was to collect data for the social, hydrological, economic, governance, legal and integrated research teams for input into an integrated model and to better understand:

- 1) What innovative practices landholders are adopting now and who plans to do so in the future; and,
- 2) The key drivers influencing adoption of innovative practices and/ or changes in land use.

We also sought to extend the social research team's work on community member trust in government agencies by exploring: 1) licence-holders' perceptions of the trustworthiness of NSW Office of Water and its staff; and, 2) the relationships among agency and staff trustworthiness and licence-holders' intention to trust the agency.

In this section of the report we use the first two project key questions to provide the structure for a synthesis of the key research findings. We discuss the trust findings in relation to their implications for NRM practitioners.

Land use change and innovative practices being undertaken now and in the past five years

The questionnaire included 26 property management actions that were considered strategies landholders might undertake to adapt to changes in water availability and climate. Over the past five years the majority of respondents had made adjustments to their cropping regimes through changes to tillage technique (74%), changes of crop types in rotation (70%) and changes to crop rotation frequencies (62%). Licence-holders had also invested in new planting machinery (57%). However, these actions may not have been taken solely to adapt to reduced water availability. As with the implementation of most on-farm innovations, a mixture of factors appears to be influencing landholder decision making. In this study these actions may have also been undertaken because they are thought to improve crop yield (and profitability), reduce labour or fuel inputs (contain costs and improve lifestyle) or respond to changes in markets (maintain income). Nevertheless, some of the 10 most frequently implemented actions can be linked to concerns about water availability and efforts to improve water use efficiency, including modifying flood irrigation (40%), decreasing cropping area (40%), changing to spray irrigation (28%), changing drainage methods (26%) and deepening dams (25%). However, these actions were not undertaken by the majority of respondents. Larger dam capacity was associated with the uptake of several water use efficiency measures, including: deepening dams; dividing dams into cells; measuring evaporation losses; and, implementing soil moisture mapping. Evidence of these significant relationships suggests landholders who store larger volumes of water, and who are operating on a larger scale, are more interested in and are more likely to adopt water use efficiency measures.

Land use data also indicated a four-fold increase in the proportion of respondents growing dryland cotton, up from 4% in the 2005-2006 water year to 19% in the 2010-2011 water year. In this period, the proportion of respondents growing irrigated cotton also increased by 7%. Again, it seems there is a mix of factors influencing land use decisions. The likely explanation for such a large increase in the proportion of respondents growing dryland cotton is a combination of increased recognition of the need to adapt to less groundwater for irrigation, precision farming techniques reducing some of the risk with dryland cotton and higher prices for cotton in recent years. The majority of respondents (75%) were growing cereals in the 2010-2011 water year, but this proportion had declined from the

2005-2006 water year when 83% of respondents had grown cereals. These findings suggest that survey respondents had also moved away from cereals and invested in dryland cotton, or to a lesser extent, irrigated cotton in the 2010-2011 year.

Land use changes and innovative practices being undertaken in the next five years

The land use data showed that respondents were not planning many changes in the next five years to the crop types they were growing in the 2010-2011 water year. The proportion of respondents who projected that they would be growing dryland or irrigated cotton and pasture for silage/ feed in 2015-16 varied by less than 3% for each crop type from 2010-2011. While the proportion of respondents who said that they would grow cereals, legumes, oilseeds and pasture for grazing or silage/feed in 2015-2016 decreased, these changes were not statistically significant. Neither the median total area cultivated or laid out to irrigation varied significantly across the three time periods employed in the survey (i.e. 2005-2006, 2010-2011, 2015-2016), again suggesting that respondents had not made and were not planning to make large-scale changes to their farming systems.

Analysis of survey responses suggested there was on-going interest in improving water use efficiency and conservation. For example, more than half of the respondents who had undertaken a number of related property management actions in the past five years were definitely planning to implement the same actions in the next five years, including: utilise spray polymers (75%); change to spray irrigation (74%); implement soil moisture mapping (51%); and, routinely test water quality (51%). Survey data also suggests that encouraging uptake of water use efficiency and conservation actions by licence-holders who have not already commenced doing so will be challenging. For most of the 26 actions, less than 10% of those who had not implemented a specific action in the past five years were planning to implement those practices in the next five years. The exceptions were: purchasing/ leasing more land (34%); investing in planting machinery (17%); changing to spray irrigation (17%); modifying flood irrigation approach (15%); and, deepening dams (17%).

Key drivers influencing adoption of innovative practices and land use change

The questionnaire included a large number of items exploring factors which may influence adaptive behaviours. As might be expected, there were significant relationships (positive and negative) between many of these items and specific adaptations. Preliminary data analyses suggest that there are at least two key licence-holder types based on respondent's level of personal commitment to economic objectives (including values, personal norms and beliefs), the scale of the farming operation, and the types of adaptive actions being implemented (or planned). We have described these two groups as those *More committed to farm business viability (MCFB)* and those *More committed to environmental sustainability (MCES)* to emphasise that, as evidence presented in this report illustrates, almost all respondents will give a high rating to some environmental, economic and social objectives.

