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ACHIEVING WATER SECURITY FOR SUSTAINABLE FARMING FAMILIES AND COMMUNITIES

PROJECT FINAL REPORT

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Table of contents

Figures and Tables

Figures

Tables

Executive summary

Water stress is increasing around the world. Nearly all countries around the world project increasing water risks due to climate change, with extreme events (floods and/or droughts) cited as a primary concern for regional catchments. Healthy catchments provide water for people and food production, mitigate floods and droughts, recharge groundwater supplies and provide for aquatic ecosystems. However, around the world poorly managed farm dams contribute to unhealthy catchments and in turn the detriment of regional communities.

Due to the nature of the Constitution, there has been a fragmented institutional response to the problem in Australia. Agricultural water interception activities, such as the capture and storage of surface water, are being monitored in individual ways across the country. Climate change induced drought can encourage water 'hoarding'; various policy mechanisms that can sometimes allow for such behaviours results in significantly diminished streamflows, increasing the vulnerability of regional businesses and communities to the effects of drought. Furthermore, behaviours that allow for unfair water sharing in drought, such as water hoarding, also create unsafe water storage infrastructure (ie farm dams) that harbour considerable risk of damage and disaster downstream in times of intense rainfall. Where states like Tasmania and Victoria have taken an integrated approach to farm dam safety and fair sharing from farm dams, other states such as New South Wales and Queensland do not link the problems of water storage safety and equity and do not integrate policy. South Australia whilst working extensively to endeavour to protect catchments with water allocations and planning, has a gap in safe dam management policy. Often farmers can be uncertain as to what the requirements are, where their dams place amongst the competing pressures on resources and what, if anything, they can do to make sure that dams are managed sustainably and safely around them.

This report presents the results of three phases of research that develops and tests a Water Equity Typology (WET) Model for South Australia. Through key expert advice and in-depth farmer surveys it was possible to gain improved understanding of the threats of unsustainable and unsafe water storage/sharing, including the increasing impacts from climate change, a lack of alignment of some elements of policy with farm business goals and the enhanced risk to farmers that they will fail to be competitive in a region. Results indicate that farmers are capable of adapting quickly to new water storage demands and can improve regional water sharing and contribute toward greater water security for their communities. This may be supported by alternative policy elements such as education initiatives, funding mechanisms and technology support from government.

The project examines behavioural responses in different farming communities and in various environments in SA and how these can inform alternative/enhancing policy elements that can help discourage resistance amongst landholders and that can in turn influence behaviour for sustainable and safe water storage that can sustain SA farming communities. Regionally sensitive programs that introduce sustainable and safe dam management education and awareness, enhanced further by basic dam sensing, spillway capability or low flows technology, could reduce drought and flood impacts that damage yield but would also create cost burdens for already stressed farming families and communities. Therefore programs must have socio-economic sensitivity built in – this includes consideration of competitive power of farmers in a catchment. Furthermore, programs that utilise alternative sustainable funding mechanisms such as green bonds that are directed at growers with potential for large productivity gains could advance secure and safe water storage for catchments more widely in order to maintain SA's farming communities.

The project has implications for academics and farmers by using theoretically driven strategic response underpinnings that expand knowledge of how and why water storage decisions are made. Importantly, implications for policymakers are the provision of general guidance on programs that can:

- allow for improved on-farm understanding of the threats of unsustainable and unsafe water storage/sharing, and
- reduce drought and flood impacts that damage yield and create cost burdens for already stressed farming families and communities.

1. Introduction

The project was designed to help improve the sustainability of SA's farming families by delivering guidance on enhancing policy elements for safe and sustainable water storage in an important but often overlooked asset in SA's rural landscape – farm dams. Through its novel methodology, the project aims to develop new and important knowledge on how SA farmers do, can and should respond to unsustainable and unsafe water storage in dams which can negatively impact their production outcomes, causing subsequent business and community failures. It investigates a new conceptual framework – the Water Equity Typology (WET) - for understanding the decision making and behaviour of farmers with respect to their dams.

Water stress is increasing around the world with more than 40% of the world's population set to be living under water stress by 2050 (OECD, 2013). Around the world farm dams continue to be the cause of catchment ill-health to the detriment of regional communities (Wishart et al., 2018). In Australia, the number of farmers facing threats to their water security and who are subsequently at risk of leaving the land due to infrastructure failure is increasing. Therefore understanding potential advancement on the optimal policy that will help farmers improve their water storage management practices in SA will have benefits for farming families and communities throughout the state. Furthermore, by understanding farmer water storage responses to the increasing water-related pressure they and their families are under, this project will add a critical component to the effort of understanding how government policy can make even greater headway into supporting sustainable and safe water storage for fragile farming communities who are at risk of leaving the land (Edwards et al., 2015).

The project methodology is to develop, test and apply a new conceptual framework – the Water Equity Typology (WET) model – for understanding decision making and behaviour of farmers with respect to their dams. Phase 1 is development of the expert-informed theoretical model through theoretical investigation and key-expert interviews, followed by Phase 2 model testing via farmer surveys, statistical analysis and data modelling. The development and testing of the model in Phases 1 and 2 will enable guidance to be developed in Phase 3 on how farming families in SA can be further supported with programs for improved water sharing equity and safety. The following section will detail the project background including understanding of the issue of sustainable and safe water storage in SA farm dams and how this project advances that knowledge, including the a review of the specific regions in SA most at threat from dam safety issues.

2. Project background

The following sections detail the background of the project, including the case of South Australia and regions of interest.

2.1 Understanding of sustainable and safe water storage in SA's rural farm dams

Water from irrigation is responsible for 80% of all farm profits (Land and Water Australia, 2008). Much of this water comes from farm dams, which are a fundamental feature of Australian agriculture (Land and Water Australia, 2008). While large dams are generally well regulated, the majority of small farm dams do not attract the attention of authorities (Pisaniello et al., 2012). However, farm dams can have substantial negative impacts on public safety, the efficiency of production and the health of farming families (Edwards et al., 2015). Thousands of dams have failed in Australia with impacts on farming families and communities through business, infrastructure and other losses, and even more so when the cumulative effect of many dams in a catchment is considered (Pisaniello and Tingey-Holyoak, 2017a; 2017b).

Farm dams are an especially critical component of dryland agriculture with many farms wholly dependent on rainfall and runoff. Individual farm dams capture all of the runoff that reaches them until they are full and then flows occur through the spillway, which if blocked or not operating as designed can withhold water from downstream environments, and also create an unsafe structure for the farmer and downstream communities (Pisaniello et al., 2012; Patrick et al., 2014)[1]. Whilst farm dams were originally designed for water storage for livestock during summer months, with the growth of more intensive agriculture, farm dams are increasing in number, especially in regions such as the Murray Darling Basin (MDB). The MDB has had farm dam development increase threefold from the 1970s to 2000s and almost 90% of the dams in the catchment are of 5 ML or less capacity (ABS, 2007; Savadamuthu, 2007). For example, the Marne sub-catchment in South Australia has more than 75% of its water withheld by small farm dams which means the impacts on stream flows can be significant, especially if low-flow bypasses[2] are not installed (Lee et al., 2007).

2.2 The need for this research to improve sustainability of SA's farming families

Building up water supply in dams through spillway blocking is not uncommon around the world and in Australia (Pisaniello et al., 2012; Pisaniello and Tingey-Holyoak, 2017c). By blocking or under-designing spillways farmers are able to store significant amounts of potentially non-entitled water; significant because small increases in storage height at the top end of the reservoir (which has a triangular prism-like geometry) results in large increases in storage volume (Pisaniello and Tingey-Holyoak,, 2017a). Recent on-site case studies from 4 Australian states including SA found many dams were storing extra water because of spillway blocking or under-designing (Pisaniello and Tingey-Holyoak 2017a). Furthermore, climate change brings with it increased variability, so greater reliance on on-farm dams, and increased pressure on farmers (Beer et al., 2014). This variability in climate exacerbates the risks from inadequately managed farm dams so that in times of:

- limited rainfall they create risks of farm production losses - farmers downstream from inadequately managed upstream dams do not receive their fair share of water, causing 'artificial drought' induced yield losses (ABS, 2007); and
- intense rainfall they create the risk of increased farm production costs - dam failure, where the dam is not operating as intended, results in leaks and inefficiencies, including erosion, oxygen depletion and nitrogen loss in soils nearby the dam, meaning these areas are unproductive or need to be re-established for crops and grazing - if the dam actually breaks then there is the high risk of liability for damages and production

[1] In areas of undulating topography, it is very common to find catchment dams which are water storage structures constructed in rural areas for capturing surface water runoff generated from the catchment area above them. The undulating surface guides the surface water runoff into streams and small tributaries that are then dammed to capture the water for agricultural and domestic uses. These dams are most commonly earth-fill embankments (for a fully comprehensive guide to types and details of farm dam construction see Lewis (2002)).When constructed in catchments, farm dams allow farmers to restrict streamflow and surface water runoff downstream until the dam fills and overflows through a spillway which can subsequently be blocked to store more water, creating an unsafe structure.

[2] On-stream dams can impact significantly on streamflow in catchments and low flow bypasses can be installed which allows flows up to a set threshold to bypass and continue to downstream users including the environment depending on certain dam and catchment characteristics (Nathan et al., 2005; Fowler & Morden, 2009).

interruption costs; and injury and death - farm dams are generally only designed to withstand the risk of 1-in-100 year floods, however most of Australia's 2 million farm dams actually have design lives much less than this with potentially devastating impacts on life downstream when they fail (see Pisaniello et al., 2012, 2015; Land and Water Australia, 2008). Furthermore, catchments continue to develop significantly downstream of dams due to growing populations seeking housing meaning community-wide risks are increasing (Pisaniello and Tingey-Holyoak, 2017b).

This suite of risks demands an integrated approach to land use planning and policy and the use of novel tools. Across Australia there has been a push for improved water allocation policy since the Council of Australian Governments (COAG) competition policy reforms of 1994 and each State took the opportunity to revise their water laws to incorporate some form of water sharing regulations, especially SA which took the lead in many respects. However, most states neglected to fully consider farm dams with many systems accounting only for water stored in large farm dams and there is a current absence of existing dam safety policy (Pisaniello and Tingey-Holyoak, 2017a).

Whilst impacts can appear greater the larger the dam (e.g. public dams), such dams usually have regulator supported release and safety systems in place. For example, the Murray Darling Basin Authority (MDBA) work cooperatively with state authorities to adjust water flows to meteorological information shared between MDBA operated dams along the Murray River. Unfortunately, the much more usual circumstance is many small dams creating a cumulative barrier to run-off and local operators lacking such close relations to each other or with authorities and so there is less information on or awareness of how to manage dams sustainably and safely (Pisaniello and Tingey-Holyoak, 2017a). The risks are further exacerbated if spillways are not operating as designed.

Farmers make most water decisions by relying on practical experience and observation and it is important to focus on policy that supports farmers' water decisions under pressure (Molden et al., 2009). However, without education and guidance, there can be misunderstanding of the public consequences of unsustainable behaviours such as spillway mismanagement, which can increase the risk of dam failure and has impacts on water security of the owner and downstream users. When rules governing dam management do not reflect the farmers' desired dam management behaviours, policy can be met with avoidance or defensiveness (Tingey-Holyoak, 2014a; Greiner et al., 2016).

It is not reasonable to expect that farm dam policies can incorporate understanding of all possible farmer responses in different farm size settings and socioeconomic contexts and so they necessarily overlook many underlying farmer strategic influences (Lankford, 2012). This project attempts to provide insight into understanding of the likely farmer behavioural response and how alternative policy designs can be built upon these. To do so it develops the theoretical extension required to preliminarily identify farmer population 'segments' with differing responses to scarce and variable water and facing different consequences from increasing capture by other farmers.

The following section explores the SA context resulting in focus on 4 regions of interest to the project and discussion of the setting in each.

2.3 Regionally specific water issues

In Australia, agricultural water use and storage has witnessed significant changes in the past century (Garnaut, 2008). The intensification of agricultural land use has increasingly placed pressure on inputs, particularly surface water runoff (ANRA, 2009). Farm dams play a critical role in providing water supply for agriculture and domestic purposes, worldwide and in Australia. Australia has in excess of 2 million farm dams storing more than 8 million ML of water and many irrigation enterprises are reliant on water stored in these dams (Land and Water Australia, 2008). As a result of drought and water shortages, farm dam management is becoming more important. Furthermore, farm dams are being subject to greater controls in most jurisdictions (Land and Water Australia, 2008). All around the country, privately owned dams are storing more than their entitlement (Pisaniello et al., 2012) and have failed in the thousands (Pisaniello, 2009; Tingey-Holyoak, 2014b). It is estimated there are over 30,000 farm dams in SA and interest in the health of catchments has meant that a conservative regime of water allocations and a strong water allocation policy through the Water Resources Act (1997) were established early (Crase, 2008).

The South Australian government in 2018 formally acknowledged the serious drought situation in the state (Sullivan et al., 2018). This recognition of drought was announced after farmers reported dry conditions for many months as they were facing water shortage, feed shortage and cutting crops prematurely. According to the fifth annual biennial State of the Climate report (CSIRO and BoM, 2018) there will be decreases in rainfall across southern Australia with more time in drought, but an increase in intense heavy rainfall throughout Australia. According to the Bureau of Meteorology (BoM) rainfall for 2018 was the seventh-lowest on record (since 1900) for the Murray-Darling Basin. Mean monthly temperature for December was the warmest on record for Australia, with prolonged periods of extreme heat, especially late in the month (BoM, 2019a). Despite patchy rainfall during October and November, to date, very dry conditions persist across eastern districts of South Australia (PIRSA, 2019). In addressing the drought conditions and to mitigate issues relating to water security, dams have been discussed as a means to conserve and access water (Simmons, 2014). However, it is not just drought but increasing heavy rains that impact water sharing equity from dams. When dams are managed in ways that conserve additional water in times of drought, they can also pose increased risk of failure in times of flood (Pisaniello, 2010).

The need for private dam safety assurance policy has been expressed on many fronts since the 1980's: a Bill on dam safety was introduced to parliament but lapsed, a Flood Warning Consultative Committee report from 1990, and flood damages in 1992, exacerbated by widespread farm dam failures, resulted in recommendation by the Hydrological Society of South Australia for a Dam Safety Bill to be enacted (Sheuard, 1993). At present, Councils have responsibility for assessing certain dam applications for development authorisation under the Development Act 1993 (SA). Natural Resources Management (NRM) Boards under the NRM Act 2004 (SA) have control over dam capacity within specified catchment and zone interception limits however, licensing under the Act is issued in respect of environmental flows and water allocations only and the issuing authority would not be obliged to consider questions of building or flood safety. In fact, Section 135(19) specifically provides that an authority is not liable for injury, loss or damage caused by, or resulting from, the manner in which an activity authorised by the permit is carried out, the design of a dam or the materials used for construction. So whilst the NRM Act provides for a permit/licence process to build new dams or alter existing dams which may restrict the storage capacity of the dam or require environmental low flows to bypass the dam, neither the NRM Act nor Development Act include an assessment process of how a dam is designed or constructed, nor an ongoing supervision process to check on-site water collection activities and ensure both new and existing dams are maintained safely and store only the water that they are entitled to store.

The following regions were selected as focus for this study, with farmers in these regions most aware of and exposed to farm dam water sharing issues. The following provides a brief overview of recent climate change projections, NRM policy and planning developments.

2.3.1 Adelaide Hills and Mount Lofty Ranges

The Adelaide and Mount Lofty Ranges Natural Resource Management region (AMLR NRM) has the most complex landscape and greatest biodiversity of South Australia's NRM regions (GIWR, 2015a). Ensuring the quality of surface water in the Mount Lofty Ranges watershed is challenging as over 90 per cent of the land in the watershed is privately owned, increasing the demand for surface water and greatly increasing risks to water quality (AMLRNRMB, 2014). Out of South Australia's 30,000 privately owned dams, 15,300 dams are located in the AMLR region capturing an average of 10 per cent of the annual surface water flow, with up to 70 per cent in some catchments (AMLRNRMB, 2014). On the eastern side of the Mount Lofty Ranges (EMLR) dams are the primary farm water storage. Studies have shown that currently in the EMLR there are 7500 dams with an estimated storage capacity of 30,000 ML of which, 87% have a capacity of less than 5 ML (Lundstrom, 2008). On the other hand, development of thousands of dams within catchments over many decades has significantly altered the timing and volume of flow provided to the environment (SAMDBNRM, 2017).

Climate change is recognised by the Adelaide and Mount Lofty Ranges Natural Resources Management Board as one of the key drivers of change in the region. The region is projected to become drier overall (AMLRNRMB, 2018a). According to Resilient Hills and Coasts (2015) while there is natural variability in the climate of the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island region, climate change is creating a different climate with warmer and drier conditions, increasing heatwaves and bushfire risk, higher sea levels and increased storm surge. According to Goyder Institute of Water Research Project (GIWR, 2015a) by the end of the 21st century average annual rainfall in AMLR could decline by 7.8-17.4%. These climate change projections have major implications for vulnerable sectors such as viticulture, perennial and annual horticulture, annual cropping, extensive livestock, and dairy.

Different water plans and regulations are in place for the AMLR NRM region. One of these are Water Allocation Plans that manage prescribed areas to provide certainty to current and future water users. Water Allocation Plans are implemented under the Natural Resources Management Act 2004 (the NRM Act) through licenses and permits for important water resources identified as being significant, or 'prescribed', (AMLRNRM, 2018b). Also, according to AMLRNRMB (2018c,d), the activities in a watercourse or floodplain that can have adverse impacts on the health and condition of water resources and the dependent ecosystems may require a permit. These activities include:

- the construction or enlargement of dams or structures to collect or divert water
- building of structures, obstructing or depositing solid materials in a watercourse, lake or floodplain (e.g. erosion control, construction of water crossings or dumping material)

- excavating material from a watercourse, lake or floodplain (e.g. excavating or cleaning soaks, waterholes and on-stream dams)
- destroying vegetation in a watercourse, lake or floodplain (e.g. removal of reeds)
- draining or discharging water or brine into a watercourse or lake (e.g. desalination waste, stormwater including urban discharge, drainage and salinity control)
- drilling, deepening and back filling wells, bores and groundwater access trenches
- the use of effluent or water imported to an area for commercial activities, e.g. irrigation.

The AMLRNRMB plan and Water Allocation Plans (WAP) for prescribed surface water areas set out the criteria by which any application for a farm dam will be assessed. Under these rules, Water Affecting Activities permit is required for dam construction, enlargement or modifications to a volume of 5 ML or less, and/or with walls of 3 metres or less above the natural ground surface. Local council development approval is required for dam construction, enlargement or modifications of a volume greater than 5 ML, and/or with walls greater than 3 metres above the natural ground surface or if the property is located within the Hills Face Zone. However, there are limitation to construct a new dam on properties in the Western Mount Lofty Ranges until the 'Reservation of excess water' is removed (AMLRNRMB, 2018e).

Furthermore, in the Mount Lofty Ranges area, downstream water users often share water which originates from upstream areas. Keeping the environment sustainable whilst maintaining productivity is a balancing act that can be achieved by allowing water to flow downstream at the right times, and in the right amounts. As a result, the 'Securing Low Flows Project' is now a key part of the WAP and eleven trial sites have been established to investigate practical ways to pass low flows around farm dams in the Eastern and Western Mount Lofty Ranges to provide water for the environment. The project aims to maintain health of the 74 catchments across the Mount Lofty Ranges (SAMDBNRM, 2018). To fund the above-mentioned activities, the NRM Act allows the regional NRM Boards to collect a NRM water levy from licensed users of surface and ground water resources. The levy is based on the volume of the water allocation listed on the water licence. Some uses of water do not need to be licensed, including general stock watering, household domestic use, irrigation of an area less than 0.4 hectares in size for non-commercial purposes, and special purposes such as fire-fighting and are exempt from being charged a water levy. Watering intensively-kept stock or all areas of land larger than 0.4 ha does need a licence, and the water levy applies to water allocated for these purposes (AMLRNRMB 2018d). There are a few special situations where a water licence and water allocation are required for certain stock and domestic uses – however, there is no water levy charged on these stock and domestic water allocations. In the AMLR region, the water levy is charged at 0.6 cents per kilolitre (or AUD6 per ML) of allocated water.

2.3.2 Fleurieu Peninsula and Kangaroo Island

On Kangaroo Island (KI) farm dams are prominent across the region in all areas except conservation and national parks. There are over 8590 dams in the region that assist in fulfilling the demand for water from residential, tourism, agriculture and industrial uses (DEWNR, 2013; McMurray, 2007). KI is the only region to establish private dam maintenance and management emergency guidelines due to the large number of dams in the small region (KINRMB, 2018).

Many properties in the region rely on surface water held in farm dams for irrigation of agriculture and stock water supply, and the Middle River Reservoir or desalination for town water supplies. A reduction in rainfall and ultimately runoff would impact the water supply to the Middle River Reservoir and the numerous farm dams in the region, directly influencing the users of water resources (DEWNR, 2013). KI is classified as one whole river basin. The region is defined by 53 catchments, which comprises 20 major catchments and numerous smaller ones (DEWNR, 2013).

According to the Department of Water, Land and Biodiversity Conservation's report on Surface Water Assessment (Clark et al., 2007), there are 5839 farm dams distributed on 55 catchments of this sub-region. There is increasing pressure on water resources in this sub-region leading to decline in water quality and quantity. The surface water resources of Southern Fleurieu subregion have been extensively developed with dams and watercourse diversions. The 'natural' flow regime and water availability have changed significantly because of land clearance, water interception by dams, diversions and commercial forestry (SAMDBNRM, n.d. a).