Compared to the *MCES*, the *MCFB* have larger properties, larger areas cultivated and irrigated, larger total dam capacities, and are working longer hours on-property and are less likely to seek off-property work. The *MCFB* licence-holders are also more likely than the *MCES* to take actions which allow them to maintain or expand production, such as buying more water on the temporary and permanent water markets and investing in water use efficiency measures. The *MCES* are more likely than the *MCFB* to have pro-conservation and altruistic values and beliefs, believe in human-

induced climate change, rate its nature of impact as negative and be less optimistic about their capacity to adapt to climate change impacts. The *MCES* respondents were also more likely than the *MCFB* to be concerned about the over-allocation of groundwater, believe that water should be returned to rivers for environmental benefits and say that they could adapt to further cuts in surface water and groundwater entitlements. Additionally, the *MCES* respondents were more likely than the *MCFB* to say that the Office of Water and its staff were trustworthy and to agree with the science used to develop sustainable diversion limits.

The survey findings, including the differences between the *MCFB* and *MCES* groups of licence-holders, have important implications for practitioners wishing to engage licence-holders in dialogue about climate change and the implementation of new land uses or technologies. There is some survey evidence suggesting that a lack of knowledge or understanding underpins beliefs or attitudes that are inconsistent with contemporary NRM policy and management objectives. For example, there may be a lack of knowledge about: the extent of groundwater depletion and the future implications of continued pumping at current rates; the current status of key flora and fauna; and, the links between the future health of these species and environmental flows. However, our assessment of survey evidence is that much of the difficulty of engaging licence-holders in dialogue about water reform or climate change is more likely to revolve around a clash of values, beliefs and risk perceptions and the distrust of government agencies by some licence-holders. For example, only 39% of respondents supported a stewardship ethic, that is, they agreed that short-term reductions in farm production are justified when there are long-term environmental benefits. This demonstrates the extent of the challenge facing government agencies attempting to implement reform processes that prioritise environmental values over economic ones. Furthermore, survey findings suggest that engagement processes for water reform have mostly attracted participants who already trust government water agencies and share the values and goals they express/represent. Risk communication theory suggests that providing additional scientific evidence/proof is unlikely to persuade opponents of the merits of a policy initiative when the basis for opposition stems from differing risk perceptions and distrust in science or the lead agency (Garvin, 2001; Slovic, 1999).

Survey findings and risk communication theory provide some indications of what might be a more effective approach to engaging groundwater licence-holders in water reform and climate change dialogues. These suggest that agencies should: 1) focus on a set of common concerns and values; and, 2) build positive perceptions of trustworthiness in local agency staff and in the Office of Water itself.

At least three-quarters of respondents said they felt a personal obligation to act as an individual or as part of a group to protect the district's groundwater resource. There was also widespread commitment to community well-being and the economic and social benefits of a healthy Namoi river. These common values and personal norms could be used as the basis for engaging licence-holders with dialogue focused on the long-term benefits of environmental sustainability in irrigation districts. There is abundant evidence that agencies attempting to engage rural landholders in complex and contentious issues should do so through locally respected platforms, including groups where dialogue, learning and action can occur with peers over time (Curtis, Lucas, Nurse & Skeen, 2008). In the Namoi, the use of industry groups as that platform would seem to be a more effective strategy than using Landcare because the former reaches a larger audience (67% compared to 28%) and is more likely to include a mix of the *MCFB* and *MCES* groups. We also suggest that, if using local platforms for dialogue, opportunities for

collective management should also be considered. The findings suggest that there is support among licence-holders for collective management which features government acting as a regulatory backstop. Finally, we suggest that agency communication about water reform, climate change or the adoption of innovative practices, be tailored to emphasise the different interests of the *MCFB* and *MCES* groups. For example, the *MCES* licence-holders are more likely to show interest in dialogue and practices that are aligned with the sustainable and fair use of natural resources by licence-holders. The *MCFB* licence-holders may be more likely to show interest in dialogue and practices that focus on production, lessen the economic impacts of water reform and improve the 'bottom line'.

Given that 40% of respondents currently do not have a formed opinion about the trustworthiness of the Office of Water and its staff, there is still a substantial opportunity to build positive perceptions of trustworthiness in local agency staff and the agency itself. Focusing on effective engagement at both the agency and interpersonal levels is important. Our analysis of survey data indicates that while local staff are important for effective implementation of programs at the local level, and that trust in local staff influences trust in the agency, agency trust is also dependent on the trustworthiness of the agency itself. In this case, *MCFB* licence-holders were less likely than the *MCES* licence-holders to find the Office of Water and its staff trustworthy. It seems a more determined, coherent and intensive effort is required to engage these landholders in ways that demonstrate agency trustworthiness. For example, engagement that focuses on agency trustworthiness needs to establish that the agency and its staff are competent (i.e. effective in managing the water-delivery system: e.g. don't waste water, respond quickly to queries), act with integrity (i.e. share licence-holder's values and personal norms: e.g. optimise economic and environmental outcomes, don't favour some over others), and benevolent (i.e. acts in the community's best interests: e.g. interprets policy to achieve best outcomes for community, will respond to community leaders, prepared to articulate community concerns to government). While face-to-face community engagement as a result of the activity of local staff may build trust in the agency, effort also needs to be targeted at the agency level to complement the efforts of local staff.