The future climate of the KI region will be hotter and drier. Reductions in rainfall are projected for all seasons, with the greatest declines in spring, while rainfall events will become more sporadic and intense (Resilient Hills and Coasts, 2016). According to Climate Change in Australia (n.d.) the following briefly illustrates some of the projections for Southern and South-Western Flatlands (SSWF) cluster including the Western Australian wheat and sheep belt, Eyre Peninsula and KI:

- Average temperatures will continue to increase in all seasons (very high confidence). More hot days and warm spells are projected with very high confidence. Fewer frosts are projected with high confidence.
- A continuation of the trend of decreasing winter rainfall is projected with high confidence. Spring rainfall decreases are also projected with high confidence.
- More time in drought is projected with high confidence.
- Mean sea level will continue to rise and height of extreme sea-level events will also increase (very high confidence).

As reported by Resilient Hills and Coasts (2016) under intermediate emissions by 2070 for KI rainfall is projected to decline by about 7.9% and rainfall intensity could increase by 8%. The report also indicates that under intermediate emissions by 2070 for the Adelaide Hills and Fleurieu Peninsula rainfall is projected to decline by about 6% and rainfall intensity could increase by 11%. Similarly, climate change is one of the main drivers of change to natural resources in the Southern Fleurieu sub-region. Potential natural resource impacts of climate change projections in this sub-region include (SAMDBNRM n.d. b):

- decline in winter rainfall, increase in daily mean, minimum and maximum temperatures and increase in frequency of heatwaves affecting agricultural production, habitat condition, soil health and erosion risk
- decreasing water availability impacting on health of aquatic ecosystems
- changes in presence and distribution of weed species
- increased fire intensity and frequency may favour 'coloniser' species.

In response to these climate change implications, the new KI NRM Plan 2017-2027 (KINRMB, 2017a) sees water resources management to be one of the important areas that requires careful consideration. Moreover, the KI NRM Board and the KI Council have together with local community developed a regional climate change adaptation plan for the Adelaide Hills, Fleurieu Peninsula and KI Region (KINRMB, 2018b; Resilient Hills and Coasts, 2016).

Under the Natural Resources Management Act 2004 the KI Natural Resources Management Board is legislatively responsible for developing and enforcing regulations to manage water-affecting activities in this region to ensure the equitable management of water. According to KI Water Affecting Activities policy (KINRMB, 2017b), the following activities may require a permit:

- constructing or enlarging dams, drains or other structures that collect or divert water
- placing/depositing solid materials in a watercourse (e.g. buildings, erosion control, constructing water crossings or dumping materials)
- excavating material from a watercourse (e.g. excavating or cleaning soaks, waterholes and on-stream dams)
- destroying vegetation in or near a watercourse (e.g. removal of reeds, riparian vegetation)
- drilling, deepening and back filling wells and bores.

The current administration fee for a standard permit is AUD53. The price is set by the State Government. Previously, construction of a dam with a capacity of less than 5 ML was exempt from requiring a permit. In the revised NRM Plan, the Water Affecting Activity policy has been modified as follows (KINRMB, 2017 b,c):

- To reduce red tape, the construction or modification of a dam with a capacity of less than 2 ML may be undertaken using the Current Recommended Practice process described in KINRMB (2017 b,c).
- The construction or modification of a dam with a capacity of 2 ML – 5 ML, and a wall height of less than three metres, requires a WAA permit.
- The construction or modification of a dam with a capacity of greater than 5 ML, or a wall height of greater than three metres, requires development approval from the KI Council.

Furthermore, SA Water released the new KI Long-term Plan in late 2018 reviewing water security options in light of a number of major development objectives for the Island. The revised long-term water plan includes:

- updated demand and supply projections
- revisited options to increase supply
- confirmed preferred supply augmentation option
- considered alternative augmentation options.

As KI is not a prescribed water area, a water levy is not charged in the region (KINRMB, 2018c). Water management strategies in Fleurieu sub-region include actions such as undertaking sustainable water management planning and implementation of the Water Allocation Plan. The Water Allocation Plan developed by the Adelaide and Mount Lofty Ranges Natural Resources Management Board adopted by the Western Mount Lofty Ranges also applies to the south western parts of the Prescribed Water Resources Area which includes the Fleurieu Peninsula (DEWNR, 2016). Other strategies in the area include promoting the sustainable use of water resources in urban and high growth areas, improving the understanding of water supply limitations and opportunities, improving outcomes for the environment and water dependent ecosystems by applying additional measures and increasing community understanding of pressures on water resources (including irrigation and dams) (SAMDBNRM, n.d. b). Clark et al. (2007) in their surface water assessment for the Southern Fleurieu Region have suggested mechanisms for improving water resources management in the area including farm dam management practices such as:

- Improved location
- Limiting upstream farm dam density
- Consider voluntary retrospective removal of farm dams directly above high value ecological assets or on springs
- Licensing required for all farm dams (including those less than 5 ML), however metering only required on that used for irrigation or intensive industrial use

2.3.3 Eyre Peninsula

Water has always been an important factor for farming on Eyre Peninsula due to relative water scarcity and salinity issues in the area. As a result of low rainfalls, high evaporation rates, soil quality and flat landscapes there is a lack of sufficient runoff and surface water resources on Eyre Peninsula. Based on the region's varying climate, geology and topography the characteristics of Eyre Peninsula water resources are different. The western, central and northern parts of the Eyre Peninsula have limited watercourses due to low rainfall, high evaporation, permeable soils and low topography. In comparison, the southern and eastern parts have a greater number of watercourses due to steeper topography, soil type and areas of higher rainfall. Most catchments have been extensively developed for agriculture, which has modified the hydrology and ecology of the area (EPNRMB, 2009).

A substantial proportion of Eyre Peninsula farms rely on dams and catchment drains to provide water supplies for domestic uses and livestock. According to the Eyre Peninsula Natural Resources Management Board (EPNRMB) Plan, the majority of dams are located in the southern and eastern range. A combination of factors has resulted in low levels of water storage in farm dams, including minimum or no-till farming practices. This has now become a limiting factor for the current and potential expansion of livestock enterprises on Eyre Peninsula (EPNRMB, 2011; EPNRMB, 2009). Some issues have been identified with these farm dams such as poor construction and salinization of siting of dams in low lying areas and high evaporation rates from the dam storage. In a report on Impact of farm dams on streamflow in the Big Swamp and Little Swamp catchments on Eyre Peninsula, Alcorn (2009) noted that the increasing community concern in recent years over a reduction in quality and quantity of stream flows led the EPNRMB to commission the Department of Water Land and Biodiversity Conservation (now the Department for Environment and Water) to investigate the possibility that farm dams may be having a negative impact on water resources in the catchment (see also EPNRMB, 2016b).

As a result, the EPNRMB has developed plans to respond to these issues. In order to protect downstream users from flood hazards and to ensure equitable water sharing between water users and the environment the critical aspects of dam design is considered by the EPNRMB through the approval process (see Water Affecting Activity permits described below). In priority catchments located in southern Eyre Peninsula, where levels of dam development are high with potential adverse impacts to sensitive water-dependent ecosystems, new dams and modifications to existing ones, require permits through the EPNRMB, and capacities are restricted (EPNRMB, 2011). The Farm Dams – A Guide to siting, design, construction and management on Eyre Peninsula document provides technical information to support landholders in key areas of dam design (EPNRMB, 2011). Furthermore, a number of initiatives has been established to address water management and infrastructure planning for the region such as Eyre Peninsula Water Taskforce, Eyre Peninsula water demand and supply statement, storm water management, and water sensitive design for urban areas (EPNRMB, 2017). In 2008 SA Water together with the NRM Board developed a Long Term Plan for Eyre Peninsula's drinking water system and consideration of seawater desalination to achieve further water security for the region. In SA water's long-term plan for the Eyre region (SA Water, 2008), the then Minister for Water Security noted that: "While this severe drought has reminded us our climate can have devastating impacts, we also have to ensure we are prepared for the longer term impacts of climate change, including likely reduced rainfall and reduced inflows into farm dams and waterways" (SA Water, 2008, Foreword).

Following a number of years of low rainfall and low recharge of the groundwater supply, SA Water is now re-investigating the option for a seawater desalination plant to support water security for the Eyre Peninsula (SA Water, 2008). Similar to other regions, and as part of water management strategies in NRM Eyre Peninsula, an approved permit is required to undertake a Water Affecting Activity that can impact on the health and condition of water resources, the environment and other water users. Water Affecting Activity permits are applied to, and approved by, the EPNRMB and must comply with the Regional NRM Plan. Activities and works that require permits include but are not limited to constructing or enlarging dams or structures that collect or divert water. Permit authorised by the EPNRMB is required for dams smaller than 5ML, which have wall heights equal to or less than 3 metres and are within the hundred areas containing the priority surface water catchments. Under the Development Act 1993 a Development Approval authorised by the relevant local Council is required for dams larger than 5ML or that have wall heights greater than 3 metres and occur anywhere in the Board's region (EPNRMB, 2018a).

The future climate of the EP NRM region will be drier and hotter, though the amount of global action on decreasing greenhouse gas emissions will influence the speed and severity of change (GIWR, 2015b). According to the 5th Assessment by the Intergovernmental Panel on Climate Change in 2013 the Eyre Peninsula communities are likely to witness rising sea levels and increasing ocean acidity. The way natural resources is used and thus various sectors will be impacted by these changes. Among these is the agriculture sector which will most likely experience a fall in cropping yields in the face of future temperature rises and rainfall declines. By the end of the 21st century average annual rainfall could decline by 10-20.9% Average annual maximum temperatures could increase by 1.8-3.3°C, average annual minimum temperatures could increase by 1.4-2.8°C (GIWR, 2015b). In responding to these changes, the Regional Climate Change Adaptation Plan for the Eyre Peninsula was developed by the Eyre Peninsula Integrated Climate Change Agreement Committee (EPICCA) to contemplate how individual sectors will be able to deliver regional priorities under this condition (Siebentritt et al., 2014). EPICCA was established in 2010, a partnership between the following (EPNRMB, 2016a):

- the Eyre Peninsula Natural Resource Management Board
- Regional Development Australia -Whyalla and Eyre Peninsula Board
- Eyre Peninsula Local Government Association
- the South Australian Government.

2.3.4 South East

In the South East NRM region, the main water supply for industry, agriculture and town water supplies is sourced from groundwater, with the relatively flat topography characteristic of the region and limited available surface water resources (Harding, 2014). Land drainage is considered to be a major water management issue in the South East of South Australia. The region is rich in agriculture; however, surface and groundwater resources are under pressure from changing land uses (Wood and Way, 2011).

As noted in the amended South East Natural Resources Management Plan (SENRMB, 2017a), climate change will be a key consideration in the management of the natural resources of the South East and vulnerability and resilience of natural resources to a warmer and drier regional climate must be considered. According to projections of climate change for South East of South Australia, the region will be drier and hotter in future as it will experience changed seasonality of rainfall (drier spring and summer) as well as changes in relation to sea level rise and ocean conditions. The climate projections show that by the end of the 21st century average annual rainfall could decline by 6.5-15.9% (UPRS, 2016; GWRI, 2015c). The South East NRM Board is incorporating planning for climate change into its new Regional NRM Plan. Accordingly, the Board in partnership with Regional Development Australia Limestone Coast and the Limestone Coast Local Government Association has worked with the community to develop the Limestone Coast Regional Climate Change Adaptation Plan (UPRS, 2016; SENRMB 2017b).

Key water plans for the South East NRM region include South East Regional Natural Resources Management Plan, Water Affecting Activities, Water Allocation Plans, Irrigation management, saving and caring for water in urban environments, Coastal Action Plan, Drainage and Wetland strategy 2018, and Water planning and permits project with the purpose of providing a framework to manage underground water resources sustainably (SENRMB, 2014).

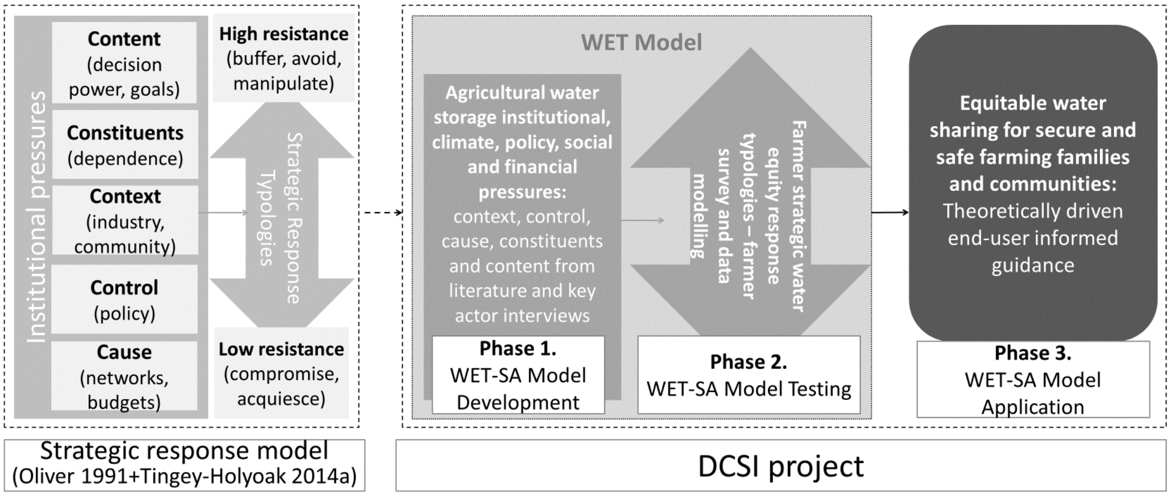
Water Allocation Plans have been developed for Padthaway, Tatiara, Tintinara – Coonalpyn, and Lower Limestone Coast, each setting out the rules for managing and taking prescribed water. In addition, there are two levies: land and water in South East region. Those who have a water allocation for irrigation or industrial use will also pay a water levy. Moreover, like other regions, the South East NRM region's water affecting activities in relation to dams and draining or discharging into any watercourse, floodplain or lake may require permits through the NRMB. The regions Water Allocation Plans outline requirements for the permitting of water affecting activities. Dam construction, enlargement or modifications to a volume of 5 ML or less, and/or with walls of 3 metres or less above the natural ground surface can only be undertaken with a Water Affecting Activity permit and for the larger dam development approval should be obtained from the local council (SENRMB, 2018a). It should be noted that in line with South Australia's commitment to implementing the Murray Darling Basin Plan, changes are being made to existing planning documents including Part 4 of the South East NRM Plan Water Affecting Activity Permit Policy. The Amendments were approved in June 2017. For South East region, changes include the introduction of a new surface water policy area called the Murray Darling Basin Surface Water Policy Area and will ensure an effective and consistent level of water resource planning for the management of surface water in non-prescribed areas across the SA Murray Darling Basin. Based on these changes, Water Affecting Activities policy applies to the total capacity of all new dams to ensure the capture of surface water does not exceed the limit of 1351 ML. Current dam development is approximately 481 ML. This excludes dams that currently exist in the policy area. All new dams will need approval from Natural Resources South East. If the proposed dam is greater than 5ML in size, development approval from Local Government will be required (SENRMB, 2018b).

The above 4 regions were chosen to focus the study on as they are most exposed to farm dam water sharing issues. They will be discussed further in the results section.

3. Project methods

The proposed project draws upon recent theoretical developments in the field in order to develop guidance for alternative or enhancing policy models required for more sustainable and safe water storage in SA regions. A three phase design engages theoretical perspectives that advance Oliver's (1991) strategic response model which combines institutional and resource dependence theories providing the theoretical basis for the break through development of the WET model for SA (Figure 1). Each of the institutional pressure and resistance constructs underpinning the strategic response model in Figure 1 are discussed in more detail in Section 4.1.1 below.

Figure 1. Conceptual Framework and Methodology



The project was undertaken through three main methods which will be detailed in the following sections.

3.1 Phase 1. Model development – Theoretical modelling and key expert interviews

Firstly, each construct in the original strategic typology model in Figure 1 (left hand side) were refreshed and updated for farm dam water storage. Secondly, these concepts were used to frame open ended questioning of key experts.

3.1.1 Strategic response theoretical advancement

The theory of the strategic typology model was deeply investigated, applied to agricultural water storage and then theoretically advanced based on recent developments in application of the strategic response typology model to natural resource issues. These concepts were included in key-expert interviews including the (i) predictive pressure variables of farmer context and control, such as specific industry, social and regional factors, financial pressure etc, and (ii) farmer response variables including attitudes and behaviours.

3.1.2 Interviews

The study considers both key experts perspectives and farmer perceptions in order to provide direct feedback from those developing and those affected by current policy and program outcomes and impacts (Woolcock, 2009). Interviews with those at a high level of policy and practice can provide rich insight into the current issues at stake in an area of need and also help develop and refine the optimal quantitative indicators for surveys that are more robust to construct validity issues (Rao and Woolcock, 2003). These were the dual aims in this phase of the study. Key South Australian policy, NRM and community expert interviews were proposed in order to facilitate conceptual linking of subsequent expert-informed variables into a strategic response model to form the WET model for SA. Twelve experts from state and local government departments, farming industry groups, regional community groups, and natural resource management groups were interviewed via phone in early 2018. The population of focus included experts in and around regions identified in Section 2.3. Interviews were professionally transcribed and resulting data was sorted and coded in NVivo. An open ended question outline is provided in Appendix 7A.

3.2 Phase 2. Model testing – Farmer survey and data modelling

Model testing required implementation in the population of SA farmers from the 4 regions of interest through a perceptions based survey.

3.2.1 Survey design

To understand strategic responses to water sharing equity from farm dams, research must thoroughly explore the context in which farmers make decisions about their farm dams. This includes their perceptions of farm dam management practice and their attitudes toward real and perceived institutional pressures to manage dams in a certain way. Adequate information about farmer's sustainable farm dam management practices can be obtained through farmer surveys. Survey questions were firstly derived to inquire open-endedly what the largest challenges were being faced by farmers with regard to their water security. Based on the authors' previous experiences, questions were then framed around the policy in regions for water and dam management. Where possible these were framed in a positive tone to avoid pre-empting respondent's dissatisfaction (Vossler and Evans, 2009).

The survey was designed to incorporate the key policy and industry expert interview data and also the theoretical modelling but also to provide an open voice for farmers to potentially influence water policy, or at least dam management policy, as it relates to their farm and community. Appendix 7B details the questions asked in the survey. Farmers were provided with options to provide open-ended responses and also Likert style questions. Typically respondents will respond on a 5-point scale rated from 'strongly agree' to 'strongly disagree' however evidence suggests that 6- and 7-point scales are optimal (Nunnally, 1978 - who tested scales from 2- to 20-point and found that reliability increase rapidly to a 7-point scale and then levels off to little incremental gain in reliability). The survey instrument incorporated farmer, farm and other demographics in addition to the constructs from Phase 1. The survey was designed to be conducted over phone where possible using a professional survey firm.

3.2.2 Survey analysis

Reliability and validity are critical issues of measurement which relate to connecting survey measures with constructs and although impossible to achieve perfectly, their attainment nevertheless should be strived for (Neuman, 2006). Reliability[3] is addressed in this research by: (1) clear conceptualisation on constructs founded in the literature and given input on by key-experts interviewed, (2) increasing the level of measurement (here the use of a 7-point Likert, as opposed to 3- or 5-point), (3) using multiple indicators of a variable (see Appendix 7C which highlights the multiple items used to measure each dependent 'response' variable), and (4) using pretesting and pilots in the field and on colleagues (Neuman, 2006). Reliability can be tested statistically using Cronbach's alpha which tests how well the elements of a measure correlate with each other, that is, are internally consistent and is presented in Section 7C. Validity[4] is a more abstract term than reliability and often refers to a measure being 'true' or 'correct' but really depends on the quality of the marriage of the conceptual and operational definitions of a construct (Neuman, 2006). Validity is addressed in this project by: (1) pretesting measures with members of the scientific community which was undertaken with colleagues at UniSA and through key actor interviews (Section 4.1.3), (2) endeavouring to seek the full definition of a construct and its concurrency by using established measures wherever possible, especially for the dependent variable which is based on pre-existing literature in parallel areas of study, modified for the farm dam setting (Section 4.1.2), and (3) statistically testing convergence of measures onto a construct through factor analysis (Section 4.2.2.1).

The cross sectional study design[5] incorporated SPSS v24 statistical tests of validity, reliability, chi-squareds, multiple regression analysis, and analysis of variances between variables. The project employed Principal Component Analysis (PCA) as a form of Exploratory Factor Analysis (EFA) in order to give validity to the structure of the set of dependent variables developed based on theoretical constructs (Costello and Osborne, 2005). Once the set of items measuring a factor or dimension were determined, these were then grouped together as a measurable variable and their reliability tested using Cronbach's alpha[6] (see Field, 2009, results in Appendix 7C). Demographic variables were summarised into mean responses and tested for inter-regional variables using Chi-Squared testing (Field, 2009) then for WET modelling, multiple regression[7] was appropriate for evaluating relationships between the constructs (Tabachnick and Fidell, 2001). The advancement of WET using attitudinal variables were analysed by region in ANOVA (Analysis of Variances)[8] testing which assesses whether mean scores for groups are equal with Bonferroni's Post-Hoc tests to assess the level of difference between means (Field, 2009).

[3] Stability reliability refers to reliability across time and can be verified through pretesting and the original group in the pre-test having the same results as the later sample (Neuman, 2006). Representative reliability which refers to reliability across subpopulations or groups of people and can be tested by checking an indicator across different groups, such as states (Neuman, 2006). Equivalence reliability applies when a construct is measured with multiple specific measures and can be tested statistically using the Cronbach's alpha coefficient.
[4] Face validity is the simplest validity that can be strived for and can be measured through the judgement of others in the scientific community (Neuman, 2006). Content validity is concerned with measurement of the full definition of a construct being captured by a measure. This can also be achieved by expanding the breadth of a measure (Neuman, 2006). Criterion validity can be concurrent, in that a measure agrees with an established measure or predictive in that it agrees with predictive behaviour. Construct validity aims for consistency of multiple indicators in that they are convergent (i.e. like ones are similar) or discriminant (i.e. different ones differ) (Neuman, 2006).
[5] The benefit of a cross-sectional study is that several groups of people can be observed at one point in time to examine differences between their behaviour at a point in time (Salkind, 1997). This study has adopted this approach in order to compare farm dam management behaviour under different policy settings in 4 different regions in SA. Cross-sectional research has the advantage of being inexpensive and short-term in terms of engagement as necessary for such a complex multi-party analysis (Salkind, 1997).
[6] A desirable threshold of reliability for Cronbach's alpha is around 0.70, (Nunnally & Berstien, 1995; Field, 2009). However, alpha also depends on the number of items in a scale and can be acceptable as low as 0.3 or 0.4 with fewer items (Cortina, 1993).
[7] Multiple regression is a tool that allows for prediction of variance in a dependent variable, based on linear combinations of independent variables. The proportion of the variance in the dependent variable explained by the independent variables in the model is the coefficient of multiple determination, or R^2 and the F test is used to test the significance of R-squared (Field, 2009).
[8] ANOVA is an 'overall' test and thus post-hoc or planned comparisons are required to try and determine what relationship is significant and how.

3.3 Phase 3. Model application – Policy guidance development

There is a need for theoretically-driven projects that can contribute toward developing guidance on how to enhance programs and policies that can maximise water equity in the face of growing demands for scarce and variable supply (Ward and Michelsen, 2002; Ward, 2016). Guidance that can balance the conflict among alternatives stemming from economic and physical water resources is in demand, particularly guidance that can consider competition amongst types of users in agriculture, between geographic locations in catchments, and between current and future uses (Ward and Michelsen, 2002). For this project, theoretically driven quantified evidence of farmer water storage equity strategic typologies developed in Phase 1 will be combined with WET testing from Phase 2 and compared and contrasted in an effort to develop preliminary guidance informed by farmer strategy types that may be able to contribute toward enhancing some elements of water storage policies. Guidance will contain suggestions for regionally specific strategies for governments, NRM Boards and others to target support for farm dam management to enhance sustainable and safe farming families and communities.

4. Results

The following sections detail the three phases of research and the results obtained.

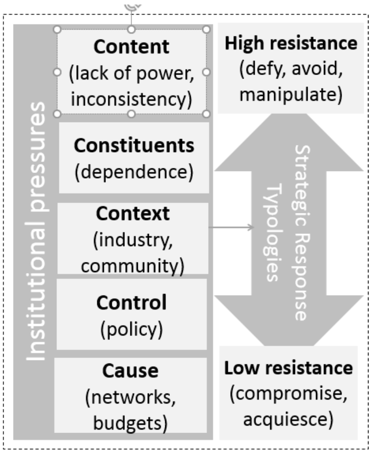
4.1 Phase 1 results: Theoretical advancement and key expert interviews

The first part of Phase 1 was to update and advance the theoretical model for concept inclusion and testing in key-expert interviews.

4.1.1 Theoretical advancement

A review of recent applications of the Oliver's (1991) framework and/or any combining of institutional and resource dependence theories formed the necessary part of the project's first phase. The basis of the framework are Resource Dependence Theory (RDT) and Institutional Theory. Resource dependence theory has individually been applied to selected agricultural studies (Fazzi, 2010; Ganz, 2000) and the lens facilitates the understanding that managers do have some discretion over how to structure their activities to respond to the uncertainty created by interdependencies (Pfeffer and Salancik, 1978). Institutional theorising has also been influential in research into agriculture (Lynggaard, 2002; Ransom, 2007). The contribution of resource dependence theory to institutional theory helps facilitate the understanding of the response to institutional pressure with respect to the rational identification and use of the rare, valuable resource of water (Barney, 1991). The institutional theory and RDT are complementary and the combination of the two theories has been applied to many issues in a strategic response model (Oliver 1991). The predictive 'pressure' elements of the model shown on the left-hand side in Figure 2 have individually or together been employed in several studies as has the range of 'response' variables on the right-hand side (Tingey-Holyoak, 2014b).

Figure 2: Strategic responses to institutional water storage pressure model (adapted from Tingey-Holyoak 2014b)



Oliver's (1991) combined theoretical framework has been used as a guidance to explore the strategic responses of organizations to institutional pressure and complexity in different contexts. Most recently, for example, the two theories have been utilized to investigate balanced private dam management policy and law in the face of increasing weather extremes in SA and Tasmania (Tingey-Holyoak and Pisaniello 2015), and to investigate aspects of decision-making processes of farmers including variables of location and gender (Tingey-Holyoak and Pisaniello, 2017). Wijethilake et al. (2017) have studied strategic responses to institutional pressures for sustainability management. Alon and Dwyer (2014) studied early adoption of International Financial Reporting Standards as a strategic response to transnational and local influences. Other examples include: the influence of institutional pressures on hospital electronic health record presence (Fareed et al. 2015), stakeholders' corporate social responsibility pressures on firm's legitimacy (Zheng et al., 2015), higher education response to human resources policy reforms in Spain (Cruz-Castro and Sanz-Menendez 2015), strategic responses of inland ports to institutional pressure for adoption of sustainability practices (Vejvar et al 2017). Gao and Hafsi (2017) have used the two theories to build a two-step model of organizational response to social needs through Corporate Philanthropy (CP), in situations of disaster relief. Their findings clarify the important role of government in driving CP and perhaps explaining ethical behaviour in general.

Further, and most relevant here, Tashman (2011) has developed the Natural Resource Dependence Theory (NRDT) to explain how organizations' financial performance depends on the natural environment and thus the climate change. Tashman (2011) suggests that the biophysical environment is also part of the environment and all organizations depend directly or indirectly on natural resources such as air, clean water, energy, a suitable climate. Based on Tashman's (2011) work, Bergmann et al. (2016) conducted a comprehensive investigation on how extreme weather events affect financial performance focusing on small and medium-sized organizations from industry sectors in South-East Germany. By considering the ecological uncertainty and environmental institutional pressure in their conceptual model, Tashman and Rivera (2016) have empirically investigated how institutional pressures shape firms' management of resource dependence-related uncertainty and have examined the adaption and mitigation practices in the US ski resort industry. Oliver (1991) introduced five institutional predictors of strategic responses, context, control, content, constituents and cause to be discussed and advanced in the following sections.

4.1.1.1 Context

The context of the environment in which farming businesses operate is important because some institutional fields are better settings for compliance than others (Ingram and Simons, 1995). Environmental uncertainty explains the extent to which the future cannot be accurately predicted (Pfeffer and Salancik, 2003). Managers are more willing to comply with external demands imposed upon them in an endeavour to protect the organisation under these conditions (Oliver, 1991). When applied to agricultural water management, this means a farmer may not only be more willing to comply with the efforts of regulators to issue licences to reduce regional uncertainty of water entitlements and risk of catastrophe, but also may mimic other managers who are having success in an uncertain environment (Tashman, 2011). In recent advancements, strategic responses to *natural* resource dependence allows for the investigation of a direct relationship between organizations and the natural environment (Bergmann et al., 2016, p. 1362). Based on Tashman and Rivera's (2016) work the context variable of environment uncertainty is modified to ecological uncertainty and extreme weather events such as those exacerbated by climate change. This also has links to industry effects and those operating in the same industry having a higher likelihood of interconnectedness and similar operating styles (Tashman and Rivera, 2016). Therefore, it is hypothesised that:

H1a: Farmer perceptions of ecological uncertainty relate to low resistance to pressures for equitable and safe water storage.

H1b: Farmer perceptions of regional or industry interconnectedness relate to low resistance to pressures for equitable and safe water storage.

4.1.1.2 Control

Control in the institutional environment refers to the means by which institutional pressures are imposed on organisations (Oliver, 1991, p. 168). The theoretical framework predicates that high levels of control through legal coercion increase manager awareness of threats for noncompliance and reduce resistance to pressure (Oliver, 1991). Research has also found that legislation mandating socially and environmentally sustainable behaviour encourages organisational compliance (Bansal and Clelland, 2004; Clemens and Douglas, 2005). Water resource legal coercion can have a focus not only on the continuous meeting of a standard, such as water allocation plans, but also on encouraging organisations to undertake certain behaviours that will serve to improve their own efficiencies, such as water trading when inflow into the storage is good (Bjornlund, 2004; Brooks and Harris, 2008; Tingey-Holyoak, 2014a). Recently, for natural resources the driver for compliance is not only the threat of fines through legal coercion but also the losses of legitimacy that reduces resistance (Bansal, 2005; Tingey-Holyoak, 2014b). Also recently, Tashman and Rivera (2016, p.1514) measured environmental control through voluntary diffusion of ideas and practice. The authors argue that voluntary diffusion may constrain firms' ability to adapt to ecological uncertainty with natural-resource-intensive practices. Therefore, it is hypothesised that:

Hypothesis 2a. Perceptions of legal coercion relate to low resistance to pressures for equitable and safe water storage.

Hypothesis 2b. Perceptions of voluntary diffusion relate to low resistance to pressures for equitable and safe water storage.

4.1.1.3 Cause

The cause of institutional pressures relates to the underlying motives for introduction of the rules in the first place (Goodstein, 1994; Zucker, 1987). When a manager of a firm believes that compliance with rules or norms will enhance social fitness, and can be taken advantage of for improved competitiveness, they are likely to be less resistant to pressure from the institutional environment (Gao, 2010; Oliver, 1991; Rivera-Camino, 2012). When applied to agricultural water management, to ensure a manager is fit enough to access water as a scarce resource, behaviours such as compliance with regulation to appear more legitimate are more likely (Cleaver, 2002), especially in interconnected close communities or catchments. Furthermore, unhealthy financial conditions create opportunities for organisations to subvert social welfare, for example disregard safety, undertake environmental damage or deceive regulators, in order to pursue profit growth and maximisation (Campbell, 2007).

Being economically 'fit' can mean the requirement to spend money if a dam poses threat to lives and property – for equitable and safe water storage this also means that there would be obvious economic detriment to the farm and farmer if the dam failed and so they would be likely to acquiesce to demands to store the water equitably and safely (Tingey-Holyoak, 2014b). Recently, in addition to social and economic fitness (see Tingey-Holyoak and Pisaniello, 2017; Tingey-Holyoak, 2014b), environmental legitimacy has emerged as a key strategic pressure for natural resources (Tashman & Rivera, 2016). Considering the farmers' interaction with the natural environment around them and since they take environmental conservation into account (for example, by allocating water for the environment), environmental legitimacy can be another dimension of the cause variable. Therefore, it is hypothesised that:

Hypothesis 3a. Perceptions of social fitness and legitimacy relate to low resistance to pressures for equitable and safe water storage.

Hypothesis 3b. Perceptions of economic fitness relate to low resistance to pressures for equitable and safe water storage.

Hypothesis 3c. Perceptions of environmental fitness relate to low resistance to pressures for equitable and safe water storage.

4.1.1.4 Constituents

When institutional and resource dependence perspectives are combined, constituents can have multiplicitous effects or create dependencies for businesses (Oliver, 1991). If regulators, interest groups and financial bodies are all placing water resources pressure on a firm, the organisation may decide that the increase in legitimacy to be gained through compliance with them all is outweighed by the political uncertainties that come with this multiplicitous pressure (Guo et al., 2014). When applied to agricultural water management, different constituents can exert conflicting definitions of farm dam water storage sharing equity and management on farmers which can cause them to perceive incompatible and competing demands (Pisaniello et al., 2012; Tingey-Holyoak, 2014b; Tingey-Holyoak and Pisaniello, 2017) – demands to which they are very unlikely to acquiesce to but more likely to avoid, compromise and manipulate (Oliver, 1991; Tashman and Rivera, 2016). However. if a farmer is dependent on an organisation, such as a farming industry body for agricultural supply chain legitimacy (Maloni and Brown, 2006), or a natural resources management board for access to increases in allocations and entitlements for runoff (Robins and Dovers, 2007), or even government for subsidies, then they are less likely to resist demands to manage sustainably. Therefore, it is hypothesised that:

Hypothesis 4a. Perceptions of multiplicity of constituents relates to high resistance to pressures for equitable and safe water storage.

Hypothesis 4b. Perceptions of dependence constituents relates to low resistance to pressures for equitable and safe water storage.

4.1.1.5 Content

Resistance to pressure is dependent not only on the water storage management decision making discretion that remains for farmers, but also on the inconsistency of the content of the pressures with organisational goals (Clemens and Douglas, 2005, 2006). Farmers will acquiesce to pressure under the theory if they retain decision making power on activities such as the allocation of their water and sustainable practices (Varela-Ortega et al., 1998). For equitable sharing of water from farm dams, resistance can be an increasing response for managers when substantive organisational decisions, such as the amount of surface water runoff that can be stored for farming operations, are curtailed by regulatory pressure (Varela-Ortega et al., 1998). Furthermore, the provision of incentives or benefits that clearly align pressures with organisational goals will help organisations overcome perceived losses in efficiency resulting from reduced resistance to pressures (Bansal and Roth, 2000; DiMaggio and Powell, 1983; Pfeffer and Salancik, 1978). When water licensing terms and conditions are placed on agribusiness managers that are not consistent with their internal operations then it may be perceived that they are in a position to lose profits (Bjornlund, 2004; Tingey-Holyoak, 2014b; Tingey-Holyoak and Pisaniello, 2017; Tashman and Rivera, 2016). More recently it has been noted that location can also influence as cultural expectations can also generate imitative pressures on firms to restrict their use of natural-resource-intensive practices as a response to ecological uncertainty (Tashman and Rivera, 2016, p.1510). Therefore, it is hypothesised that:

Hypothesis 5a. Perceptions of a lack of decision making power relate to high resistance to pressures for equitable and safe water storage.

Hypothesis 5b. Perceptions of inconsistency of pressure with business goals relate to high resistance to pressures for equitable and safe water storage.

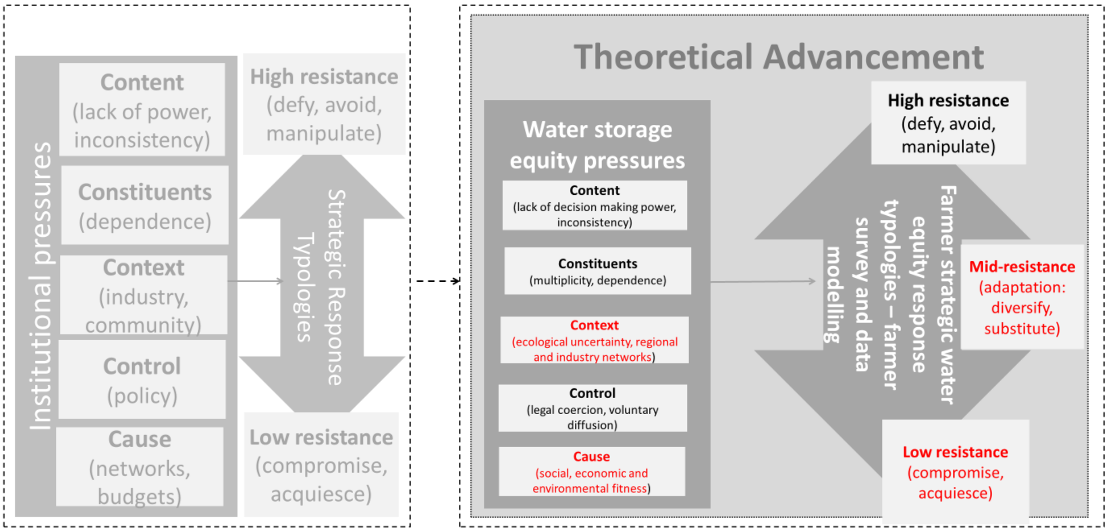
4.1.1.6 Strategic responses

Oliver (1991) identified a repertoire of strategic responses possible to any institutional pressures that range from a low resistance response (acquiescence and compromise) to a moderately resistant response (avoidance) through to a strongly high resistance response (defiance or manipulation). These are largely unchanged by updates in recent literature other than the discovery of additional categories of an *adaptive* response to ecological uncertainty. Tashman and Rivera (2016) propose how ecological uncertainty might lead to natural-resource-intensive adaptation and/or ecological mitigation. Firms may undertake two types of natural-resource intensive adaptation practices, namely substitution and diversification. Substitution requires developing substitutes for uncertain natural resources by expanding capabilities that draw on different or more stable supplies of those resources. Firms may be able to diversify their revenue streams by using natural-resource-intensive practices to develop new lines of business that are less sensitive to ecological uncertainty.

WET Model Theoretical Advancement Summary

Theoretically, for the purpose of continuing into the second part of Phase 1, the key expert interviews, the constructs in Oliver's (1991) model were utilized for the development of a WET model for SA in addition to the advancement of dependent variable strategic response mid-point of **adaption** (diversification and substitution) (Tashman and Rivera, 2016) (Figure 3). The **contex**t variable was also modified by including ecological uncertainty. The **cause** variable was further updated to *environmental fitness,* which is the predictor of the perceived ability of the farmer to deal with environmental issues related to their own water storage (Tashman and Rivera, 2016).

Figure 3. WET Model theoretical advancement



The following section details application of these concepts and in-depth discussion of them with key experts in the field.

4.1.2 Key expert interviews

Key-expert interviews were conducted with key policy, NRM, industry and community actors (*n*=12) to identify and integrate the expert-informed variables into a strategic response model based on which the WET model for SA will be further developed and utilized in the next stages of the project. Interviews were conducted over the phone in all cases. Initially, the interview transcriptions were scrutinized to develop main categories to provide an overall picture of the data. In doing so, the data segments related to each category were initially marked in reference to 1) the institutional or environmental pressure imposed on the farmers with a main 'pressure' code, 2) factors that could influence the type of farmers' strategic response to these pressures, and 3) possible actions taken by the farmers with a key 'response' code. The codes were then grouped to generate more abstract codes known as 'themes'. Of these broad themes some encompassed a series of sub-themes which provide a deeper insight into the broad themes.

4.1.2.1 Context

For the variable of context, the key issues of climate change and catchment position and interconnectedness emerged as themes for what context drive farmer water sharing and storage responses.

Climate change

Ecological uncertainty in the context of climate change was identified by most participants as one of the most significant pressures on farming communities and businesses. The specific climatic element of drought, and farmers' heavy dependence on water resources has resulted in high level of uncertainty around water resources availability: "…*probably the number one threat [to farmers] would be climate variability. So, you might have a period of a wetter, more reliable period, and now we're experiencing some drought, some wet years, and there's a bit more variability in the system. And compounding that is just an increasing demand for water*" (State NRM Manager).

Interconnectedness

Key experts indicate that issue of climate threats to water sharing equity are compounded by farmers' interconnectedness in a region which is large contextual influence over the types of behaviours farmers undertake with relation to their water storage. Most of the participants indicated that pressure to manage water in certain way is only covert when it is the proximate neighbour, rather than communities further downstream: *"*[if pressure is coming from] *their immediate neighbours [then that is because] neighbours would like to see the overflow come on to their property*" (State Government Manager in Water Resources Area). Key experts indicated that 'location' of the farm dam in a catchment has an important role in generating certain farmer reactions and responses to water policy. Respondents frequently referred to 'downstream' and 'upstream' in the Murray-Darling Basin (MDB) and other smaller catchments and the perception of adverse impact of water storage activities from upstream users.

Being located downstream of a catchment was seen as one of the pressure factors that could potentially generate a negative strategic response from farmers. According to one respondent, interconnectedness could be promoted in relatively smaller catchments and results in stronger interpersonal connection among the community. However, this was noted as challenging among the farm dam owners within larger catchments: "… *if a catchment actually has that social cohesion …that is because they are a community in their* [own] *right and I've seen example of that. They're generally small, physical catchments but people literally hang out with each other and they, and then therefore it becomes a personal connection … But when a catchment is large and diverse, and you literally don't see your neighbour that often enough to connect with them* [about water] *at an emotional level*" (State Government Manager in Water Resources Area).

4.1.2.2 Control

For the variable of control, the key issues of policy strength, communications, complexity and voluntary diffusion through catchments were the key themes from the control environment that can predict farmer water sharing and storage responses.

Legal coercion

The interview data revealed that while current water policy (the water allocation plans in particular) have an important role in promoting equitable water sharing among farmers, key experts did point out the pressures that different aspects of policies can impose on the farming community. Due to the farming community's growing awareness of current extreme weather events, the key experts supported the water allocation plans as the primary vehicle for equitable water sharing, also ensuring that the water needs of the environment are taken into account. Such a strong and coercive legislative regulatory framework places positive pressures on farmers to do the right thing with their dams for downstream producers and the environment: *"… we have these policies to provide low flows to try and get this water moving through the system, and trying to reduce the impact that farm dams have in terms of blocking all flow. […] So what we're trying to do is encourage that water sharing, and that notion of equity, not only provision of water for the environment, but actually provision of low flows for downstream producers as well"* (State Government Manager Water Resources Area 3). Furthermore, it was perceived that farmers generally understand the motivation of regulators and this is received positively amongst the community: "….*[farmer stakeholders confidence in the government's response to water management and security is] probably a very regional question. I think in areas like the Murray Darling Basin where [there is] direct extraction from the River Murray, or water delivered through large trusts … there's a reasonable understanding and a reasonable support for what* *government's trying to achieve there…"* (State Government Manager in Primary Industries and Resources 1).