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Appendix 1 – Property management actions taken in the past five years (Items with N/A > 50% shaded grey)

Actions taken or considered in past 5 years	n	Not applicable (%)	Didn't think about doing this (%)	Gave serious consideration to doing this (%)	Planned to do this, but did not do it (%)	Did this (%)	Mean score
Changed tillage technique	197	9	7	7	4	74	3.58
Changed crop types in rotation	199	12	7	8	3	70	3.55
Changed crop rotation frequencies	197	14	10	8	6	62	3.41
Invested in new planting machinery	198	14	13	12	5	57	3.23
Modified flood irrigation approach	197	41	11	6	3	40	3.22
Deepened dam	199	46	17	4	8	25	2.79
Decreased cropping area	199	20	33	5	2	40	2.61
Changed to spray irrigation	197	33	20	14	5	28	2.61
Sought additional off-property work	198	26	31	6	2	35	2.55
Changed drainage method	197	40	26	6	3	26	2.48
Routinely tested water quality	199	24	34	7	8	29	2.41
Purchased/leased more land	197	29	34	9	3	25	2.27
Measured dam evaporation losses	199	48	27	6	5	15	2.16
Implemented soil moisture mapping	199	27	39	9	5	20	2.08
Bought water on the temporary market	199	31	46	7	3	14	1.77
Bought water on the permanent market	199	30	45	9	5	11	1.75
Sold water on the temporary market	198	28	51	11	3	8	1.57
Utilised spray polymers on dams	197	49	33	14	1	3	1.47
Sold water on the permanent market	199	29	55	6	3	7	1.45
Changed to drip irrigation	197	44	40	11	2	3	1.44
Sold part/all of my property	199	40	49	6	1	5	1.34
Leased part of the property	199	41	50	4	1	5	1.33
Increased dryland cotton cultivation area	199	63	15	3	1	19	2.66
Changed row widths of cotton	200	63	22	5	1	10	1.96
Divided dam into cells	199	54	28	8	3	8	1.77
Changed row length of cotton	199	65	27	5	1	3	1.44

Appendix 1 (continued) - Property management actions being considered in the next 5 years (N/A > 50% shaded grey)

Actions being planned or considered in next 5 years	n	N/A (%)	Not interested at this time (%)	Will give serious consideration to doing this (%)	Planning to do this/ do more (%)	Definitely intend to do this, do more (%)	Mean score
Change crop types in rotation	199	13	17	26	23	22	2.57
Change crop rotation frequencies	199	13	18	25	23	22	2.55
Change tillage technique	198	13	22	19	25	21	2.51
Routinely test water quality	199	19	21	25	18	18	2.40
Modify flood irrigation approach	199	39	20	17	12	13	2.28
Invest in new planting machinery	197	15	30	22	18	15	2.21
Implement soil moisture mapping	198	25	30	19	19	11	2.09
Deepen dam	198	45	27	10	8	10	2.01
Measure dam evaporation losses	198	47	25	13	9	7	1.94
Change to spray irrigation	199	37	35	10	8	11	1.90
Change drainage method	199	39	36	8	8	9	1.84
Seek additional off-property work	199	24	46	7	15	9	1.82
Buy water on the temporary market	199	21	47	19	6	7	1.64
Buy water on the permanent market	199	22	48	17	6	7	1.63
Purchase/lease more land	199	19	49	18	8	6	1.63
Utilise spray polymers on dams	196	47	34	14	3	2	1.50
Decrease cropping area	199	19	61	8	8	6	1.49
Divide dam into cells	198	47	37	11	2	4	1.48
Sell water on the temporary market	199	18	61	16	4	2	1.36
Lease part of the property	199	24	63	8	3	3	1.30
Sell water on the permanent market	198	18	71	7	3	2	1.20
Sell part/all of my property	197	22	69	7	2	1	1.16
Change to drip irrigation	198	37	57	3	1	2	1.15
Increase dryland cotton cultivation area	199	53	24	12	8	4	1.82
Change row widths of cotton	197	55	29	8	3	5	1.61
Change row length of cotton	198	57	35	4	2	3	1.36