Policy communication

Several experts mentioned governments' strategies to engage the community in the decision-making processes. Effective and timely communication engagement can have a positive impact on farmers' strategic response type and enhance farmers' confidence in government's position in water management and policy outcomes: *"So [community consultation] is a big part of the whole water allocation planning process in South Australia. We provide lots of opportunities for the community to be involved, and hopefully that instils more confidence in that they're part of a – they feel that they have a role in informing some of these settings.…when water allocation plans are being developed very often there are community reference groups that are established to help inform these planning processes. …So we're talking about a fairly lengthy sort of series of consultation events, it's sort of where people actually can get quite involved from an early stage to inform the policy…. It's sort of more about bringing people along that journey and engaging early, and probably more of a true sort of consultation style"* (State Government Manager Water Resources Area 3). However, some participants highlighted the gap that emerges when transferring the policy details to the community. This gap could result in difficulties in understanding the policy, as the policy language could be sometimes complicated: "*I do believe that farmers have struggled to understand the policies …we write them in a really alien language … we don't write them in simple terms. And often they are very complex documents and they involve [complex] trade-offs … often we're not very clear in actually articulating when there's that kind of complexity as well. So… definitely I do believe the vast majority of producers would not find it clear and simple to understand policies*" (State Government Manager in Water Resources Area).

Policy complexity

The need for further policy improvements, including simple dam policies that interact with water allocation plans were raised by some respondents. While most of the interviewees stated that the government's general position in water management and water security in regions is simple and known to the farming community, some key experts highlighted the gap in transferring the policy details to the community especially in large scale catchments: *"… the more complex a system is, the more difficult it is to get to the bottom of these things … if you look at the Murray Darling Basin Plan …it's very, very complicated. Sitting down in South Australia, how can you possibly gather, grasp what's happening when the water's coming from the Northern Rivers and what contribution they make.."* (State Government Manager in Agricultural Resources 2). Some key experts noted that there is still scope to improve stakeholder engagement by devising more effective communications methods: "*I think there's a number of ways [water management policy] can get better with the communications and stakeholders engagement, but there's also this risk of co-design takes a long time, and co-design takes a long time to get it right*" (State Government Manager in Primary Industries and Resources 1), and "…*I think that there's a crisis in the public's confidence in the government in anything… So given that the climate's drying, given that, I would say they don't feel confident ….but… I think good communication helps. … how do you get your voice heard … It's a very, very big challenge. It's how do we get our voice heard…. It's actually a real challenge to actually find a way to reach people"* (Senior Industry Body Representative and Grower 1).

Voluntary diffusion

Key actors largely mentioned many farmers' sense of ownership of the rainfall on their land and thus a right to capture and collect it which can lessen the voluntary diffusion of water policy meaning water is then not shared equitably from dams. However, the role of the water allocation plans is important in this context, as it promotes equitable water storage in dams, and challenges farmers' ownership of water on their land by separating water property rights from land*: "… landowners generally don't like being told what to do. They don't like having a resource taken away from them*" (Regional Irrigators Council Chairperson and Grower); and "…*some people just don't believe in government control and you hear lots of comments from farmers about "Oh, they're taxing my rainfall" […], "They're telling me what to do with my property and the rainfalls on my property, therefore it's mine" … So, what one person might think of is inequity because somebody's got more water than them….So it just again, comes back to the idea, "It's my water. I own it and I can do what I like with it". I think that's under challenge by the impact of water trading"* (State Government Manager in Agricultural Resources 2). In regards to voluntary diffusion of current initiatives, key actors discussed projects such as voluntary take-up of low flow bypasses and related policy as ways of regulating farm dams and achieving water security for specific regions: "*At the moment the big discussions are around low flowing bypasses [Securing Low Flows project by the Department for Water and Environment[9]]. So… when there's low flows in creeks some of it isn't captured by the dam and continues down the water course…. So, there's people certainly prepared to participate*" (Industry Peak Body CEO).

However, entirely voluntary water sharing and storage equity schemes do not have support of most key experts: "*I don't believe that voluntary management is a system that works entirely….. I've seen it happen with meter readings and I think it's a convenient way to save money. I don't believe it works because I think … people's motivation when it comes to water management is to maintain as much water as possible. And if you're asking them to voluntarily manage that I think you're opening yourself up to abuse" (Regional Irrigators Council Chairperson and Grower).*

4.1.2.3 Cause

For the variable of cause, competitive, economic and environmental fitness were all key factors identified by policy actors that can drive farmer water sharing and storage responses.

Competitive fitness

The competitive environment among the farming community could result in unsustainable and unsafe water storage in dams. The market of competition between larger producers can be seen as a variable determining farmers' response strategy: "[in order to] *be reliable quality suppliers… that will generally mean you need access to water across the variable seasons. So as a consequence of that I think there is pressure to maximise the amount of water stored. And competitive pressure from other grape growers … [so] I suppose you're competing for a market…. That will mean that you need to improve your water security which then means if it's a farm dam thing you want to store as much as you can*" (Senior Industry Body Representative and Grower 1); and "*At the end of the day farms are businesses and they're in competition with each other, and so whilst I think that … there's probably very strong personal relationships between farmers, and they come together in a crisis, when it comes to business and selling stuff, possibly even sharing water, they may find there's lower levels of cooperation because of that" (*State

[9] According to South Australia's Department for Environment and Water, the Securing Low Flows project is a key element of water management policy in the Mt Lofty Ranges. It aims to give the 74 catchments across the MLR small amounts of water at critical times in the seasonal cycle, while maintaining current water allocations. Under the program low flows below certain threshold flow rates will be required to pass downstream of some dams and diversions in order to maintain catchment health.

Government Manager in Primary Industries and Resources 1). And yet it was also noted that the presence of market competition among farmers could lead to better dam maintenance to "…*improve their productivity and achieve long-term sustainable irrigation*" (private agricultural industry/water consultant – owner) and likely lower resistance to pressure to manage dams well.

Economic fitness and financial support

Many key experts interviewed did not agree that farmers required financial support for dam maintenance, unless it is in the public interest however it was noted there is a balance to be achieved between public and private benefit for water storage and sharing between dams. The environmental or social outcomes of such government's funding initiatives that are in the public interest could include provision of water for the environment and removing inefficient dams or downsizing the dams to allow more water flow for other farming businesses: *"If there's no quid pro quo for government [subsidy scheme] in terms of an outcome, and the only upside is private, from my perspective I wouldn't support that"* (State Government Manager in Primary Industries and Resources 1), and "…*where there's community benefit, which […] regional water security is about community benefit or environmental benefit, then there's an opportunity for […] incentives. […] then the farmers shouldn't be expected to pay for the provisions of that community benefit*" (Industry Peak Body CEO), and *"….[Government] tend to be more focused on whether it would improve the water distribution in the region rather than the actual farmer*." (State NRM Manager).

Environmental fitness

Most key actors interviewed agreed that farmers are strongly connected to the environment because a healthier environment supports their business productivity, especially under currently changing climate conditions. Therefore, key experts believe that most farmers are aware of benefits of managing water efficiently and sharing from their dam in order to provide water for the environment, as required by the water allocation policies: "*I'd say they [are connected to the environment]… an example of that would be, farmers in a Landcare group who have put together a bit of a system that diverts [inaudible] water away from the productive farmland and some of the healthier wetlands in those areas. It's to keep them a bit healthier, so that's better, they're quite connected to the environment…"* (State NRM Manager).

4.1.2.4 Constituents

For the variable of constituents, interdependencies between various bodies and landholders and financial dependence for water sharing and storage management were key factors identified by policy actors that can drive farmer responses.

Interdependencies

Most key experts suggested that interdependency is more noticeable where farmers rely on government bodies to interpret the water policy or use their technical expertise, or for funding purposes. Local institutions such as technical experts, NGOs and industry associations are also among these institutions: "…*this comes back to the conversation about bringing the people that rely on the resource and who actually own the resource, bearing in mind a water license is a permanent property [inaudible] then the government needs to bring those people into the conversation so while they would rely on the government because the government controls the regulatory regime but the government also has a bunch of technical expertise and is able to manage the data and explain the data so to that extent, they do rely on them"* (State Government Manager in Agricultural Resources 2). The key experts largely indicated that for downstream farmers, there can be too much dependence on the uncontrollable behaviour of upstream farmers, thereby undermining downstream water security: *"…. I think a lot of growers get extremely frustrated when you see on the television huge corporate farms in the upper reaches of the Darling Basin building storages that dry up a river [so] the inequality across the states I think is a huge issue. And […] the nature of rivers, of water flowing from uphill to downhill, so the higher up on the landscape you are the better off you are*" (State Government Manager in Water Resources Area).

Financial dependence

Overall, dam maintenance was seen as an activity concerning farmer's own personal benefit and not a scheduled routine task unless there is an external pressure for dam maintenance (such as dam leaking or critical weather condition): "*And I don't think there is massive awareness. I see a lot of farmers, and maybe the hobby farmers are worse than others, or small scale farmers are worse than others that don't maintain dams*" (Senior Industry Body Representative and Grower1). Overall it was considered that although size/corporatisation can be a factor for dam maintenance, that usually it is not a factor that can be clearly determined: "…*the number of smaller entities that tend not to be as robust in terms of their governance and management, but I think generally there's those that do the right thing and those that don't…..But most farmers in the main would be very diligent about the way they manage their water resource; it is a big asset that they use on the farm, and it's pretty critical to their production. So if they get it wrong, either intentionally or by accident, there are risks there. I would suggest that most try and play their part in a bigger system*" (State NRM Manager). However, it was noted that "….[*Government] tend to be more focused on whether it would improve the water distribution in the region rather than the actual farmer. So, they might give incentives for putting in load bypasses or removing inefficient dams as they do in the Mount Lofty Ranges* […] *(State NRM Manager).*

4.1.2.5 Content

For the variable of content, the key issues of uncertainty, lack of decision making power and inconsistent pressures emerged as themes for what context drive farmer water sharing and storage responses.

Policy and institutional uncertainty

According to the Department for Environment and Water (SA), for each prescribed water resource, a Water Allocation Plan once developed by the relevant regional NRM Board must be reviewed within 10 years to ensure it is still meeting the needs of the environment and the community. While government key experts advocated for the reviews, the non-government experts' did not perceive the reviews were necessarily a positive aspect of water management as they result in uncertainty and change especially for those seeking to plan over a longer time horizon: "*… they keep changing [the policies and the legislative underpinnings]… So in the 10 years since I constructed the last dam, I think the rules have changed four times. And the fees keep changing…they just introduced two years ago…an administrative charge on top of your use charge. And two years previous to that they reduced my allocation of dam water… I invested in a major 6.5-megalitre dam, 10 years ago…. And then I was given a water allocation license, and then because I wasn't using as much water they reduced my license…So what farmers are really looking for is certainty, long-term certainty*" (Private Agricultural Industry/Water Consultant – Owner).

Decision making power

Some key experts indicated farmers have different levels of decision making power in different regions across the state which can effect farmers' strategic response to water management and farm dam policies: "[Farmers confidence with the government's response to water management and farm land policies] *depends…where you're talking about because in the [inaudible] prescribed wells area*[10]*, water allocation plan has been in place since 2002 … but then if you look at the west of Mount Lofty, so in the west of Mount Lofty…still don't really have … a water allocation plan in place and, so that their confidence is… significantly less* (Regional Irrigators Council Chairperson and Grower). This also means that in some regions farmers can plan easily and have awareness of the rules and in others it does not seem as transparent: "*… in South Australia we have this legislative framework which comes under the Water Resources Act, and so they had this system called a "proclaimed wells area," so it's a defined boundary where inside the boundary there are very strict rules, outside the boundary there are no rules…. The rates of payment for water [in each region] is different* (Private Agricultural Industry/Water Consultant – Owner).

Institutional fragmentation

Some key experts discussed the lack of holistic farm dam safety and sustainability governing mechanism and basin-wide approach (with reference to MDB). Two respondents viewed this issue as a threat to water security for the farming community: *"The greatest threat to water security [would] be Government policy. I believe it is because…we are in a connected basin and … but the way the States manage the water is different, so each State having its own, you know, water allocation plan and those sorts of things it can impact and, and South Australia being at the end of the Catchment sometimes we do get forgotten about. So that's why I think public policy, more than climate change is the issue*" (Consultant in Water Resources and Environment); "*I think each State tries to protect their own interest and generally … is not the best for the whole of the system… I think it would be taken out of the State's hands and put into a National [Strategy]. Saying where it's managed, and the targets are clearly identified of what that water's there to do and how it's going to managed rather than each state having their own vested interest.."* (Consultant in Water Resources and Environment). This institutional fragmentation could advance farmers' perception of inequity between regions: "[the threats to water security for farmers] *depends…because each of the regions has very different structures and infrastructures, and therefore risks. So… one of the major risks is the inequity that applies between regions. So everybody's got a different set of rules and the government, it's very political, and there's no transparency or equitability on it…for example, Coopers Brewery draws a substantial amount of water from the aquifers on the Adelaide plains, and pays no water use fee whereas small farmers in the Clare Valley, and then other areas where they're in a defined irrigation area, pay administrative and usage fees as well"* (Private Agricultural Industry/Water Consultant – Owner).

4.1.2.6 Farmer strategic responses

Various possible farmer strategic responses to the above perceived pressures were suggested by policy makers, focused mainly on low resistance and adaptive responses.

[10] Important water resources in South Australia are protected and managed by being 'prescribed' under the Natural Resources Management Act 2004. Prescription means that the water resource must be sustainably managed to provide security for all water users, now and into the future (South Australia's Department for Environment and Water).

Low resistance

Key experts interviewed largely believed that acquiescence, acceptance of policy and policy change were among the most common strategies perceived to be used by farmers in the face of water storage and sharing pressures. Key actors indicate that the majority of the farming community is fairly accepting of the water allocation plans and water trading rules and policies. The findings highlight the presence of a large silent majority within the community who tend to comply with the water policy without direct contribution to policy making, as well as a small group of vocal farmer groups: "[Farmers] *just... want to hunk down and grow what they're growing look after what they're looking after, so they tend to not be, I don't think they tend to be those sorts of manipulators of policy*" (State Government Manager in Water Resources Area). Under the new NRM governance model, governments have undertaken various strategies to engage stakeholders in decision making processes. This collaborative approach is substituting for the past top-down management approaches. According to a state government manager, this approach has replaced the need for bargaining in policy process: "I *think maybe some time ago they [bargained], but I think that was … a "throw and catch" scenario… And so I'd suspect that because it was very much a directive imposed position, maybe even 20, 30 years ago… But [now] the actual policy design is more engaged with stakeholders and [the impacted community], and I think that that removes that bargaining pressure*" (State Government Manager in Primary Industries and Resources 1).

Adaptation

As noted above, participants viewed climate change as an ongoing pressure on farmer stakeholders. While the climate change factor and market competition can lead to maximizing the water storage in dams in some cases, however, it has also resulted in high level of awareness among the farming community about the need for water use optimization and voluntary adaptation of efficient water-use practices and diversifying or substituting crop selections: "[*Farmers] take on-board very seriously their ability to optimise, not necessarily maximise, but optimise their use of water. So […] there's not a lot you can do to improve the collection […] Every grape grower is trying carefully to ensure that they don't put too much water on, but they put enough on to balance out getting the most profitable crop …*" (Private Agricultural Industry/Water Consultant – Owner). In addition the changing nature of perceptions of efficiency are a factor: "*… I'm almost certain that that kind of pressure to produce more from, exists but I think more the growing change in the industry group's expectations on water use efficiency…. If … you have an allocation of water and you use really good watering practice it means you save water, so you can either give it back to the environment or you can expand your business……the changes in policy over the years around the size of dams can have a negative impact on farmer's production but again if farmers are switched on operators they go for water use efficiency or they change their crop selections*" [products] (State Government Manager In Water Resources Area).

High resistance

According to the theoretical model, the farming community can make manipulative strategic responses through the existing community groups and associations to influence the policy. The key experts responses suggest there are regions of farmers who maintain moderate levels of individualism rather than a catchment/region-based water management approach: *"I think most farmers manage their dams for their business. It's, it's the rare people or the people who are open to conversations that think about how their dams sit in the catchment. So, … people think about their own water first*" (State Government Manager in Water Resources Area); and "*… I* *would say that most farmers really just try and intercept as much water as possible, and store as much water. And so there is more awareness about water sharing within catchments, so farmers very much think of their own property as a place in the world, independent of everyone else […] there's very little awareness about catchment scale management*" (State Government Manager Water Resources area 3).

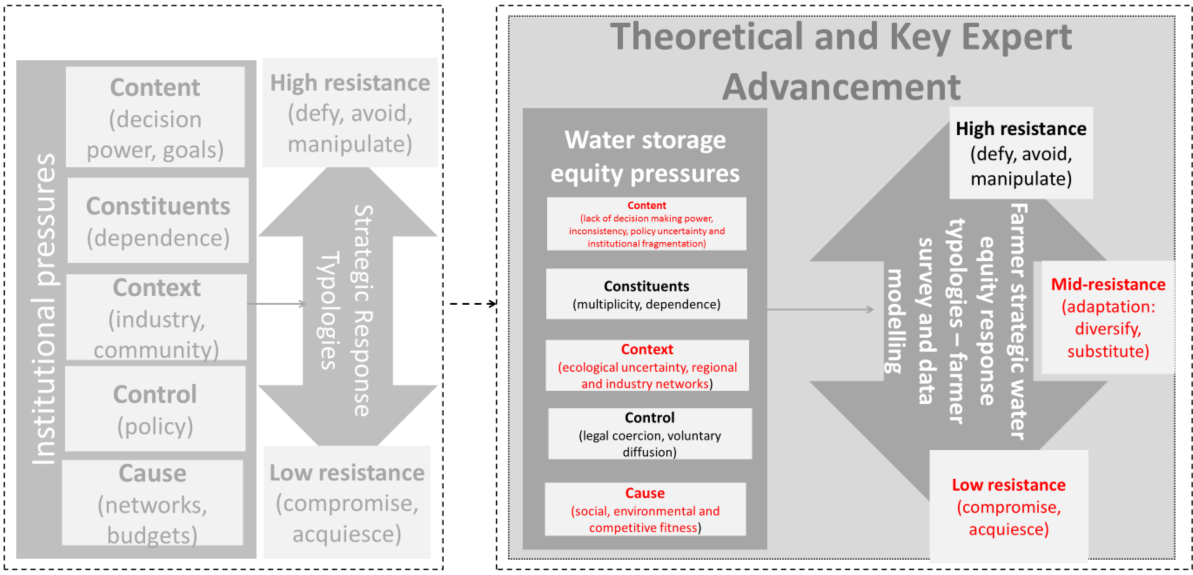
The participants made reference to some well-known associations, advocacy groups and organizations that actively engage with policymakers and add input into the policy process to better understand and influence the policy. The examples include Barossa Wine and Grape Association, International Farmer's Federation, The Agricultural Bureau of South Australia, the Adelaide Hills and Mount Lofty Ranges NRM Board, SA Farmer's Federation, South Australian Murray Irrigators, FLAG Australia, etc: "[Farmers] *must have a seat around the table and I think generally farmers are politically savvy through International Farmer's Federation, SA Farmer's Federation […] certainly in the wine industry Wine Maker's Federation did influence, did attempt, manipulate sounds sinister, but did they provide input to policy makers, absolutely… And with success"* (Senior Industry Body Representative and Grower 1).

WET Model Key Expert Input Advancement Summary

Dimensions introduced to the WET model through theoretical advancement were validated by the key expert interviews, including **adaptation** as a new farmer response variable, likely as a mid-point of resistance as per the literature, or perhaps lower range resistance – this can be tested empirically in Phase 2. Other additional dimensions were then added to the WET Model based on the feedback from the key experts (Figure 4). These include:

- Policy and institutional uncertainty added to the **Content** variable (*H3c Farmer perceptions of policy and institutional uncertainty relate to high resistance to pressures for equitable and safe water storage*)
- Competitive fitness added to the **Cause** variable which replaces the economic fitness variable from original theory (*H5b Farmer perceptions of competitive fitness relates to low resistance to pressures for equitable and safe water storage*)

Figure 4. WET Model theoretical and key expert advancements



Key expert advice will also be taken into consideration separately when finalising guidance in Phase 3. The following section considers the objective measures required for advancing the WET model.

4.1.3 Objective measures included in WET Model

The model was also advanced by objective regional control measures to be included in the analysis. These were positioned as inclusions in the model to test the pressure/response relationship above setting-based or contextual regional variables. These included post-code based regional socio-economic proxy variables of household income, remoteness, mean annual regional precipitation, mean annual regional temperature and rootzone soil moisture.
The following sections describe these objective elements.

4.1.3.1 Socio-economic variables

Socio-economic fitness or wellbeing are notoriously difficult to measure. In cases where deriving such a metric is not the purpose of a project, then various proxies can be used. The following sections discuss the two proxies used for the purpose of this study, namely to hypothesise that the worse off a farming region is socio-economically, then the more likely actors in that region are to resist pressure (Bansal and Clemens, 2005; Tingey-Holyoak, 2014).

Income

One of the more common socioeconomic status measures is income or equivalised household income, as a proxy for economic resources (ABS, 2011). Equivalised means including the fact that children in the household do not generally contribute to total income. This project has employed the ABS measure of household income which uses the 'modified OECD' equivalence scale, where the first adult in the household having a weight of 1 point, each additional person who is 15 years or older is allocated 0.5 points, and each child under the age of 15 is allocated 0.3 points (ABS, 2011). It is acknowledged that there are weaknesses with using household income as a measure of socio-economic status – families and individuals often do not share income evenly and furthermore, often draw from, or contribute to, savings on a regular basis. However, besides its convenience as a measure, in a report on Human and Social Aspects of Capacity to Change to Sustainable Management Practices, it has been argued that some measures are effective in indicating the ability of farmers to implement more sustainable management practices and these include level of farm income as a proxy measure (Cary et al., 2001). Income can be considered an element of economic wellbeing (ABS, 2011) and so is used here as such. Therefore, it is hypothesised that:
H6a: Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in low income regions.

Remoteness

While income as socioeconomic status is important, the type of community in which an individual resides is also of importance (ABS, 2011). Remoteness can be utilised as an area-based measure of socioeconomic status because of the assumed effect on the individuals who live in the area. Of course, as with all regionally based variables discussed in Section 4.1, there are variation in the characteristics of the overall population in any one place and judgements about individuals based solely on the area in which they live have a high potential for error (Robinson, 1950). However remoteness is relatively reliable as it gives an indication of 'access to services' (ABS, 2011). Remoteness can be used to help analyse where additional services are in more need and how accessible services are to the population from a policy perspective (ABS, 2011). Therefore, it is hypothesised that:

H6b: Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in increasingly remote areas.

4.1.3.2 Climate variables

Climate variables are frequently employed in farming studies. For the purpose of this study, the theoretical premise is that the more vulnerable farmers are to low rainfall, high temperatures and in regions of low soil moisture, the more resistant they will be to manage their dams in equitable and safe ways and the more likely they will endeavour to manipulate or defy pressure so they can manage in a way that makes them less exposed (e.g. store more water than entitlement) (Tingey-Holyoak, 2014b; Tashman and Rivera, 2016).

Mean annual precipitation

A review of available metrics reveals that studies including analysis of rainfall trends across Australia, have mainly relied on rainfall data time series and indices provided by the Bureau of Meteorology (BoM). For example, Jones et al. (2009) work on high quality rainfall data (as part of the AWAP) using the area-averaged rainfall for each of the four regions (southeast Queensland, northeast New South Wales, central east New South Wales and southeast New South Wales) is the average of the 'high-quality' rainfall station data within each of the four regions. BoM's gridded rainfall data provides a continuous record of rainfall for at least 100 years across all of Australia. Using the interactive maps provided on the BoM website, the historical, daily and monthly statistics (includes maps for rainfall totals, deciles[11], percentages, anomalies, drought or rainfall deficiency and rainfall comparisons) , and average conditions (includes maps for mean rainfall, decadal and multi-decadal rainfall, rainfall percentiles[12], rainfall percentages, rainfall variability index (which is an indication of the regularity of rainfall from one year to the next, distributed across Australia)) data are available for different weather stations which can be linked to post-codes or regions of interest. Lower rainfall areas are more likely to be exposed to water management challenges that can impact farm dam management (Pisaniello et al., 2012). Therefore, it is hypothesised that:

H6c: Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in lower rainfall areas.

Temperature

The BoM provides historic statistics and maps on recent conditions for average max, min and mean temperature, temperature percentiles, potential frost days, daily maximum temperature, etc. for any chosen location/weather station. BoM also provides information for extreme temperature indices, decadal and multi-decadal temperature, etc. Data from BoM and SILO have been used in a number Australian studies. For example, Lough (1997) developed temperature and rainfall index based on data from a number of stations in Queensland which extends from 1910. The temperature indices (seasonal average, maximum, minimum, and daily temperature range) represent state-wide temperature variations. Jarvis et al. (2017) analysed historical

[11] Deciles are used to give an element a ranking. For example, a decile rainfall map will show whether the rainfall is above average, average or below average for the time period and area you have already chosen (very low rainfall is in decile 1, low in decile 2 or 3, average in decile 4 to 7, high in decile 8 or 9 and very high is in decile 10).

[12] According to the BoM glossary, the term for denoting thresholds or boundary values in frequency distributions. Thus the 5th percentile is that value which marks off the lowest 5 per cent of the observations from the rest, the 50th percentile is the same as the median, and the 95th percentile exceeds all but 5 per cent of the values. When percentiles are estimated by ranking the items of a finite sample, the percentile generally falls between two of the observed values, and the midway value is often taken.

temperature data and maturity records for 45 vineyard blocks in 15 winegrowing regions across Australia in order to evaluate the suitability of common viticultural indices to estimate date of grape maturity. For climate data the authors used gridded daily maximum/minimum temperature data for Australia from 1913 to 2015 to extract temperature data for each location. The premise for inclusion is that in hotter areas it is more challenging to manage demands of livestock and crops for water which has impacts for water management in dams (Pisaniello et al., 2012). Therefore, it is hypothesised that:

H6d: Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in increasingly warm areas.

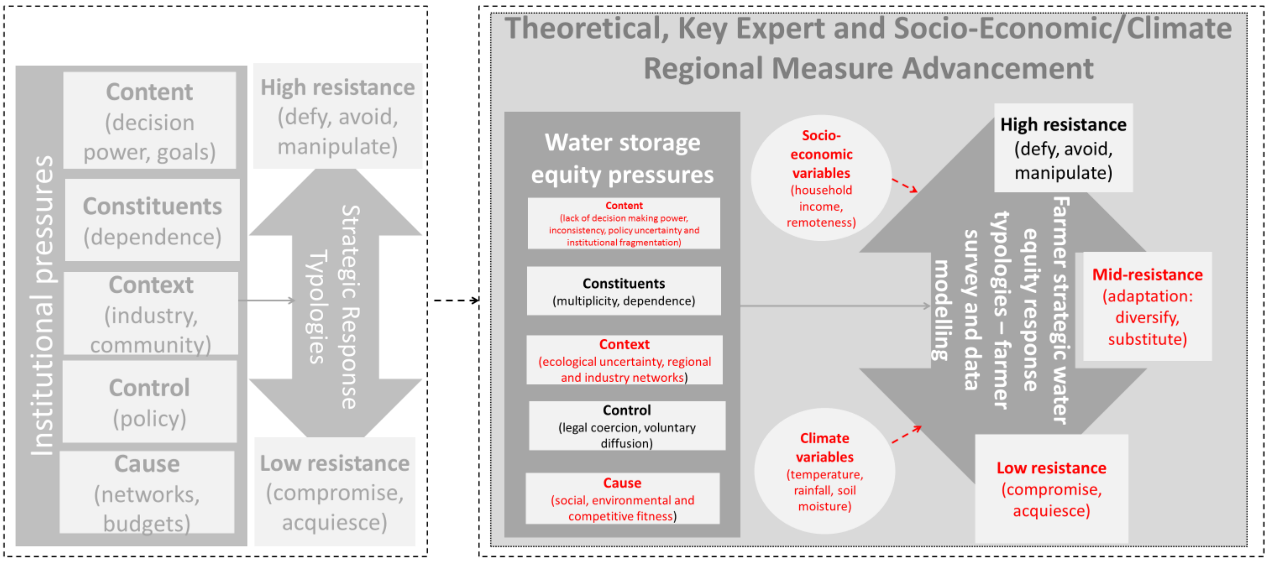
Rootzone soil moisture

The maps for different monthly periods rainfall deficiencies (rainfall percentile rankings) and also for lower level soil moisture (decile ranges: highest on record to lowest on record) can also be accessed in the Australian Landscape Water Balance (BOM, 2019b). Soil moisture is a key variable for water management, especially in crop growing areas as it dictates the demands of the plant – lower rootzone soil moisture indicates greater demand for precise and productive water management (Tingey-Holyoak, 2014b). Therefore, it is hypothesised that:

H6e: Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in areas of low soil moisture.

Figure 5 summarises the development of a conceptual WET Model for SA based on the (i) theoretical advancements in the strategic typology field related to agricultural water management, (ii) key expert interview contributions, and (iii) critical regional objective variable inclusion, including socio-economic and climate measures.

Figure 5. Conceptual WET Model for SA



Phase 2 now pursues the necessary farmer perceptions and attitudes through field surveys to be reported as follows.

4.2 Phase 2 results: Farmer survey

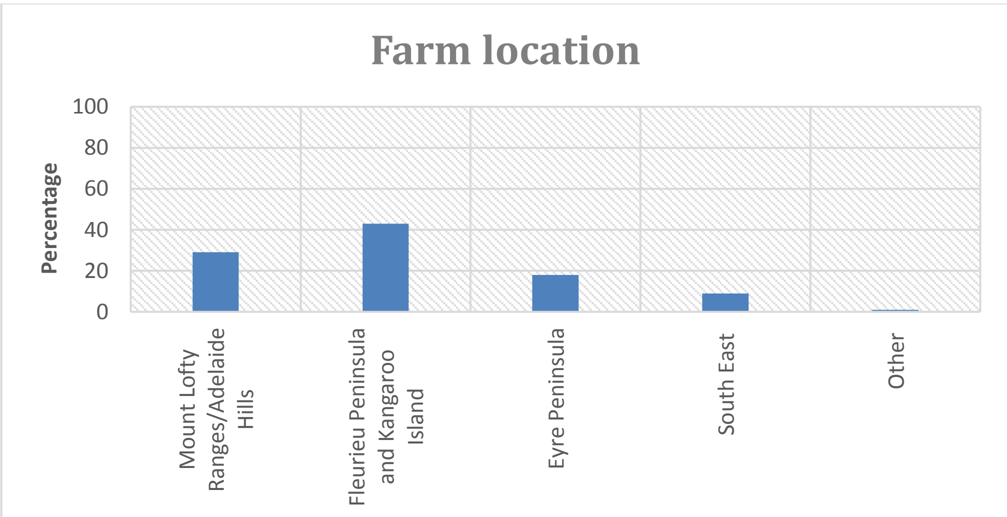
Once the survey design was complete, the farmer survey was undertaken using targeted sampling from publicly available sources with verification of physical regional variables through online mapping technology (Tingey-Holyoak 2014a; 2014b). However, ethical considerations revealed the need for completely anonymous sampling and so regions were sampled with strict limiting questions regarding landownership and water sources. If participants did not have dams they were unable to complete the survey. Initially 3 regional concentrations were targeted however response rates were unsatisfactory so an additional region (South East) was included. Respondents were randomly drawn from the database until the target sample of approx. *n*=150 (*n*=157 was attained) was met in order to gain a meaningful sample size for inter-regional comparison.

The survey was put into the field using phone methodology by professional survey firm Square Holes. The firm are ISO 20252 certified (international standard for market, social and opinion research) and endorsed by AMSRO Trust Mark, in addition to University of South Australia's Human Research Ethics Protocol # 20856 requirements. The survey was piloted on 20 farmers and 6 questions removed and wording changes made. Piloting also revealed the need for an 'opt out' item ("8") to be included in the Likert scale to ensure farmers did not feel pressured to respond (Carson and Groves, 2007). It total 125 completed by phone and 32 online. The length was approximately 20-40 minutes. Missing data meant case wide participant deletion was undertaken unless there were values before and after the missing value which meant the item result could be linearly interpolated (Westbrook et al., 2006). Participants were also excluded if the respondent was not a landholder, farm manager or leaseholder of farming land. Out of 235 partial or complete responses, a total of 157 were retained.

4.2.1 Demographic analysis

A requirement for participation was that participants were the landholder or leasing or managing in so far that they had responsibility for on-farm water management and 99% of respondents identified as the landholder. The majority of respondents were located in the Fleurieu Peninsula and KI (43%), followed by Mount Lofty ranges/Adelaide Hills (29%), and the Eyre Peninsula (18%) (Figure 6).

Figure 6. Farm location



Most farmers surveyed were running sheep with a strongly significant difference between the regions, with farmers in the South East reporting the highest rates of sheep (48%) and MLR/Adelaide Hills the lowest (14%) (X^2=29.51, p =0.00) (Table 1). The second highest reported form of production was cattle, also with a significant difference – only 8% in Eyre Peninsula, compared to nearly a third of farmers in the Fleurieu Peninsula and KI (32%) (X^2=8.05, p =0.05). There was a significant difference between regions with regard to grain production with Eyre

Peninsula farmers reporting the highest rates (27%) and MLR/Adelaide Hills the lowest (2%) (X^2=57.70, p =0.00). However fruit production was highest in MLR/Adelaide Hills (8%) (X^2=14.42, p =0.01) (Table 1). Up to 35% of farmers had experienced a production change in the past 5 years, the most in the Fleurieu and KI (35%).

Farms size by acres was significantly different between respondents in each region (X^2=33.72, p =0.01). The smallest farms of between 0-50 acres were located in Adelaide and MLR (40%) and the least proportion of small farms was found in the South East (9%) (Table 1). However the South East reported the largest number of farms over 1000 acres with 73% of respondents from this region owning/operating farms of this size, followed by 39% in Eyre, and 35% in the Fleurieu and KI. In terms of employees, there was no significant difference reported between farmers in the 4 regions, with most farmers having between 1-3 employees in all regions and the least having less than 1 or 7 and above (Table 1). There was a marginally significant difference in land under irrigation with farmers in the Adelaide and MLR and Fleurieu and KI regions reporting the highest acres with 18% of farmers in both regions reporting irrigating 60 acres or more, compared to 10% in the South East and 0% in Eyre (X^2=25.05, p =0.04) (Table 1). The change in irrigation over the past 5 years was highest in the South East (21%) with all farmers there reporting an increase (100%), followed by 13% changing irrigated area in Adelaide and MLR. However, in Adelaide and MLR the change was interestingly downward in the majority of cases reported (77%) (Table 1).

Table 1. Farm Demographics

Farm Demographics	MLR/Adelaide Hills % (*n*=48)	Fleurieu Peninsula & KI % (*n* =67)	Eyre Peninsula % (*n* =28)	South East % (*n*=14)	Chi-Squared
Farm Type[i]					
Grain	2	5	27	15	57.70***
Fruit	8	1	0	0	14.42***
Wine Grapes	6	3	0	0	6.64
Vegetables	5	1	0	0	7.09
Other crops[ii]	14	12	23	11	6.47
Cattle	29	32	8	22	8.05*
Sheep	14	32	40	48	29.51***
Dairy	3	4	0	0	2.49
Poultry	5	0	0	0	7.62
Other livestock[iii]	14	10	2	4	4.78
Production change 5 yrs					
Agreed[iv]	22	35	11	5	5.05
Farm size (Acres)					
0-50	40	23	30	9	33.72**
51-100	16	9	0	0	
101 – 200	12	7	0	0	
201 – 500	23	14	0	18	
501-1000	0	12	31	0	
1001 +	9	35	39	73	
Farm size (employees FT)					
>0.9 FTE	5	0	0	0	5.99
1-3	75	89	86	92	
4-6	15	11	14	8	
7-9	5	0	0	0	
Acres under irrigation					
0-20	43	77	100	70	25.05*
21-40	26	5	0	20	
41-60	13	0	0	0	
61-80	9	0	0	0	
81-100	0	5	0	0	
101 +	9	13	0	10	
Change irrigation 5 yrs					
Agreed	13	7	0	21	3.93
- Increase	33	0	0	100	4.89
- Decrease	77	5	0	0	
Number of dams					
0-5	80	58	35	64	36.18**
6-10	10	8	38	29	
11-15	7	13	4	7	
16-20	3	5	15	0	
21-50	0	13	8	0	
51 +	0	3	0	0	
Size of largest dam (ML)					
0-5	48	48	38	25	18.66
6-10	4	0	0	0	
11-20	16	4	0	0	
21-30	4	13	0	0	
31-50	8	0	0	0	
51 +	20	35	62	75	
Industry body membership					
Agreed	43	29	33	29	2.34
Landcare Group Membership					
Agreed	3	11	4	0	4.97
Environmental or Water Group Membership					
Agreed	3	5	0	7	1.98

[i] respondents could choose more than one production type

[ii] Other crop types reported included cherries but also cut flowers, forestry, hay/pasture, legumes (including beans), olives, oil seeds and Lucerne.

[iii] Other livestock types reported included alpacas, horses, kangaroos.

[iv] Production change included cutting back generally, rotating grain and sheep, including garlic, doing less cropping and making more seasonally based changes. Only three respondents recorded changes to increase production including continuous cropping and increasing the number of sheep.

*= sig. at p<0.05

** = sig. at p<0.01

***=sig. at p<0.001

There was a significant difference in the number of dams reported between the regions with most farmers in Adelaide and MLR (97%) and the South East (100%) having under 15 dams, and many farmers in the Fleurieu and KI (21%) and Eyre (23%) regions having over 16 dams (X^2=36.18, p =0.01). The largest dams were located in the South East with 75% over 51 ML and the smallest located in Adelaide and MLR with 68% of dams below 20ML (Table 1).

Table 2 demonstrates that nearly half of farmers in the Adelaide and MLR region (43%) are members of industry bodies but far less are members of Landcare (3%) or environmental (3%) groups. The highest representation in Landcare or environmental groups is in the Fleurieu and KI region with 16% of farmers reporting to be involved in such groups (Table 2). Industry bodies have various representations reported per Table 2 with the most prominent being the Farmers Federation followed by livestock groups.

Table 2. Industry body memberships

Industry body membership types	MLR/Adelaide Hills % (*n*=21)	Fleurieu Peninsula & KI % (*n*=19)	Eyre Peninsula % (*n*=9)	South East % (*n*=41)
Ag Bureau	0	18	11	0
Ag KI	0	6	0	0
AHWR	8	0	0	0
Apple and Pear Growers SA	8	0	0	0
Cherry SA	8	6	0	0
Alpaca Association	8	0	0	0
Aust Wine and Brandy Board	17	0	0	0
CSGA	0	0	0	0
Farmers Federation	0	7	11	100
Grain Producers SA	0	7	56	0
Meat and Livestock Australia	17	18	11	0
Institute of Engineers	0	6	0	0
Livestock SA	17	32	11	0
Marino SA	0	0	0	0
Poultry Board	8	0	0	0
Oz Veg	8	0	0	0

Most farmers were male in all regions with no significant difference between the regions reported (Table 3). There was a high representation of the over 65 age range with over half of farmers in Fleurieu and KI (58%) reporting to be 65 and over, followed by 45% in Eyre Peninsula (Table 3).

Table 3. Farmer demographics

Farmer Demographics	MLR/Adelaide Hills % (*n*=48)	Fleurieu Peninsula & KI % (*n*=67)	Eyre Peninsula % (*n*=28)	South East % (*n*=14)	Chi-Squared
Gender					
Male	69	75	70	64	0.96
Female	31	25	30	36	
Age					
25-34	2	0	11	0	23.68
35-44	7	5	11	14	
45-54	20	11	11	21	
55-64	45	26	22	30	
65-74	19	32	30	21	
75+	7	26	15	14	

*= sig. at p<0.05
** = sig. at p<0.01
***=sig. at p<0.001

The following section details the process of measuring and testing the theoretical WET Model for South Australia.

4.2.2 WET Modelling – Multiple regression model

The followings sections detail the measures and modelling process including the results of the multiple regression analysis for the full sample.

4.2.2.1 Measures

In order to understand manager responses to water storage pressure in different institutional environments, the survey instrument was developed through the use of the measures established by Clemens and Douglas (2005) and Tingey-Holyoak and Pisaniello (2015) where possible, applied to water storage specifically (Appendix 7C). In the absence of an established measure, efforts were made to increase reliability by clear conceptualisation through foundations in the literature (see Appendix 7C). Questions were asked on a 7-point Likert scale to use as wide a scale as possible (with benefits diminishing at 7-points, see Matell and Jacoby, 1971). During pre-testing an additional 8^{th} item was added as 'not applicable' as this emerged as distinct from the mid-point #4 which was 'don't know/not sure'.

Because the cross-sectional study collected data for the independent and dependent variables using the same instrument and participants, common method bias is a possible threat to validity (Lindell and Whitney, 2001). Several procedural measures were employed to minimise bias: respondents remained anonymous and responses confidential (Brito et al., 2014); and the questionnaire was randomly ordered and there were also extensive pre-tests of the scales with academics, practitioners and a professional survey organisation to reduce item ambiguity (Podsakoff et al. , 2003). Items were tested for validity to confirm that they measure what they are intended to measure (i.e. face validity), represent the full breadth of a construct (i.e., content validity), and agree with or predict behaviour (i.e. criterion validity) (Hardesty and Bearden, 2004). Firstly, face validity was measured through the judgement of others in the scientific community (Hardesty and Bearden, 2004) by pretesting measures with expert academic colleagues. Secondly, content validity was addressed by using multiple indicators where possible (Nunnally and Bernstein, 1994, Appendix 7C). Thirdly, criterion validity (which can be concurrent, in that a measure agrees with an established measure, or predictive, in that it agrees with predictive behaviour (Nunnally and Bernstein, 1994)) was addressed by using established measures wherever possible. Construct validity, which aims for consistency of multiple indicators in that they are convergent, that is, like ones are similar, or discriminant, that is different ones differ, was tested statistically using an exploratory factor analysis, undertaken with Principal Axis Factoring and Direct Oblimin rotation (see Field, 2009). Reliability of the resulting scale was tested statistically using Cronbach's alpha (Appendix 7c). Appendix 7C summarises the key variable and hypotheses relationships and advancements based on Phase 1 of the project.

Owners or managers of farms were chosen as the unit of analysis because they represent the organisation, and because they are often part of, or solely responsible for, a small organisation in terms of employee numbers, where it is likely that their views represent those of the entire organisation (NFF, 2012). The objective measures including socio-economic variables of household income and remoteness, in addition to climate based data were included as the first step of a multiple regression model. It is of interest whether socio-economic and climate related variables are associated with response to water storage pressure and so to make sure they do not explain away the entire form of strategic response, they are placed in the model first to ensure any shared variability with the subjective, farmer predictors of interest in the model is acknowledged. Any observed effects of perceptions of farmers as predictors of strategic response will then be independent of the effects of socio-economic and climate variables.

4.2.2.2 Modelling

For the dependent variable acquiescence, the model predicted 42% of variability in acquiescence (F(17,125) =1.58, p = 0.08). Table 4 presents the significant regression weights and results indicate that perceptions of farmers' own competitive fitness significantly predicted acquiescence (β = 0.22, t(142) = 2.43, p = 0.02). That is, when farmers surveyed perceive that they are experiencing positive growth comparatively in a region and are competitive with their peers, then they are most likely to comply and continue with low-resistance water storage habits and practices, thereby confirming WET Model hypothesis 5b.