Appendix 2 – Management zone profiles

Appendix 2

Zone LOWER N=55			
Median age:	58 yrs	3 most common land enterprises:	
Farmer by occupation:	81 %	--Irrigated Cotton	79%
		--Cereals	71%
		--Legumes	49%
Landcare membership:	11 %	3 most commonly adopted property management adaptations in past 5 years:	
Industry group membership:	74 %	--Changed tillage technique	81 %
		--Changed crop types in rotation	76 %
		--Changed crop rotation frequencies	66 %
Median property size:	1200 ha	3 most common property management adaptations being considered in the next 5 years:	
Property not principal residence:	13%	--Change tillage technique	25 %
		--Deepen dam	25 %
		--Routinely test water quality	25 %
Median length of property management:	30 yrs	Willing to sell groundwater entitlement to government if buyback offered:	
Percentage with government funded work on property:	30 %	Percentage who think there will be a lot less surface water available in the next 25 years:	22%

Appendix 2

Zone 1,6,7,10		N=21	
Median age:	57 yrs	3 most common land enterprises:	
Farmer by occupation:	81%	--Cereals	78%
		--Oilseeds	44%
		--Pasture for grazing	44%
Landcare membership:	53%	3 most commonly adopted property management adaptations in past 5 years:	
Industry group membership:	62%	--Changed crop rotation frequencies	79 %
		--Changed crop types in rotation	68 %
		--Invested in new planting machinery	68 %
Median property size:	1050 ha	3 most common property management adaptations being considered in the next 5 years:	
Property not principal residence:	14%	--Change crop rotation frequencies	26 %
		--Change crop types in rotation	26 %
		--Invest in new planting machinery	21 %
Median length of property management:	22 yrs	Willing to sell groundwater entitlement to government if buyback offered:	
			45%
Percentage with government funded work on property:	29 %	Percentage who think there will be a lot less surface water available in the next 25 years:	
			26%

Appendix 2

Zone 2,9		N=21	
Median age:	55 yrs	3 most common land enterprises:	
Farmer by occupation:	91%	--Cereals	100%
		--Pasture for grazing	55%
		--Oilseeds	35%
Landcare membership:	35%	3 most commonly adopted property management adaptations in past 5 years:	
Industry group membership:	71%	--Changed tillage technique	80%
		--Changed crop rotation frequencies	80%
		--Changed crop types in rotation	70%
Median property size:	1243 ha	3 most common property management adaptations being considered in the next 5 years:	
Property not principal residence:	20%	--Invest in new planting machinery	15%
		--Change tillage technique	15%
		--Change crop rotation frequencies	10%
Median length of property management:	13 yrs	Willing to sell groundwater entitlement to government if buyback offered:	
Percentage with government funded work on property:	38%	Percentage who think there will be a lot less surface water available in the next 25 years:	
			26%

Appendix 2

Zone 3		N=20	
Median age:	55 yrs	3 most common land enterprises:	
Farmer by occupation:	85 %	--Cereals	89%
		--Irrigated Cotton	42%
		--Legumes	32%
Landcare membership:	20 %	3 most commonly adopted property management adaptations in past 5 years:	
Industry group membership:	60 %	--Changed crop types in rotation	68%
		--Invested in new planting machinery	68%
		--Changed crop rotation frequencies	63%
Median property size:	725 ha	3 most common property management adaptations being considered in the next 5 years:	
Property not principal residence:	25%	--Implement soil moisture mapping	26%
		--Routinely test water quality	26%
		--Change crop rotation frequencies	21%
Median length of property management:	20 yrs	Willing to sell groundwater entitlement to government if buyback offered:	
			10%
Percentage with government funded work on property:	30 %	Percentage who think there will be a lot less surface water available in the next 25 years:	
			19%

Appendix 2

Zone 4		N=39	
Median age:	55 yrs	3 most common land enterprises:	
Farmer by occupation:	77%	--Cereals	66%
		--Pasture for grazing	55%
		--Legumes	29%
Landcare membership:	39%	3 most commonly adopted property management adaptations in past 5 years:	
Industry group membership:	54%	--Changed crop types in rotation	74%
		--Changed tillage technique	65%
		--Changed crop rotation frequencies	47%
Median property size:	440 ha	3 most common property management adaptations being considered in the next 5 years:	
Property not principal residence:	13%	--Change crop types in rotation	34%
		--Change crop rotation frequencies	29%
		--Change tillage technique	24%
Median length of property management:	20 yrs	Willing to sell groundwater entitlement to government if buyback offered:	
Percentage with government funded work on property:	41%	Percentage who think there will be a lot less surface water available in the next 25 years:	
			21%

Appendix 2

Zone 5,11		N=23	
Median age:	62 yrs	3 most common land enterprises:	
Farmer by occupation:	82%	--Cereals	65%
		--Grazing for pasture	65%
		--Legumes	40%
Landcare membership:	23%	3 most commonly adopted property management adaptations in past 5 years:	
Industry group membership:	73%	--Changed tillage technique	57%
		--Changed crop rotation frequencies	52%
		--Invested in new planting machinery	44%
Median property size:	700 ha	3 most common property management adaptations being considered in the next 5 years:	
Property not principal residence:	18%	--Change crop rotation frequencies	30%
		--Routinely test water quality	26%
		--Change crop types in rotation	17%
Median length of property management:	23 yrs	Willing to sell groundwater entitlement to government if buyback offered:	
Percentage with government funded work on property:	27%	Percentage who think there will be a lot less surface water available in the next 25 years:	
			14%

Appendix 2

Zone 8		N=25	
Median age:	62 yrs	3 most common land enterprises:	
Farmer by occupation:	83%	--Cereals	84%
		--Pasture for grazing	72%
		--Oilseeds	68%
Landcare membership:	36%	3 most commonly adopted property management adaptations in past 5 years:	
Industry group membership:	80%	--Changed tillage technique	84%
		--Changed crop types in rotation	72%
		--Invested in new planting machinery	68%
Median property size:	400 ha	3 most common property management adaptations being considered in the next 5 years:	
Property not principal residence:	12%	--Change crop rotation frequencies	24%
		--Change crop types in rotation	24%
		--Change drainage method	24%
Median length of property management:	21 yrs	Willing to sell groundwater entitlement to government if buyback offered:	
			8%
Percentage with government funded work on property:	32 %	Percentage who think there will be a lot less surface water available in the next 25 years:	
			29%

Appendix 3 – Mail survey items

Your views on current water policy issues

In this section we would like to know **how closely the statements presented below reflect your views on current water policy and other issues which may affect your property management.** There are no right or wrong answers and there is no need to think at great length about your responses. *[Examine each statement in the table, then place the number for your response in each space provided for 'Your view']*.

RESPONSE OPTIONS:

Strongly disagree	Disagree	Unsure	Agree	Strongly agree	Not applicable
1	2	3	4	5	6

Your views on current issues	Your view
I believe the science used to develop sustainable diversion limits in the Guide to the MDB Plan released in October 2010 was sound.	
If the revised Guide to the Murray Darling Basin (MDB) Plan includes groundwater entitlement reductions around 20%, I think I could readily adapt my property enterprise(s) to those reductions.	
If the revised Guide to the MDB Plan includes surface water entitlement reductions around 15%, I think I could readily adapt my property enterprise(s) to those reductions.	
I would be willing to sell part of my groundwater entitlement to the government if it offered me a buyback as part of the sustainable diversion limits set under the MDB Plan.	
Over-allocation of groundwater is a problem in my management zone.	
It is possible to calculate a sustainable yield for groundwater which can be taken without affecting the integrity of the resource.	
Groundwater zone boundaries in the Namoi catchment are appropriate.	
Coal mining presents a substantial risk to aquifer integrity in my zone.	
My decision-making would be improved if I had ready access to accurate information about groundwater levels and quality in my zone.	
There were meaningful opportunities for me to participate in the development of the water sharing plan(s) in my area (between 2001-2006).	
I believe input from local farmers helped shape the current water sharing plan in my area.	
The decision-making process for the water sharing plan in my area was fair.	
Landholders should have the right to use groundwater underlying their properties, even if that action impacts on others.	
It is fair that the wider community asks landholders to manage their land in ways that will not cause foreseeable harm to the environment.	
Short-term reductions in farm production are justified when there are long-term benefits to the environment.	

Your views on aquifer storage and recovery

There are many examples where reclaimed/recycled water is stored in aquifers and then recovered for urban or rural uses. This process is called Aquifer Storage and Recovery (ASR). Our research team thinks it may be possible to intercept large floods in the Murray-Darling Basin and store some of that water in aquifers. In this way, it could be possible to lift groundwater levels and reconnect surface water and groundwater flows, as well as provide additional groundwater for irrigators. To do this would require the approval of government and the support of landholders, and any specific proposal would need to be subject to stringent feasibility assessments. This section seeks to understand your views about ASR based on intercepting large flood events. *[Examine each statement in the table, then place the number for your response in each space provided].*

RESPONSE OPTIONS:

Strongly disagree	Disagree	Unsure	Agree	Strongly agree	Not applicable
1	2	3	4	5	6

Your views about ASR	Your view
Aquifer storage and recovery (ASR) based on intercepting large flood events appears to be a good idea.	
If public funds were used to develop the infrastructure for ASR based on intercepting large floods, I would be prepared to invest in technology to improve the water-use efficiency on my farm.	
I would be prepared to invest, along with others, without public funding to develop ASR based on intercepting large floods in my water sharing plan (WSP) area.	
I am interested in learning more about the interception of large floods to implement ASR in my WSP area.	

Do you have **any other comments** about aquifer storage and recovery?

Your interactions with NSW Office of Water

The next set of statements seeks information about **your interactions with the NSW Office of Water (NoW)** at the **organisational level** and with **agency staff**. *[Examine each statement in the table, then place the number for your response in each space provided for 'Your view']*.