Table 4. Multiple regression weights (t) for significant predictors of farmer WET (n=157)

Variables	**β (t)**
Acquiescence (DV1)	
Competitive fitness (H5b)	0.22 (2.43)**
Compromise (DV2)	
Competitive fitness (H5b)	0.22 (2.51)**
Legal coercion (H2a)	0.19 (2.20)*
Defiance (DV4)	
Household income (H6a)	-0.21 (-2.08)**
Adaptation (DV6)	
Consistency with farm goals (H3b)	0.21 (2.32)**
Competitive Fitness (H5b)	0.25 (3.07)***

*= sig. at p<0.05
** = sig. at p<0.01
***=sig. at p<0.001

For the dependent variable compromise, the model predicted 50% of variability in the dependent variable (F(17,125) =2.50, p = 0.00). Table 4 demonstrates that again, competitive fitness predicted the low-resistance strategic response of compromise (β = 0.22, t(142) = 2.51, p = 0.01) which further confirms WET Model hypothesis 5b. However, the threat of legal coercion also predicted a compromise response amongst farmers surveyed (β = 0.19, t(142) = 2.20, p = 0.03). Farmers who are competitive and doing well with their growth on a regional basis, do not wish to have heavy handed regulation surrounding their water, and so could be more likely to demonstrate compromise strategies, such as negotiating openly with regulators, thereby confirming WET Model hypothesis 2a.

The model for avoidance was not significant. The predictor variables explained 40% of variance in avoidance however there were no significant individual predictors so the mid-range response in the original theoretical model was not significant. However, for the more resistance 'defiance' dependent variable, the model was significant, predicting 46% of variability in defiance (F(17,125) =2.00, p = 0.02). Table 4 demonstrates that the regional objective measure of household income *negatively* predicted defiance (β = -0.21, t(142) = -2.08, p = 0.02). That is, in regions of low income, farmers might be more likely to ignore the water or dam management regulatory requirements or even try to reduce the extent to which regulators access their property. This confirms WET Model hypothesis 6a.

For the highest resistance strategic response, manipulation was significant with 45% of the response explained by the predictor variables ($F(17,125) = 1.84$, $p = 0.03$). However, there were no significant individual predictors and so the sample of farmers are not likely to exhibit a response such as trying to influence policy makers or use lobbyist and elected officials to achieve changes to regulation.

The new dependent variable adaptation (diversification and substitution) was significant and the model predicted 58% of variability in adaptation. ($F(17,125)=3.71$, $p = 0.00$). Table 4 shows that consistency of water regulations with farm goals significantly predicts an adaptation response from farmers ($\beta = 0.21$, $t(142) = 2.32$, $p = 0.02$) confirming WET Model hypothesis 3b. Furthermore, competitive fitness again predicts this level of strategic response, in so far that the more competitive a farmer perceives they are in their region or industry, the more likely they will diversify or substitute production methods as a response to pressure ($\beta = 0.25$, $t(142) = 3.07$, $p = 0.00$). This links into hypothesis 5a and is an indication that the adaptation variable is lower range resistance than the mid-point, as this is close to the type of response experienced for low resistance acquiescence and compromise responses. The following section will advance understanding of these significant predictors with attitudes analysis.

4.2.3 Regional WET Model Advancement: Attitudes analysis

Farmer attitudes on water storage equity and toward water and farming generally were derived from key expert interview, relevant literature and researchers' past experience, grouped on a key variable basis and then explored by region, as per Table 5. A one-way analysis of variance (ANOVA) was calculated on participants' attitudes. There was a significant difference in attitudes for 7 of the 22 attitudes explored which will be discussed based on thematic groupings of competitive fitness, legal coercion, consistency with farm goals and household income related factors. Further open-ended comments provide additional context across the factors.

Table 5. Regional WET attitudes assessment

Attitudes % [i ii]	MLR and Adelaide Hills (*n*=48)	Fleurieu Peninsula and KI (*n*=67)	Eyre Peninsula (*n*=28)	South East (*n*=14)	Weighted SA average agreeance %	One-way ANOVA *F*-test
Competitive fitness						
I am open to new ideas and technologies for water and dam management	95	89	100	93	94	2.66*
I have adopted irrigation efficiency improvements on my farm	75	47	33	86	60	0.62
Rapidly changing climate factors are a significant threat to water management and security in my region	82	69	54	45	63	3.73**
My general health is good	93	89	100	93	94	2.95*
My health has suffered due to water insecurity in my region	18	11	0	20	13	2.10
Legal Coercion						
The government's position on water and dam management in my region and how it will implement policy is clear	36	41	32	29	35	1.87
When water and dam management policy change this is communicated to me clearly	38	23	8	33	26	3.12*
Water and dam management policy in my region changes too frequently	37	57	50	75	55	3.96**
I voluntarily installed low flow bypasses on my dams	3	19	33	11	17	0.56
I have been ordered to have low flow bypasses on my dams	7	8	0	0	4	0.04
I have voluntarily improved the size or condition of my spillway`	25	35	29	14	26	0.50
I have been ordered to improve the size or condition of my spillway	0	2	0	0	1	0.78
I understand the concept of environmental flows and why low flow bypasses would be needed on dams	60	67	53	91	68	1.63
Consistency with farm goals						
Managing environmental problems on my farm is a very high priority	95	93	100	100	97	0.45
I believe in climate change	72	63	39	88	66	4.10**
Financial policy incentives or subsidies would encourage me to improve my water and dam management	71	50	70	40	58	0.51
I allow for an annual maintenance spend on my dam to ensure it brings positive benefits to my production	58	63	74	43	60	0.45
Household income						
In the last 5 years this farm has had a positive productivity change	61	70	86	80	75	1.15
A maximum annual return from my property is my most important aim	49	70	83	75	70	136
In the past 5 years me or a member of my family have had to take off-farm work to subsidize/support on-farm activities	50	63	30	36	45	3.65**
It would help me to obtain water management funding from government	63	33	74	22	48	1.72
I have a successor for this farm in place	43	61	77	62	61	2.35

[i] Mean percentage agree (does not include no answer or n/a responses

[ii] Underlined region mean indicates they are significantly different from another underlined region(s) percentage(s) at $p<0.05$ using Bonferroni post-hoc comparisons

*= sig. at p<0.05
** = sig. at p<0.01
***=sig. at p<0.001

Competitive fitness

Technology and efficiency competitiveness. Many farmers are open to new ideas and technologies for water and dam management (94%) and many have adopted some form of irrigation efficiency improvements on their farm (60%). Farmers in the Eyre (100%) and Adelaide and MLR (95%) regions are the most open to new technologies with farmers in Fleurieu and KI regions less likely (89%) but still very much in favour of new water technologies ($F(3,150)=2.66$, $p=0.05$) (Table 5).

Climate and environmental impacts to competitiveness. Whilst about two thirds of farmers agreed (63%) that rapidly changing climate factors affect their water management and security, those in the Eyre Peninsula were least concerned about rapidly changing climate facts threatening them (54%) compared to those in Adelaide and MLR (82%) and Fleurieu and KI regions (69%) ($F(3,150)=3.73$, $p=0.01$) (Table 5). Farmers were also asked broadly what they perceived the biggest threats to water security in their region were and text analysis results demonstrated overall 39% of farmers surveyed perceive the climate change related factors to be the biggest threat they currently face. Factors noted by these farmers include rainfall variability, drought and water availability with comments including: "*if we don't get rain we are in trouble*" (Fleurieu farmer), and "*we are not in any water supply, we depend on rain or aquafer*" (Adelaide and MLR farmer). Around 15% of the respondents perceive water capture from competing users beyond the environment including large farming businesses (vineyards), forestry, urbanization activities, and meat production as a major threat to water security in their region. Over half (58%) of this group of farmers were located in Fleurieu Peninsula and KI and about a quarter (21%) were in the MLR/Hills regions with comments including: "*The biggest threat is if you allow huge vineyards to take all the water. Must control the water to the properties"* (Fleurieu Peninsula Farmer), and *"Corporate farming, when the land is not an owner operator, they live in New York, England*" (Fleurieu Peninsula Farmer), and "*The growth of Mt Compass taking all of our water*" (Fleurieu Peninsula Farmer).

Health impacts to competitiveness. Most farmers report having good general health (94%) which is slightly less in Fleurieu and KI (89%) than other regions (Adelaide and MLR 93%, Eyre Peninsula 100%, South East 93%) ($F(3,150)=2.95$, $p=0.04$) (Table 5). Furthermore, only 13% report having had negative impacts to their health because of water security in their region. There is no statistically significant difference between regions however 20% and 18% in the South East and Adelaide and MLR respectively report their health suffering due to water insecurity, compared to 0% in Eyre Peninsula.

Legal Coercion

Policy clarity. Over a third of farmers surveyed in SA (35%) find water and dam management policy in their region and how regulators will implement the policy to be clear. Whilst nearly half those in Fleurieu and KI find policy and implementation clear (41%) the results are not statistically significantly different between the 4 regions sampled ($F(3,150)=1.87$, $p=0.14$) (Table 5)..

Policy consistency. Over half of farmers surveyed on average (55%) perceive that water and dam management policy changes too frequently in their region. However, there was a statistically significant difference between regions ($F(3,150)=3.96$, $p=0.01$) with considerably fewer farmers in Adelaide and MLR (37%) perceiving too-frequent policy changes, compared to three quarters of farmers in the South East (75%) (Table 5). When open ended comments are assessed, most of the farmers surveyed (74%) indicated that the policies and programs in place are adequate to face these threats to water security. Of those, most (41%) were located in Fleurieu Peninsula and KI regions, with about a quarter (27%) in the MLR/Hills regions.

Policy communications. Only about one quarter of farmers surveyed (26%) perceive that when policy does change, it is communicated to them clearly. However, there was again a statistically significant difference between the regions, with only 8% of farmers surveyed in Eyre Peninsula satisfied with policy change communications, compared to 33% satisfied in the South East, and 38% satisfied in the Adelaide and MLR region ($F(3,150)=3.12$, $p=0.03$) (Table 5). However, there appears to be an overall general dissatisfaction with communication of policy change for farmers surveyed in all regions. Open ended comments were also explored and indicate that 19% of farmers, mostly farmers situated in Fleurieu Peninsula and KI (67%), suggest better education and awareness could be achieved through different methods such as rural seminars and sharing information: "*More education of farmers more communication from the regulatory agencies improved capabilities in agency staff"* (Fleurieu Peninsula Farmer), and "*there should be regular forums to emphasise risks and benefits of water storage"* (Fleurieu Peninsula Farmer).

Specific policy elements: Low flows. Over two thirds of farmers surveyed (68%) understand the concept of environmental flows and why low flow bypasses would be needed on dams (Table 5). However only 17% of farmers surveyed report to voluntarily installing low flow bypasses. Although the regional comparison did not result in statistically significant differences, the voluntary installation was reported the least in Adelaide and MLR with only 3% reporting to voluntarily install compared to 33% in the Eyre Peninsula. Furthermore, only a very small amount (4%) of farmers surveyed in all regions had been ordered to have low flow by passes installed.

Specific policy elements: Spillways. About a quarter of farmers surveyed (26%) have voluntarily improved the size or condition of their spillway[13] (Table 5). There was no statistically significant difference between regions however most commonly this was reported in the Fleurieu and KI regions (35%), possibly due to the high concentration of farm dams in othese areas. Only 1% of farmers reported having been ordered to improve the size or condition of their spillway which was common in all regions sampled and to be expected with no specific dam safety regulations and supervision.

Consistency with farm goals

Environmental and climate change management goals. Almost all farmers surveyed in all regions make managing environmental problems on their farm a very high priority (97%). Furthermore, the majority of farmers surveyed believe in climate change (66%) (Table 5). However, there was a statistically significant difference reported between regions

[13] Studies show that dams fail most often by overtopping because of inadequate spillway capacity due to under sizing or blockage: this failure mode represents 40% of those recorded worldwide (Foster et al., 2000). In fact most existing dams will have insufficient spillway capacities when reviewed due the significant, recent advances made in the fields of meteorology and flood hydrology whereby acceptable design floods are commonly found to be considerably greater than the floods which could cause failure of existing dams (Pisaniello et al, 1999; 2012). Furthermore, embankment dams (which typify private farm dams) are most susceptible representing 70% of recorded failures (Pisaniello, 1997; Foster et al., 2000). At the catchment-wide level numerous individual dams with inadequate spillways pose a cumulative threat to unfair water sharing and can also pose a higher hazard due to their cascade/cumulative risk of failure – this is known as the 'dual-extreme cumulative threat' phenomenon (Pisaniello et al., 2012; 2013): 1) exacerbation of drought threats during times of limited rainfall because of unfair storage of water in dams, and 2) exacerbation of flood threats during extreme rainfall caused by unsafe water storage in dams (Pisaniello & Tingey-Holyoak, 2018).

($F(3,150)=4.10$, $p=0.01$) with farmers in Eyre Peninsula least likely (39%) and farmers in the South East most likely (88%) to believe in climate change.

Financial policy levers. 71% of farmers in Adelaide and MLR report that financial policy incentives or subsidies would encourage better water and dam management, similar to 70% of those in Eyre Peninsula. This is compared to only 40% in the South East and 33% in the Fleurieu and KI region ($F(3,150)=0.51$, $p=0.68$) (Table 5). This reinforces the potential benefit of financial water/dam management policy mechanisms in Adelaide and MLR and Eyre of the regions sampled. Many farmers allow for an annual dam maintenance spend (60%) with most farmers in Eyre Peninsula (74%) reporting annual dam maintenance cost allocations.

Household income related factors

Production income. Three quarters of farmers reported a positive productivity change in the last 5 years (75%) and around the same number of farmers share the main aim of a maximising their annual return from their property (70%) (Table 5). There was no statistically significant difference between regions however farmers in the Eyre Peninsula were most likely to report both positive productivity change (86%) and the main aim to maximise return (83%) compared to farmers in Adelaide and MLR (61% and 49% respectively).

Off-farm income. Nearly half of farmers surveyed (45%) have had to take off-farm work to subsidize farm activities in the past 5 years (Table 5). This was statistically significant between regions with 63% of farmers in the Fleurieu and KI and 50% of those in Adelaide and MLR taking off-farm income, compared to only 30% and 36% in the Eyre Peninsula and South East respectively ($F(3,150)=3.65$, $p=0.01$).

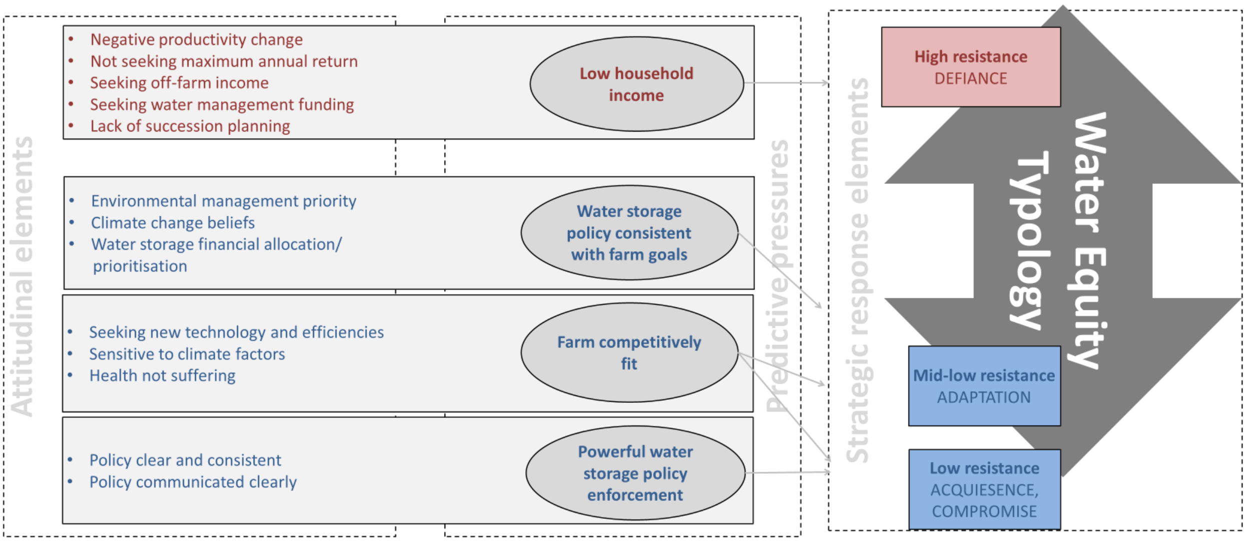
Government income. Around half of farmers surveyed (48%) indicate they would benefit from water management funding from government (Table 5). This was not statistically significantly different between regions sampled however nearly three quarters of participants in the Eyre Peninsula region (74%), and two thirds in the Adelaide and MLR region (63%) report they would benefit from water funding, compared to only a third (33%) in the Fleurieu and KI region, and a quarter (22%) in the South East.

Future income planning. Whilst 61% of farmers surveyed report to have a successor for their farm in place, it was marginally statistically significant that this was less so the case in Adelaide and MLR with only 43% of farmers with a successor compared to 77% in the Eyre Peninsula ($F(3,150)=2.35$, $p=0.08$) (Table 5).

4.3 Phase 3 results: Policy guidance development

This project report has presented the findings of a theoretically and key-expert informed WET Model, statistically tested for South Australian farmers. This model is further advanced by regional attitudes analysis that explores attitudes across climate and environment, government and regulation, financial and health factors (Figure 7).

Figure 7. Resulting statistically validated WET Model



4.3.1 Summary of results

Results from Phase 1 theoretical advancement include the inclusion of current literature on strategic responses to water pressures and results in 'adaptation' being included into the model as a key response variable from farmers in addition to ecological uncertainty and including environmental fitness. Results from Phase 1 key expert interviews find that climate change pressures are increasing on farming communities and businesses and has created significant uncertainty. In the context of large catchments, downstream users lack interconnectedness and sense water inequities that they cannot control resulting from upstream actions. Unfortunately, this is worse for smaller less competitive producers. Farmers who are competitive and have higher productivity are generally managing water better which is enhanced by environmental and ecologically responsive attitudes. Key experts indicate that whilst policy can be complex it is mostly developed and changed in a participatory way. It is acknowledged that the language can be complex and even 10-yearly change can seem too frequent so improvements in education and communications are always beneficial. Low flow bypass voluntary dissemination has been positively received and ways forward to assist those who perhaps feel at threat and are less competitive and expansion of this initiative as a way of delivering confidence in the policy and supporting farmers, yet not creating financial dependencies is a possibility. Involvement of farming professional bodies and other agencies would be beneficial. Furthermore, a longer term horizon on policy and policy change could be positive to reduce uncertainty and restore farmer decision making power.

Results from Phase 2 farmer surveys demographic analysis finds that most farmers surveyed were sheep or cattle on a variety of farm sizes across regions, most irrigating 20 acres or less, but with up to 10 dams, many of them over 50 ML. Many have industry body membership but less are members of Landcare groups. Most are male of over 65 years of age.

Results from Phase 2 farmer survey WET modelling across the whole of SA sample shows that to generate the least resistance to water management pressures, farmers competitive fitness is important, which is also reflective of Phase 1 key expert interviews. Farmers who are competitively fit in their region and catchment are likely to acquiesce or compromise to pressure to manage their dams and water in certain ways through behaviours such as following the optimal processes for their region or by other successful farmers. Legal coercion or strong enforcement of water policy also generates a compromise response, such as through farmers negotiating an agreeable solution for their dams with the regulators. Low household income emerged as a key predictor of a strongly resistant response to dam management pressures, through defiance and means such as ignoring water management regulatory requirements or reducing access by regulators to the dams. The new response variable of 'adaptation' was predicted by consistency with farm goals. This means farmers who are already satisfied with the conditions of their water license and access entitlements will be more likely to diversify or substitute if their water demands change at any time. Furthermore 'adaptation' is predicted by competitive fitness which provides theoretical advancement that this new type of strategic response variable is lower range resistance than the mid-point, as this is close to the type of response experienced for acquiescence and compromise which advances future modelling.

<u>Results from Phase 2 farmer survey WET advancement through regional underpinning attitudes analysis</u> find that:

- *Farmer competitiveness* is a strong thematic variable in the SA regions sampled and a strong predictor of a low resistant strategic response to equitable water storage management. Nearly all farmers surveyed demonstrate this by being open to new ideas and technologies for water and dam management, adopting irrigation efficiency improvements on their farm, most evident in the Adelaide and MLR region. Most farmers surveyed agreed that climate-related factors were their biggest threat, which was most evident also in Adelaide and MLR in addition to Fleurieu and KI regions.
- *Policy strength, consistency and communication* also emerges as a strong thematic variable with legal coercion predictive of low resistance to water storage pressure in the regions sampled. Over a third of farmers surveyed finding water and dam management in their region and how regulators will implement policy to be clear which was consistent across all regions. Open ended comments indicate that most farmers perceive the policy and programs in place to be adequate to face the threats to water security, particularly in the Fleurieu Peninsula and KI regions. Half of farmers surveyed did perceive that policy changes too frequently with considerably more farmers reporting this in the South East. This suggests issues like proposed cuts to water allocations in the South East NRM region in late 2017 could have been related to 'inconsistency' in the minds of participants compared to farmers in Adelaide and MLR who dealt with considerable change in the earlier part of this decade and perhaps now feel that they are part of a more stable regime (Strongplan, 2017). However, as indicated in Phase 1 key expert interviews, even 10-yearly changes can be – too frequent' and so education and awareness through rural seminars and sharing information can be beneficial. Whilst specific elements such as low flow bypasses have been suggested and implemented in certain situations by regulatory bodies, farmers whilst generally understanding of the concept, have not largely voluntarily or been ordered to install low flow bypasses, despite robust projects such as Securing Low Flows in the Mount Lofty Ranges (DEW, 2018). However, Eyre Peninsula farmers report a higher rate of installation possibly due to the high number of livestock properties in the region, combined with recent awareness raising (EPNRMB, 2018b), especially dam specific detailed guidance for dam siting, design and construction in the region (Liddicoat et al., 2011) and impact documents (McMurray, 2006). Nearly no farmers reported having been ordered to improve the size or condition of their spillway which was common in all regions sampled and possibly due to the current dam safety gap in policy.
- *Consistency with farm and farmer goals* was a strong predictor of an adaptation response and underpinning attitudes investigation indicates that all farmers surveyed in all regions make management environmental problems on their farm a very high priority, in line with

the aims of the policy and policy makers. Most farmers in Adelaide and MLR and Eyre Peninsula report that financial policy incentives or subsidies would encourage better water and dam management which is interesting given farmers in Adelaide and MLR and Eyre report the highest potential interest in technology and efficiency improvements. Furthermore, even though most farmers allow for dam maintenance spend, those in Eyre are most likely which further reinforces the potential benefit of financial water/dam management policy mechanisms in Adelaide and MLR and Eyre of the regions sampled. Projects such as the recent National Landcare Programme Regional Funding for Sustainable Agriculture in Eyre Peninsula are positive to engage and work with the region's network of farmer-based community groups and the region's land managers to encourage the adoption of sustainable land use practices require extension. For example, the furthering of sensor trials in the 2018 Charra Farm Improvement Group Understanding Soil Test project could include linking water-related costing to sensed soil information for better water management on farm (Tingey-Holyoak et al., 2019, in press). Sensors around the dam can also assist detecting leakage and minimising resulting inefficiencies, including erosion, oxygen depletion and nitrogen loss in soils nearby the dam, and also give advance dam break warning.

- *Socio-economic factors*, specifically farmers operating in low income regions, were a predictor of a defiant or highly resistant response in the WET Model. The underpinning attitudes reveal that farmers in the Eyre Peninsula were most likely to report positive productivity change, the main aim to maximise return, and appointing a successor for the farm compared to farmers in Adelaide and MLR who were also more likely to need to seek off-farm income. This potentially indicates the increased likelihood of a defiant response from the Adelaide and MLR region compared to Eyre Peninsula. Yet both regions' farmers report that they would benefit the most from water management funding from government.

4.3.2 Preliminary guidance

In light of the above results, the following preliminary policy guidance points emerge *for water storage management* for safe and healthy farming communities based on the integrated findings from key experts consulted and farmer samples surveyed:

1. **Sustainable and safe dam management education and awareness programs.**

- **Example actions:** Establishment of a sustainable and safe dam management committee or group to function through consulting and co-operating with dam owners, that makes priority provision for dam management owner education and guidance through publications, manuals, and YouTube resources on the various aspects of dam safety management. For example:
    - Development of a sustainable and safe dam management library of Information sheets (see Pisaniello and Tingey-Holyoak, 2016).
    - Disseminate library through publication of a website resource, including information and articles in Departmental and other publications (see DPIWE, 2003; 2004; 2005).
    - Department providing further encouragement via mechanisms such as extension agents with specialised skills, subsidies, or making available cost-effective dam review/design technologies – per preliminary Guidance # 2 (Pisaniello and Tingey-Holyoak, 2016).

2. Subsidised or incentivised on-farm technology and efficiency improvements.

- **Example actions:** As part of increased sustainable and safe dam management education and awareness, could pilot a water storage management improvement program on a prioritised regional basis using a multi-sectoral approach especially in regions such as Adelaide and Mount Lofty Ranges and Eyre Peninsula that subsidises or incentivises use of tools such as:
    - Sensors for minimising or to eliminate dam cracking and piping, erosion of side slopes, inlets and outlets which are issues that affect equity and safety of dam water for irrigation (Pisaniello et al., 2012, Pisaniello and Tingey-Holyoak, 2017a). Sensed soil information not only proves to be highly beneficial for water productivity improvement initiatives, (Tingey-Holyoak and Pisaniello, 2015; Tingey-Holyoak et al., 2019 in press)[14], but also placed around dams to provide piping and cracking and other leakage hotspots (e.g. TheLeadSA, 2017).
    - Encouragement of more wide-spread low flow bypass installation to increase the rate of adoption in appropriate regions, such as those in Eastern and Western MLR and Marne Saunders and the 500 low-flow water devices under the Flows for the Future program. With many farmers surveyed by this project prioritising environmental issues for their farm management, and also understanding of why low-flows are needed, it is possible that there is increasing widespread interest in low-flow bypasses than when the Flows for the Future project was established. However incentives will be required as encouragement, such as temporary water discounts.
    - Spillway capability checking and/or use of design tool[15] developed by Pisaniello (2009; 2010; 2015). Adoption of the tool provides many important benefits and importantly minimises costs to dam owners due to its ease of application. For example, consulting an engineer to undertake equivalent modern flood capability modelling and analysis can cost up to AU$10,000; the tool can reduce this fee significantly (Pisaniello and McKay, 2007). Using simple on-site input parameters such a tool can be selectively varied by the user to satisfy not only flood capability, but also other practical on-site factors, e.g. maximum storage allowed by the region's water sharing/equity policy or a farmer's minimum storage requirements for irrigation and fitting the spillway into the physical constraints of the valley with minimal excavation (see Pisaniello, 2015).

3. Alternative program funding sources. To manage dams equitably and safely and realise on-farm improvements using technology such as low flow bypasses, spillway capability tools and sensing, it can cost from the low thousands to millions and so consideration of alternative financing streams is required for the longer term.

[14] Recent project work from the UniSA investigation team in collaboration with sensing and grower industry partnerships demonstrates that SA's primary producers are demanding strategies and tools to assist in monitoring water use with a view to improving physical and financial productivity. Farm accounting systems, if present, lack the sophistication to allow growers to analyse the use, loss and productivity of water to identify areas of potential water savings. Also, emerging farm technologies do not readily link to business systems to provide the optimal real-time financial decision making data. Findings of desk-based technology benchmarking suggest best-practice elements required include production 'hotspot' identification and real-time sensory data integration that allows for strategic allocation to all direct and indirect water use drivers. Under this project, recent key actor interviews and producer demand surveys highlight demand exists for a cost-effective integrated water productivity tool, especially in regions where there is a large proportion of irrigated farming. Emerging results of an irrigated potato case study allow for preliminary demonstration of how the crucial link can be made between producers' business systems and resource technology.

[15] It should be noted that whilst checking of dam spillways alone as a mechanism for safety assurance can work in certain circumstances, it is risky if not supported by some level of policy, such as maintaining an accurate register of dams and providing guidelines to educate owners about their responsibilities, hence the inclusion of Preliminary Guidance # 1 (Pisaniello et al., 2012).

- **Example action**. NRM program that uses funding pursued in collaboration with DCSI to issue green bonds for improved water storage management. In the US there are green bond programs run by several states (ASDSO, 2016)[16]. Data from SA indicates funding would be beneficial for water storage management improvements in receptive regions, such as Adelaide and MLR and Eyre Peninsula, and the investment could be from the national level directed through local agencies in the form of green bonds for specific equitable water storage improvements (OECD, 2009)[17] from which the farmer can repay long-term based on improvements in productivity resulting from improved water management.

4. **Target support initially in low-income farming regions** with focus on improvements in such regions

- **Example action:** DEWNR working with DCSI and other NFPs working in regional and rural South Australia on joint agency approaches that consider both sustainable communities and sustainable water by more closely considering differences between revenue generating potential of some dams (e.g. large corporatized commercial grower vs family farm low income producer). Particularly in parts of Adelaide and MLR and Fleurieu and KI which are most likely to require off-farm income and lack succession plans. Ownership structure creates barriers to investment in equitable on-farm water storage management worldwide, even in countries which pay significant attention to them. For example, 58% of all U.S. dams are privately owned primarily in farming and so produce only on-farm revenue from production and do not technically feedback any funds into dam management schemes, apart from through permits and water licensing (Ingram, 2012). Local and state governments only own about 20% of dams nationwide, and the federal government and public utilities own only a small percentage of this and so water rates and other types of revenue are limited in being able to fund large scale equitable dam management schemes, beyond regular operations and maintenance

[16] Bonds are securities issued by governments, or by utilities and companies, offering a fixed rate of interest for a number of years and full repayment at a specified date. These are currently employed various states in the US, including Pennsylvania where the Department of Environmental Protection have recently enforced an annual permit fee imposed on dam owners to cover a portion of the department's costs to administer the Dam Safety program. The legislation requires private owners of high hazard dams to post a financial guarantee adequate to breach the dam if the owner does not comply with department safety requirements (Wilson, 2014). Those dangerous or very unsustainable dams (e.g. holding significant water above vulnerable users below) that are publicly owned do not have to prove fiscal responsibility and are not subject to annual fees like growers and producers. As the required fiscal guarantee obviously poses a hardship for many private individuals and associations who would be unable to obtain a surety bond to cover the massive costs of rehabilitation, the department introduced a scheme where private owners can provide a certificate of deposit that the department can draw from if the dam fails (Wilson, 2014).

[17] The OECD (2009) defines the 3Ts of sustainable financing:
(i) "tariffs" which are the monies provided through the provision of water and revenues from service users;
(ii) "taxes" which are the monies provided by domestic taxpayers through general government revenues and subsequently diverted to the water sector, commonly referred to as subsidies; and,
(iii) "transfers " which are non-repayable monies provided in the form of grants or in-kind contributions from external sources, such as through Official Development Assistance.
The 3Ts provide a useful tool in helping to unlock an understanding of the sources of the funds which underpin sustainability. The framework disentangles the contributions made by the three sustainable sources of financing (Tariffs, Taxes and Transfers) to distinguish between those monies provided through direct funding by end users, indirect funding from governments or their agencies, and funding from private sources of finance. At the operational level, it needs to be noted that dams have long lifespans, and face ongoing asset degradation and funding must therefore be sustainable over longer than short bursts. Particularly for equitable water storage management, the 3Ts are not simple to apply, particularly because it is challenging to prioritise water storage when public budgets are limited and taxes generally get subsumed by general budgets. Furthermore, when taxation systems are involved, there can be increased competition from water supply and hydropower sectors and more powerful stakeholders who argue the economic case for farm dams is not well supported (GWP, 2017). That is why green bonds as a form of repayable finance can bridge the financing gap and may come from capital markets, e.g. through the issue of loans, bonds or equities. It should be noted that attracting commercial (repayable) finance for equitable water storage projects depends on good prospects for the future flows of basic revenues from the 3Ts (GWO, 2017). Commercial finance tools such as loans, bonds and equity cannot substitute for the absence of some basic revenues from 3Ts which are needed for future debt and equity service payments.

(ASDSO, 2016; ASCE, 2017). For example, at the federal level a mechanism like the Farm Household Allowance via the Federal Government (DAWR, 2018) could be extended to include water storage criteria.

5. Conclusion

This project proposed to improve the sustainability of SA's farming families by delivering policy guidance on elements of policy that could enhance sustainable and safe farm dam management, including education. Through three project phases the project derives theoretically underpinned new knowledge on how SA farmers do, can and should respond to unsustainable and unsafe water storage in dams. Advancement of the Water Equity Typology allows for understanding the decision making and behaviour of farmers with respect to their dams at a time when the number of farmers facing threats to their water security and who are subsequently at risk of leaving the land due to infrastructure failure is increasing.

Through key expert advice and farmer surveys it was possible to gain improved understanding of the threats of unsustainable water sharing, including increasing impacts from climate change, perceptions of policy complexity, and farmer failure to be competitive in a region or industry. Results indicate that farmers are capable of adapting quickly to new water storage demands and can improve regional water sharing and contribute toward greater water security for their communities.

Generally, new program mechanisms that support education and awareness, technology and also focus on socio-economically disadvantaged regions can allow for improved understanding of regional water sharing and contribute to greater water security for farming communities. Specifically, regionally-focussed programs that introduce sustainable and safe dam management and maintenance education and awareness, supported by basic dam sensing, spillway capability or low flows technology could reduce drought and flood impacts that create cost burdens for farming families and communities. Furthermore, programs that utilise alternative sustainable funding mechanisms under a multi-agency approach, such as green bonds, that are directed at growers with large potential productivity gains could realise secure and safe water storage for catchments more widely in order to sustain SA's farming communities.

6. References

ABC NEWS RURAL. (2017). Dry season gamble for Eyre Peninsula farmers, 2 June. Available at: https://www.abc.net.au/news/rural/2017-06-02/dry-season-gamble-for-sa-farmers/8580636.

ABS. (2007). *Water in Australia.* 4613.0 - Australia's Environment: Issues and Trends 2007.

ABS. (2011). *Measures of Socioeconomic Status*, Australian Bureau of Statistics, Information Paper, 1244.0.55.001, available at: http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/367D3800605DB064CA2578B60013445C/$File/1244055001_2011.pdf.

ALCORN M. (2009). *Impact of farm dams on streamflow in the Big Swamp and Little Swamp catchments, Eyre Peninsula*, DWLBC Report 2009/26, Department of Water, Land and Biodiversity Conservation Government of South Australia.

ALON, A. & DWYER, P.D. (2014). Early adoption of IFRS as a strategic response to transnational and local influences. *The international journal of accounting* 49(3), pp.348-370.

AMLRNRMB. (2014). *Surface water*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/adelaidemtloftyranges/water/managing-water/surface-water

AMLRNRMB. (2018a). *Climate Change in the Region*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/adelaidemtloftyranges/about-us/climate-change-in-the-region

AMLRNRMB. (2018b). *Water allocation planning*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/adelaidemtloftyranges/water/water-planning/water-allocation-planning

AMLRNRMB. (2018c). *Water affecting activities*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/adelaidemtloftyranges/water/managing-water/water-affecting-activities

AMLRNRMB. (2018d). *Permits for water affecting activities*, Government of South Australia, available at: https://www.naturalresources.sa.gov.au/adelaidemtloftyranges/water/managing-water/water-affecting-activities/permits-for-water-affecting-activities

AMLRNRMB. (2018e). *Frequently asked questions answered*, Government of South Australia. Viewed 14 January 2019, https://www.naturalresources.sa.gov.au/adelaidemtloftyranges/about-us/nrm-water-levy/frequently-asked-questions

ANRA. (2009). Landuse Change, Productivity and Development - Recent Land Use Changes (1983-1997). Australian Natural Resource Atlas, available at: http://www.anra.gov.au/topics/land/pubs/landuse/landuse-changes97.html#sec3_4.

ASDSO. (2016). *Top issues facing dam community*, ASCE, available at: https://damsafety.org/top-issues-facing-dam-community

ASCE. (2017). *Infrastructure report card*, ASCE, available at: https://www.infrastructurereportcard.org/wp-content/uploads/2017/01/Dams-Final.pdf

BANSAL, P. (2005). Evolving sustainably: A longitudinal study of corporate sustainable development. *Strategic Management Journal* 26(3), 197-218

BANSAL P. & CLELLAND I. (2004). Talking trash: legitimacy, impression management, and unsystemic risk in the context of the natural environment. *Academy of Management Journal* 47, 93–103.

BANSAL, P. & ROTH, K. (2000). Why companies go green: A model of ecological responsiveness. *Academy of Management Journal* 43(4), 717-736.

BARNEY J.B. (1991). Firm resources and sustained competitive advantage. *Journal of Management* 17(1), 99–120.

BEER, A., TUALLY, S., KROEHN, M., MARTIN, J., GERRITSEN, R., TAYLOR, M., GRAYMORE, M. & LAW, J. 2014. Climate Change and the Future of Australia's Country Towns, in Palutikoff, J. et al. (eds), *Applied Studies in Climate Adaptation*, Wiley, Oxford.

BERGMANN, A., STECHEMESSER, K. AND GUENTHER, E. (2016). Natural resource dependence theory: Impacts of extreme weather events on organizations. *Journal of Business Research* 69(4), pp.1361-1366.

BERGKVIST, L., & ROSSITER, J. R. (2007). The predictive validity of multiple-item versus single-item measures of the same constructs. *Journal of marketing research* 44(2), 175-184.

BJORNLUND, H. (2004). Formal and informal water markets: Drivers of sustainable rural communities?. *Water resources research*, 40(9).

BOM. (2019a). *Drought,* Australian Government. Available at: http://www.bom.gov.au/climate/drought/

BOM. (2019b). Australian Landscape Water Balance, BoM, available at: http://www.bom.gov.au/water/landscape/#/sm/Actual/day/-36.85/139.85/8/Point/Separate/-36.85/139.85/2018/12/4/

BRITO, L. A. L., BRITO, E. P. Z., & HASHIBA, L. H. (2014). What type of cooperation with suppliers and customers leads to superior performance? *Journal of Business Research* 67(5), 952-959.

BROOKS, R., & HARRIS, E. (2008). Efficiency gains from water markets: Empirical analysis of Watermove in Australia. *Agricultural Water Management* 95(4), 391-399.

CAMPBELL, J. L. (2007). Why would corporations behave in socially responsible ways? An institutional theory of corporate social responsibility. *Academy of management Review* 32(3), 946-967.

CARSON, R. T., & GROVES, T. (2007). Incentive and informational properties of preference questions. *Environmental and resource economics* 37(1), 181-210.

CARY, J., BARR, N., ASLIN, H., WEBB, T. & KELSON, S. (2001). *Human and Social Aspects of Capacity to Change to Sustainable Management Practices: Combined Report for the National Land and Water Resources Audit Theme 6 Projects 6.2.2 and 6.3.4*, Bureau of Rural Sciences.

CASHORE, B., & VERTINSKY, I. (2000). Policy networks and firm behaviours: Governance systems and firm reponses to external demands for sustainable forest management. *Policy sciences* 33(1), 1-30.

CLARK R., TEOH K. & KOTZ S., 2007, Surface Water Assessment for the Southern Fleurieu Region, DWLBC Report 2009/05, Department of Water, Land and Biodiversity Conservation, Government of South Australia. Available at: https://www.waterconnect.sa.gov.au/Content/Publications/DEW/FIN_SW%20Fleurieu%20Report%20JMS-EP_2009-05.PDF

CLEAVER, F. (2002). Reinventing institutions: Bricolage and the social embeddedness of natural resource management. *The European journal of development research* 14(2), 11-30.

CLEMENS, B., BAMFORD, C. E., & DOUGLAS, T. J. (2008). Choosing strategic responses to address emerging environmental regulations: Size, perceived influence and uncertainty. *Business Strategy and the Environment* 17(8), 493-511.

CLEMENS, B.W., & DOUGLAS, T.J. (2005). Understanding strategic responses to institutional pressures. *Journal of Business Research* 58(9), 1205-1213.

CLEMENS, B., & DOUGLAS, T. J. (2006). Does coercion drive firms to adopt 'voluntary' green initiatives? Relationships among coercion, superior firm resources, and voluntary green initiatives. *Journal of Business Research* 59(4), 483-491.

CLIMATE CHANGE IN AUSTRALIA (n.d.). *Projections for Australia's NRM regions*. Available at: https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/clusters/?current=SSWS&tooltip=true&popup=true

CORTINA, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of applied psychology* 78(1), 98.

COSTELLO, A. B., & OSBORNE, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical assessment, research & evaluation* 10(7), 1-9.

CRASE, L. (2008). Introduction. In L.Crase (Ed.), *Water Policy in Australia: The Impact of Change and Uncertainty*, Washington DC: Resources for the Future, Washington DC, 1-16.

CRUZ-CASTRO, L. & SANZ-MENENDEZ, L. (2015). Policy change and differentiated integration: implementing Spanish higher education reforms. *Journal of Contemporary European Research* 11(1).

CSIRO and BoM. (2018). *State of climate*, Commonwealth Scientific and Industrial Research Organization/Australian Bureau of Meteorology, available at: https://www.csiro.au/en/Research/OandA/Areas/Assessing-our-climate/State-of-the-Climate-2018/Report-at-a-glance

DAWR. (2019). Farm Household Allowance, Australian Government, available at: http://www.agriculture.gov.au/ag-farm-food/drought/assistance/farm-household-allowance.

DEW. (2018). *Securing low flows in the Mount Lofty Ranges,* Government of South Australia. Available at: https://www.environment.sa.gov.au/managing-natural-resources/water-resources/planning/securing-low-flows

DEWNR. (2013). *Non-prescribed Surface Water Resources Assessment – Kangaroo Island Natural Resources Management Region*, Government of South Australia. Available at: https://www.waterconnect.sa.gov.au/Content/Publications/DEW/KI_NRM_Region_Non-prescribed_Surface_Water_Resources_Assessment_2013.pdf

DEWNR. (2016). *Western Mount Lofty Ranges Prescribed Water Resources Area: 2016 Surface water status report*, Government of South Australia. Available at: https://www.waterconnect.sa.gov.au/Content/Publications/DEW/WMLR_2016.pdf

DEVELOPMENT ACT 1993 (SA)

DIMAGGIO, P. & POWELL, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organization fields. *American Sociological Review* 48, 147-160.

DPIWE (2003). Making Dams Safe for Everyone, Tas-regions Dept of Primary Industries, Water and Environment, Tasmania, 9(1),16-17.

DPIWE (2004). Guidelines to Assess Applications for New Water Allocations from Watercourses During Winter, Department of Primary Industries, Water and Environment, Tasmania, Policy #2003/1.

DPIWE (2005). Report on the Operation of the Water Management Act 1999. Dept of Primary Industries, Water and Environment, Tasmania, Report by Water Resources Division, May 2005.