Strongly disagree	Disagree	Unsure	Agree	Strongly Agree	Not Applicable
1	2	3	4	5	6

Interactions with the Office of Water	Your view
The NoW, as an organisation , keeps water licence holders' interests in mind when making decisions about groundwater management.	
My needs and concerns are very important to NoW (organisation) in its decision-making.	
Sound principles seem to guide NoW organisational decisions about groundwater management.	
NoW (organisation) follows through with what it says it will do in relation to groundwater management.	
NoW (organisation) shows good judgement when making decisions about groundwater management.	
Local NoW staff members follow through with what they say in relation to groundwater management.	
Local NoW staff are very knowledgeable about groundwater management.	
My groundwater management needs and concerns are very important to local NoW staff .	
I can rely on NoW, as an organisation , to manage groundwater in a sustainable manner.	
I can rely on NoW, as an organisation , to manage groundwater in a way that is fair to all users.	
It is important for me to have a good way to keep an eye on NoW (organisation) decisions about groundwater management.	

Property management

In this section we want to know what changes you have made in the past 5 years, or plan to make to your enterprise in the next 5 years. *[Examine each statement in the tables, then place the number for your response in each space provided for the 'changed management' column].*

ACTIONS TAKEN IN THE PAST 5 YEARS (including this year):

Response Options for Changed Management:

Didn't think about doing this	Gave serious consideration to doing this	Planned to do this, but did not do it	Did this	Not Applicable
1	2	3	4	5

Actions taken or considered on your property	Extent you changed mgmt	Actions taken or considered on your property	Extent you changed mgmt
Changed tillage technique		Deepened dam	
Changed crop types in rotation		Divided dam into cells	
Changed crop rotation frequencies		Utilised spray polymers on dams	
Sought additional off-property work		Measured dam evaporation losses	
Invested in new planting machinery		Implemented soil moisture mapping	
Changed to spray irrigation		Routinely tested water quality	
Changed to drip irrigation		Changed row widths of cotton	
Changed drainage method		Changed row length of cotton	
Modified flood irrigation approach		Increased dryland cotton cultivation area	
Decreased cropping area		Leased part of the property	
Purchased/leased more land		Sold part/all of my property	
Sold water on the temporary market		Bought water on the temporary market	
Sold water on the permanent market		Bought water on the permanent market	

ACTIONS BEING CONSIDERED IN THE NEXT 5 YEARS

Response Options for Changed Management:

Not interested at this time	Will give serious consideration to doing this	Planning to do this/ do more	Definitely intend to do this/ do more	Not Applicable
1	2	3	4	5

Actions taken or considered on your property	Extent you will change mgmt	Actions taken or considered on your property	Extent you will change mgmt
Change tillage technique		Deepen dam	
Change crop types in rotation		Divide dam into cells	
Change crop rotation frequencies		Utilise spray polymers on dams	
Seek additional off-property work		Measure dam evaporation losses	
Invest in new planting machinery		Implement soil moisture mapping	
Change to spray irrigation		Routinely test water quality	
Change to drip irrigation		Change row widths of cotton	
Change drainage method		Change row length of cotton	
Modify flood irrigation approach		Increase dryland cotton cultivation area	
Decrease cropping area		Sell part/all of my property	
Purchase/lease more land		Lease out part of the property	
Sell water on the temporary market		Buy water on the temporary market	
Sell water on the permanent market		Buy water on the permanent market	

Do you think there will be **more or less surface water available in the next 25 years?**
(please circle your answer below)

A lot less	A little less	About the same	A little more	A lot more
------------	---------------	----------------	---------------	------------

Do you think the **carry-over amount allowed for groundwater is too small or too large?**
(please circle your answer below)

Way too small	A little too small	Just about right	A little too large	Way too large
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Your views about the Namoi catchment

In this section we would like to know **how closely the statements presented below reflect your views about the future of the Namoi catchment**. There are no right or wrong answers and there is no need to think at great length about your responses. *[Examine each statement in the table, then place the number for your response in each space provided for 'Your view']*.

RESPONSE OPTIONS:

Strongly disagree	Disagree	Unsure	Agree	Strongly agree	Not applicable
1	2	3	4	5	6

Statements about your personal beliefs	Your view
Further reductions of water entitlements will threaten economic viability for people like me.	
Groundwater pumping here can harm other users of the resource.	
Regulations created to protect the Namoi River are likely to limit my choices.	
A healthy Namoi River contributes to the improved well-being of people in local townships and rural areas.	
Conservation of groundwater in the catchment will provide a resource to future generations of people.	
A healthy Namoi River enhances the enjoyment I get from the local landscape.	
If governments and water users agreed to the collective management of groundwater at the local scale, that would ensure operating rules are appropriate to local conditions and environmental circumstances.	
As part of collective management at a local scale, it would be desirable to have Government oversee operating rules developed with landholder input.	
I feel it is important that people throughout the community play a part in protecting the district's groundwater resource.	
I feel a personal obligation to act as part of a group to protect the district's groundwater resource.	
I feel a personal obligation to do whatever I can to protect the district's groundwater resource.	
Environmental flows are essential to maintaining a healthy Namoi river.	
In the next few decades, a number of flora and fauna species associated with the Namoi River will become extinct.	
Returning water to the environment is the best way to improve habitat for in-stream life in the Namoi River.	
I feel a personal obligation to do whatever I can to reduce my carbon emissions.	
I feel it is important that people throughout the community play a part in reducing carbon emissions.	
I feel a personal obligation to act as part of a group to reduce carbon emissions.	

Climate change risks

In this section we are trying to understand the way you **perceive the risks** of climate change in the **next 25 years**. We appreciate that climate change is just one of the factors that may influence landholders' decision-making. We also appreciate that not everyone believes in human-induced climate change. If you don't believe in climate change, please move to the next section on the next page.

In Part A, we want you to indicate how likely you think that you will be affected.

In Part B, we want you to indicate whether you think the impacts are positive or negative.

In Part C, we want you to provide an assessment of your ability to respond to impacts.

[Examine each potential impact of climate change in the table, then circle your response in each row for the 'Likelihood of impact' (Part A), the 'Nature of Impact' (Part B), and your 'Ability to adapt' (Part C)].

Potential impacts of climate change	PART A: Likelihood of impact					
Personal well-being and health	Highly unlikely	Unlikely	Not sure	Likely	Highly likely	Not relevant
Water supply for your property	Highly unlikely	Unlikely	Not sure	Likely	Highly likely	Not relevant
Production on your property	Highly unlikely	Unlikely	Not sure	Likely	Highly likely	Not relevant

Potential impacts of climate change	PART B: Nature of impact					
Personal well-being and health	Large negative impact	Small negative impact	No real impact	Small positive impact	Large positive impact	Not relevant
Water supply for your property	Large negative impact	Small negative impact	No real impact	Small positive impact	Large positive impact	Not relevant
Production on your property	Large negative impact	Small negative impact	No real impact	Small positive impact	Large positive impact	Not relevant

Potential impacts of climate change	PART C: Ability to Adapt					
Personal well-being and health	Unable to adapt	Limited Adaptability	Not sure	Adaptable	Highly Adaptable	Not relevant
Water supply for your property	Unable to adapt	Limited Adaptability	Not sure	Adaptable	Highly Adaptable	Not relevant
Production on your property	Unable to adapt	Limited Adaptability	Not sure	Adaptable	Highly Adaptable	Not relevant

Your views about water availability and climate

In this section we would like to know how closely the statements presented below reflect **your views about water licence conditions and issues relating to changes in climate and water availability**.
[Examine each statement in the table, then place the number for your response in each space provided for 'Your view'].

Strongly disagree	Disagree	Unsure	Agree	Strongly agree	Not applicable
1	2	3	4	5	6
Your views on water and climate					Your view
Variability in surface water supply is an important influence on my decisions about the types of cropping I undertake.					
Variability in surface water supply is an important influence on my decision to enter the water market.					
Variability in surface water supply is an important influence on my decisions about the methods or on-farm technologies I use.					
Trends in weather and climate are an important influence on my decisions about the types of cropping I undertake.					
Trends in weather and climate are an important influence on my decision to enter the water market.					
Trends in weather and climate are an important influence on my decisions about the methods or on-farm technologies I use.					
There is no such thing as climate change.					
If we do nothing, climate change will have dire consequences for all living things, including humans.					
Human activities are influencing changes in climate.					
Climate change is out of our control.					
Humans will always adapt to their environment.					
It is not too late to take action to address climate change.					
I think it is important to comply with the conditions of my water licence.					
I do my best to comply with the maximum allowable volume of water that can be pumped under the conditions of my licence.					
In my experience, water licence holders in my zone comply with reporting requirements.					
To the best of my knowledge, farmers usually have good reasons when they do not comply with the conditions of their licence.					
Farmers should be able to take legal action against other farmers to challenge non-compliance with licence conditions.					
Farmers should <u>only</u> be able to take legal action against other farmers for non-compliance with licence conditions when the plaintiff farmer can show a consequential reduced water access.					
Only regulatory agencies should be able to take legal proceedings to prosecute or restrain non-compliance with water licences.					
I would like to be able to access compliance information provided by other farmers in my zone .					

Things of value in your life

The next set of statements seeks **information about the importance of a set of principles as guides in your life**. There are no right or wrong answers and there is no need to think at great length about your response. We are looking for your initial reaction to each statement. *[Examine each value in the table, then place the number for your response in each space provided].*

Not Important	Minimal Importance	Some Importance	Important	Very Important	Don't Know/ Not Applicable
1	2	3	4	5	6

Things of value	Your view
Looking after my family and their needs.	
Working for the welfare of others.	
Caring for the weak and correcting social injustice.	
Fostering equal opportunities for all community members.	
Protecting the environment and preserving nature.	
Respecting the earth and living in harmony with other species.	
Preventing pollution and protecting natural resources.	
Being influential and having an impact on other people and events.	
Creating wealth and striving for a financially profitable business.	
Having power and being able to lead others.	

Background information

The next table of questions seeks information about yourself and your property. Questions cover a number of factors that often influence decision-making. Again, we emphasise that information provided will never be divulged.

Background Information	Please circle or fill in your response.
1. Are you male or female ? <i>[Circle your answer please.]</i>	MALE FEMALE
2. What is your age?	_____ years
3. What is your main occupation? (e.g. farmer, teacher, investor, retiree)	_____
4. Estimate the average number of hours per week that you worked on farming/property related activities over the past 12 months .	_____ hours per week
5. Estimate the number of days that you were involved in paid off-property work in the past 12 months.	_____ days
6. Are you a member of a local landcare group ?	YES NO
7. Are you a member of a local industry group ? <i>[e.g. Cotton Australia, Grain Growers or Water Users Associations, Irrigator's Council, Namoi Water]</i>	YES NO
8a. Are you a member of any voluntary organisations ? <i>[e.g. Service clubs, RFS, Red Cross]</i>	YES NO
8b. How many different groups did you attend a meeting of in the last 12 months?	_____ groups
9. Is this property your current principal place of residence ?	YES NO
10. Are you the owner of this property ? <i>[Circle your answer please.]</i>	Owner-operator Owner Operator/ Manager
11. How long have you managed this property ?	_____ years
12. How long has the property been in your family ?	N/A or _____ years

13. Do you have family members interested in taking on your property in the future?	YES Unsure	NO N/A
14. In the past 5 years , did Federal or State government natural resource management programs, or the Catchment Management Authority, provide financial support for work on your property?	YES	NO
15. In the past 5 years , have you completed a short course relevant to property management [e.g. chemical handling, property planning, TAFE, CottASSIST, MyBMP]?	YES	NO
16. If you are an irrigator, what month (e.g. October) did you begin irrigating in 2010 ?	_____ month	
17. If you are an irrigator, what month did you end irrigation in 2011 ?	_____ month	
18a Is there any area of your property where run-off is not captured by dams?	YES	NO
18b If you answered YES to Question 18a: What is the area of land where water run-off is not captured by dams?	_____ Ha	

Your property

1. What is the total area of land currently (2011) managed (including leased or share-farmed) by you or your immediate family in your local district?

_____ Ha

2. In this table, **please estimate** the area of your property irrigated and cultivated in three time periods: 5 years ago; in the current year; and expected 5 years from now.

PART 1 - Total area of property laid out to irrigation	5 years ago (2005-06)	Current water year (2010-11)	5 years from now (2015-16)
	_____ Ha	_____ Ha	_____ Ha
PART 2 - Total area of property cultivated	5 years ago (2005-06)	Current water year (2010-11)	5 years from now (2015-16)
	_____ Ha	_____ Ha	_____ Ha
PART 3 - Area of property sown for this crop:	5 years ago (2005-06)	Current water year (2010-11)	5 years from now (2015-16)
Dryland cotton	_____ Ha	_____ Ha	_____ Ha
Irrigated cotton			
Cereals			
Oilseeds			
Legumes			
Pasture for grazing			
Pasture for silage/feed			

3. We are attempting to calculate the effects of water lost to evaporation on irrigators. In the table below, we would like you to **estimate the surface area and volume** of the **two largest** and **two smallest dams** on your property and indicate whether you use each dam to **store surface or groundwater**.

(Surface water includes rainfall, run-off and water diversions.)

Dams on your property	Surface Area	Volume	Stores Groundwater (GW) or Surface water (SW)? (please circle your answer)		
Largest dam	_____ Ha	_____ ML	GW	SW	Both
2nd largest dam			GW	SW	Both
2nd smallest dam			GW	SW	Both
Smallest dam			GW	SW	Both

4. What is the **total capacity of the dam storages** on your property? _____ **ML**

5. Please indicate whether you irrigated part or all of each crop in the **current water year (2010-11)**. IF YES, then estimate what **percent of the total area** sown for each crop was **irrigated** and the **method used** to irrigate.

Crop	Did you irrigate part or all of this crop? (please circle your answer)	Percentage of total crop area irrigated from this water source:		Percentage of total crop area irrigated by this method:	
		Groundwater	Surface water	Flood irrigation	Overhead sprinklers
Example: Cotton	<input checked="" type="radio"/> YES NO	40%	10%	30%	20%
Cotton	YES NO				
Cereals	YES NO				
Oilseeds	YES NO				
Legumes	YES NO				
Pasture for grazing	YES NO				
Pasture for silage/feed	YES NO				

Other comments and thank you for your time

Do you have any other comments about any of the topics covered in the survey, or other aspects of land and water management in the Namoi catchment? Please use the space provided at the bottom of the inside front page or attach additional sheets. Any comments you make will be recorded.

We appreciate the time you have spent answering the questions. **Please return the completed survey in the stamped envelope provided.**

If you need assistance with the survey or wish to make specific comments about it, please use the toll free number **1800 605 187** to contact a member of the research team at Charles Sturt University.



research for a sustainable future

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