EDWARDS, B., GRAY, M., & HUNTER, B. 2015. The impact of drought on mental health in rural and regional Australia. *Social Indicators Research* 121(1), 177-194.

EPNRMB. (2009). *Natural Resources Management Plan for the Eyre Peninsula Natural Resources Management Region*, Volume 2: Caring for our Resources - NRM behavioural change framework for Eyre Peninsula, Government of South Australia.

EPNRMB. (2011). *Farm dams – a guide to siting, design, construction and management on Eyre Peninsula*, Government of South Australia. Available at: http://www.naturalresources.sa.gov.au/files/9c982cb6-e8e5-419e-9014-a39600b8cb59/farm-dams-fact.pdf

EPNRMB. (2016a). *Adapting to a changing climate*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/eyrepeninsula/projects-and-partners/climate-change

EPNRMB. (2016b). *Water Allocation Plan for the Southern Basins and Musgrave Prescribed Wells Areas*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/eyrepeninsula/land-and-water/water-allocation-plan-new

EPNRMB. (2017). *Water Security,* Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/eyrepeninsula/land-and-water/managing-water-resources/water-security

EPNRMB. (2018a). Water affecting activities, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/eyrepeninsula/land-and-water/water-affecting-activities

EPNRMB. (2018b). *Future water security*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/eyrepeninsula/land-and-water/sustainable-agriculture/future-water

ETHERINGTON, L.D. & RICHARDSON, A.J. (1994). Institutional pressures on university education in Canada. *Contemporary Accounting Research*, Special Education Research Issue, 141-162

FAREED, N., BAZZOLI, G.J., MICK, S.S.F. & HARLESS, D.W. (2015). The influence of institutional pressures on hospital electronic health record presence. *Social Science & Medicine 133*, pp.28-35.

FAZZI, L. (2010). Social co-operatives and social farming in Italy. *Sociologia Ruralis* 51 (2), 119–136.

FIELD, A. (2009). *Discovering statistics using SPSS*. Sussex: Sage Publications Limited.

FOGDEN, A. (2010), Drought forces innnovation for SA dairyfarmers. *Stock Journal*. 17 Dec 2010 available at: https://www.stockjournal.com.au/story/3648994/drought-forces-innnovation-for-sa-dairyfarmers/.

FOWLER, K.J.A. & MORDEN, R.A. (2009). Investigation of strategies for targeting dams for low flow bypasses, *32nd Hydrology and Water Resources Symposium*, Newcastle : Adapting to Change, Engineers Australia, Barton.

GANZ, M. (2000). Resources and resourcefulness: Strategic capacity in the unionization of California agriculture, 1959-1966. American Journal of Sociology 105(4), 1003-1062.

GARNAUT, R. (2008). *The Garnaut Climate Change Review*, Cambridge, Cambridge.

GAO, Y. & HAFSI, T., 2017. Political dependence, social scrutiny, and corporate philanthropy: Evidence from disaster relief. *Business Ethics: A European Review* 26(2), 189-203.

GIWR. (2015a). *SA Climate Ready Climate projections for South Australia: Adelaide and Mt Lofty Ranges*, Goyder Institute for Water Research. Available at: http://www.goyderinstitute.org/_r210/media/system/attrib/file/201/SA%20Climate%20Ready%20Regional%20Summary%20-%20AMLR.pdf.

GIWR. (2015b). *SA Climate Ready Climate projections for South Australia: Eyre Peninsula*, Goyder Institute for Water Research. Available at: http://www.goyderinstitute.org/_r211/media/system/attrib/file/202/SA%20Climate%20Ready%20Regional%20Summary%20-%20EP.pdf.

GIWR. (2015c). *SA Climate Ready Climate projections for South Australia: South East*, Goyder Institute for Water Research. Available at: http://www.goyderinstitute.org/_r215/media/system/attrib/file/206/SA%20Climate%20Ready%20Regional%20Summary%20-%20SE.pdf.

GOODSTEIN, J.D. (1994) Institutional pressures and strategic responsiveness: Employer involvement in work-family issues. *Academy of Management Journal* 37, 350-382.

GOVERNMENT OF SOUTH AUSTRALIA PREMIER'S CLIMATE CHANGE COUNCIL (PCCC). (2013). *South Australia's Climate Change Vision: Pathways to 2050,* Government of South Australia, Adelaide.

GREINER, R., FERNANDES, L., MCCARTNEY, F., & DURANTE, J. (2016). Reasons why some irrigation water users fail to comply with water use regulations: A case study from Queensland, Australia. *Land Use Policy 51, 26-40.*

GUO, H., XU, E., & JACOBS, M. (2014). Managerial political ties and firm performance during institutional transitions: An analysis of mediating mechanisms. *Journal of Business Research* 67(2), 116-127.

GWP. (2017). *Repayable sources of finance for water (A3.04),* GWP, available at: http://www.gwp.org/en/learn/iwrm-toolbox/The-Enabling-Environment/Investment-and-Financing-Structures/Repayable-sources-of-finance-for-water/

HARDESTY, D. M., & BEARDEN, W. O. (2004). The use of expert judges in scale development: Implications for improving face validity of measures of unobservable constructs. *Journal of Business Research* 57(2), 98-107.

HARDING C. (2014). *Development of conceptual models of wetland and drain systems to support water policy and planning in the South East NRM region*, DEWNR Technical note 2014/23, Department of Environment, Water and Natural Resources, Government of South Australia. Available at: https://www.waterconnect.sa.gov.au/Content/Publications/DEW/DEWNR-TN-2014-23.pdf

INGRAM, E. (2012) Dam safety: Hot topics in Dam Safety, Hydroworld, 9th January 2012.

INGRAM, P. & SIMONS, T. (1995). Institutional and resource dependence determinants of responsiveness to work–family issues. *Academy of Management Journal* 38, 1466-1482

JARVIS, C., BARLOW, E., DARBYSHIRE, R., ECKARD, R. AND GOODWIN, I. (2017). Relationship between viticultural climatic indices and grape maturity in Australia. *International Journal of Biometeorology* 61(10), 1849-1862.

JENKIN, C. (2007). Dairy up to third of producers have had enough - Drought sours milk industry for farmers, *Advertiser*.

JENNINGS, P.D. & ZANDBERGEN, P.A. (1995). Ecologically sustainable organizations: An institutional approach. *The Academy of Management Review* 20 (4), 1015-1052.

Jones, E. (2018). Pitching in for bush as drought starts to bite. *Sunday Mail*.

JONES D.A., WANG W. & FAWCETT R. (2009). High-quality spatial climate data-sets for Australia. *Australian Meteorological and Oceanographic Journal* 58, 233–248.

KINRMB. (2017a). *Kangaroo Island Natural Resources Management Plan 2017 – 2027 (Volume A – Strategic Plan 2017–2027),* Government of South Australia

KINRMB. (2017b). *Kangaroo Island Water Resources Management Policy: Water Affecting Activities (Volume B: Business Plan 2017–2020*), Government of South Australia.

KINRMB. (2017c). *Water management on Kangaroo Island FAQ*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/kangarooisland/land-and-water/water-management/water-affecting-activities.

KINRMB. (2018a). *Private dam maintenance and management in emergencies,* Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/kangarooisland/land-and-water/water-management/Private_dam_maintenance_and_management_in_emergencies.

KINRMB. (2018b). *Climate change,* Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/kangarooisland/about-us/our_regions_plan/climate-change.

KINRMB. (2018c). *NRM Levy,* Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/kangarooisland/about-us/nrm-levy.

LAND & WATER AUSTRALIA. (2008). *Farm Dam Management* (Updated March 9th, 2010), Australian Government. Available at: http://lwa.gov.au/node/2640

LANKFORD, B. (2012). Fictions, fractions, factorials and fractures: on the framing of irrigation efficiency. *Agricultural Water Management* 108, 27-38.

LAVERY, B., JOUNG, G. AND NICHOLLS, N. (1997). An extended high-quality historical rainfall dataset for Australia. *Australian Meteorological Magazine* 46(1), 27-38.

LEE S, NAPIER G, & PEARCE M. (2007). *Low flow bypass trial in the Marne catchment*, Flinders University, Poster paper.

LEWIS, B. (2002). Farm *dams: planning, construction and maintenance*. Landlinks Press.

LIDDICOAT, C. CIGANOVIC, P., SINDICIC, M. & WRIGHT, S. (2011). *Farm Dams: a guide to siting, design, construction and management on Eyre Peninsula*, Rural Solutions SA on behalf of the EPNRMB, Port Lincoln.

LINDELL, M. K., & WHITNEY, D. J. (2001). Accounting for common method variance in cross-sectional research designs. *Journal of applied psychology* 86(1), 114.

LOUGH, J.M. (1997). Regional indices of climate variation: temperature and rainfall in Queensland, Australia. *International Journal of Climatology* 17(1), 55-66.

LUNDSTROM G., (2008). *Farm dam salinity audit of the Eastern Mount Lofty Ranges South Australia*, South Australian Murray-Darling Basin Natural Resources Management Board.

LYNGGAARD, K.S.C. (2002). The farmer within an institutional environment. Comparing Danish and Belgian organic farming. *Sociologia Ruralis* 41(1), 85–111.

MALONI, M. J., & BROWN, M. E. (2006). Corporate social responsibility in the supply chain: an application in the food industry. *Journal of business ethics* 68(1), 35-52.

MATELL, M. S., & JACOBY, J. (1972). Is there an optimal number of alternatives for Likert-scale items? Effects of testing time and scale properties. *Journal of Applied Psychology* 56(6), 506.

MCMURRAY, D. (2006). *Impact of farm dams on streamflow in the Tod River Catchment, Eyre Peninsula South Australia*, DWLBC Report 2006/22, Adelaide.

MCMURRAY D. (2007). *A risk assessment of the impact of farm dams on streamflow in catchments on Kangaroo Island,* DWLBC Technical Note 2007/16, Department of Water, Land and Biodiversity Conservation, Government of South Australia.

MEYER, J.W. & ROWAN, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology* 83,. 340-363.

MEYER, J.W., SCOTT, W.R. & DEAL, T.E. (1983). Institutional and technical sources of institutional structure: Explaining the structure of educational organizations, in J.W. Meyer, W.R. Scott (Eds.), *Organizational environments: Ritual and rationality*, Sage, Beverly Hills, 45-67

MOLDEN, D., OWEIS, T. STEDUTO, P., BINDRABAN, P., HANJRA, M.A. & KIJNE, J. (2009). Improving agricultural water productivity: between optimism and caution. *Agricultural Water Management* 97, 528-535.

NATHAN, R.J., JORDAN, P. AND MORDEN, R. (2005). Assessing the impact of farm dams on streamflows, Part I: Development of simulation tools. *Australian Journal of Water Resources* 9(1), 1-12.

NATURAL RESOURCES MANAGEMENT ACT 2004 (SA)

Neuman, W. L. (2006). *Social research methods: Qualitative and quantitative approaches*. New York: Pearson Education Inc.

NFF. (2012). *Farm Facts 2012.* Barton: National Farmers' Federation Ltd.

NRM. (2018a). *Surface water*, Natural Resources, available at: <https://www.naturalresources.sa.gov.au/adelaidemtloftyranges/water/managing-water/surface-water>.

NRM. (2018b). *Water affecting activities*, available at: <https://www.naturalresources.sa.gov.au/southeast/water-and-coast/water-affecting-activities>.

NUNNALLY, J.C. AND BERNSTEIN, I.H. (1994). The Assessment of Reliability. *Psychometric Theory* 3, 248-292.

OLIVER, C. (1991). Strategic responses to institutional processes. *Academy of Management Review* 16, 145–179.

OECD. (2013). *Water: Governments must deal with rising risks*, OECD, available at: http://www.oecd.org/development/water-governments-must-deal-with-rising-risks.htm.

OECD. (2009). *Managing Water For All: An OECD Perspective On Pricing And Financing*, OECD, available at: http://www.oecd.org/env/resources/managingwaterforallanoecdperspectiveonpricingandfinancing.htm

PATRICK, M. J., SYME, G. J., & HORWITZ, P. (2014). How reframing a water management issue across scales and levels impacts on perceptions of justice and injustice. *Journal of Hydrology* 519, 2475-2482.

PATTERSON, P., YU, T., & KIMPAKORN, N. (2014). Killing two birds with one stone: cross-selling during service delivery. *Journal of Business Research* 67(9), 1944-1952.

PFEFFER, J., AND SALANCIK, G.R. (1978). *The external control of organizations: A resource dependence perspective*. New York: Harper & Row.

PFEFFER, J., & SALANCIK, G.R. (2003). *The external control of organizations: A resource dependence perspective*. Stanford University Press.

PIRSA. (2018a). *PIRSA Crop and Pasture Summary: Issue 4 Spring Crop Performance – November 2018,* Government of South Australia. Available at: http://www.pir.sa.gov.au/__data/assets/pdf_file/0010/335962/Crop_and_Pasture_Summary_-_Spring_Crop_Performance.pdf.

PIRSA. (2018b). *Dry Conditions Working Group*, Government of South Australia. Available at: http://www.pir.sa.gov.au/__data/assets/pdf_file/0007/336841/Communique_Dry_Conditions_Working_Group_November2018.pdf.

PIRSA. (2019). *Current Outlook*, Government of South Australia. Available at: http://www.pir.sa.gov.au/grants_and_assistance/drought_support/outlook.

PISANIELLO, J.D. (2009). How to manage the cumulative flood safety of catchment dams. *Water SA* 35(4), 361-370.

PISANIELLO, J.D. (2010). Attitudes and policy responses to Australian farm dam safety threats: comparative lessons for water resources managers, *International Journal of Water Resources Development* 26(3), 381-402.

PISANIELLO, J.D. (2015). Helping farmers and regulators manage and assure the cumulative flood safety of agricultural dams: a cost-effective regionalised review/design tool from Australia. *Hydrology Research* 47(5), 996-1013.

PISANIELLO, J.D. & TINGEY-HOLYOAK, J.L. (2016) Pilot project on flood risk and dam safety in South Australia, Department of Environment, Water and Natural Resources (DEWNR), 11 March 2016, UniSA Project No. PG 083070.

PISANIELLO, J. & TINGEY-HOLYOAK, J. (2017a). Water storage equity and safety assurance policy to mitigate potential 'dual-extreme cumulative threats' in agricultural catchments. *Journal of Hydrology* 545, 55–71.

PISANIELLO, J. & TINGEY-HOLYOAK, J. (2017b). How to achieve best-practice integrated land-use and safety assurance policy for hazardous on-farm water storage. *Land Use Policy* 62, 268-279.

PISANIELLO, J. D., & TINGEY-HOLYOAK, J. L. (2017c). Growing community developments causing 'hazard creep' downstream of farm dams–A simple and cost-effective tool to help land planners appraise flood safety. *Safety science* 97, 58-72.

PISANIELLO, J.D., DAM, T.T. AND TINGEY-HOLYOAK, J.L. (2015). International small dam safety assurance policy benchmarks to avoid dam failure flood disasters in developing countries, Journal of Hydrology, 531(3),1141 – 1153.

PISANIELLO, J.D. AND MCKAY J.M. (2007). A Tool to Aid Emergency Managers and Community in Private Dam Safety Appraisal, Disasters. International *Journal of Disaster Studies, Policy and Management* 31(2), 176-200.

PISANIELLO, J., TINGEY-HOLYOAK, J. & BURRITT, R. (2012). Appropriate small dam management for minimising catchment-wide safety threats: International benchmarked guidelines and demonstrative cases studies from Australia. *Water Resources Research* 48.

PODSAKOFF, P.M., MACKENZIE, S. B., LEE, J.Y., & PODSAKOFF, N.P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of applied psychology* 88(5), 879.

RANSOM, E. (2007). The rise of agricultural animal welfare standards as understood through a neo-institutional lens. *International Journal of Sociology of Food and Agriculture* 15(3), 26-44.

RAO, V. & WOOLCOCK, W. (2003) Integrating Qualitative and Quantitative Approaches in Program Evaluation, in Francois J. Bourguignon and Luiz Pereira da Silva (eds.) *The Impact of Economic Policies on Poverty and Income Distribution: Evaluation Techniques and Tools* New York: Oxford University Press, 165-90.

RESILIENT HILLS AND COASTS. (2015). *Climate change projections for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island*. A report prepared for Alexandrina Council on behalf of project partners by Seed Consulting Services. Available at: https://www.alexandrina.sa.gov.au/webdata/resources/files/Resilient%20Hills%20and%20Coasts%20climate%20projections%20report%20Feb%202016_static.pdf.

RESILIENT HILLS AND COASTS. (2016). *Resilient Hills and Coasts: Climate Change Adaptation Plan for the Adelaide Hills, Fleurieu Peninsula and Kangaroo Island Region.* A report prepared for Alexandrina Council on behalf of Resilient Hills and Coasts project partners by Seed Consulting Services and URPS. Available at: https://www.kangarooisland.sa.gov.au/webdata/resources/files/RH&C%20adaptation%20plan_Final%20low.pdf.

RIVERA-CAMINO, J. (2012). Corporate environmental market responsiveness: A model of individual and organizational drivers. *Journal of Business Research* 65(3), 402-411.

ROBINS, L., & DOVERS, S. (2007). Community-based NRM boards of management: are they up to the task? *Australasian Journal of Environmental Management* 14(2), 111-122.

ROBINSON, W.S. (1950) Ecological correlations and the behaviour of individuals. *American Sociological Review* 15(3), 351-357.

SA GOVERNMENT. (2013). *Agriculture and NRML Working together 2013-2014*. Natural Resources Management Council, Natural Resources Management Boards of South Australia, Department of Environment, Water and Natural Resources, Department of Primary Industries and Regions SA, Adelaide, available at: https:// www.environment.sa.gov.au%2Ffiles%2Fsharedassets%2Fpublic%2Fnrm%2Fagriculture-and-nrm-action-plan.pdf&usg=AOvVaw1vWXLG_bl7VeKh4QHdZYUj.

SALKIND, N.J. (1997). *Exploring research* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

SAMDBNRM. (2017). *About Low Flows*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/samurraydarlingbasin/water/flows-for-future/about-low-flows.

SAMDBNRM. (2018). *Securing low flows in the Mount Lofty Ranges*, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/samurraydarlingbasin/projects/all-projects-map/low-flows.

SAMDBNRM. (n.d.a). *About Southern Fleurieu,* Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/samurraydarlingbasin-rap/Subregions/Southern-Fleurieu/sf-find-out-more.

SAMDBNRM. (n.d.b). *Southern Fleurieu,* Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/samurraydarlingbasin-rap/Subregions/Southern-Fleurieu/sf-find-out-more.

SA WATER. (2008). *SA Water's long-term plan for Eyre Region*, Government of South Australia. Available at: https://www.sawater.com.au/__data/assets/pdf_file/0020/55262/Eyre-Region-Long-Term-Plan.pdf.

SA WATER. (2018). *Kangaroo Island Long-term Plan 2018 – 2043*, Government of South Australia. Available at: https://www.sawater.com.au/__data/assets/pdf_file/0005/322799/KI-Long-term-Plan_FINAL.pdf.

SAVADAMUTHU, K. (2007). *Surface Water Assessment of the Upper Angas Sub-catchment*, Dept of Water, Land and Biodiversity Conservation. DWLBC 2006/09.

SCOTT, W.R. (1987). The adolescence of institutional theory. *Administrative Science Quarterly* 32, 493-511

SENRMB. (2010). Regional Natural Resources Management Plan, Part Two: Strategic Plan, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/southeast/about-us/our-regions-plan/our-current-plan.

SENRMB. (2014). *Water and Coast,* Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/southeast/water-and-coast.

SENRMB. (2017a). Amended South East Natural Resources Management Plan, Part Four: NRM Policy (February 2010), Government of South Australia. Available at: https://www.mdba.gov.au/sites/default/files/pubs/amended-south-east-natural-resource-management-plan-part-4-feb-10.PDF.

SENRMB. (2017b). Planning for climate change, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/southeast/about-us/our-regions-plan/Planning-for-climate-change.

SENRMB. (2018a). Water affecting activities, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/southeast/water-and-coast/water-affecting-activities.

SENRMB. (2018b). Amendments to WAA Permit Policy, Government of South Australia. Available at: https://www.naturalresources.sa.gov.au/southeast/water-and-coast/water-affecting-activities/amendments-to-WAA-policy.

SHEUARD, N. 1993. Dam Safety Requirements. Proceedings of Conference on Farm Dams hosted by Hydrological Society of South Australia, Hahndorf, April 7, 1993, 43- 46.

SIEBENTRITT M., HALSEY N. & STAFFORD-SMITH M. (2014). *Regional Climate Change Adaptation Plan for the Eyre Peninsula*, Prepared for the Eyre Peninsula Integrated Climate Change Agreement Committee (EPICCA).

SIMMONS, C. (2014). Underground dams the solution to Australia's drought problems, *The Sydney Morning Herald*. <https://www.smh.com.au/opinion/underground-dams-the-solution-to-australias-drought-problems-20140316-34v8m.html>.

SINGHAPAKDI, A., SIRGY, M. J., LEE, D. J., SENASU, K., GRACE, B. Y., & NISIUS, A. M. (2014). Gender disparity in job satisfaction of Western versus Asian managers. *Journal of Business Research* 67(6), 1257-1266.

STRONGPLAN (2017) Water security for farmers in the South East, Liberal South Australia, available at: https://strongplan.com.au/policy/water-security-farmers-south-east/

SULLIVAN, K., HOUGH, C. & THORNE, L. (2018). South Australian Government formally acknowledges drought for first time, *ABC News*. <https://www.abc.net.au/news/rural/2018-09-28/south-australia-government-officially-acknowledges-drought/10317002>.

TABACHNICK, B. G., & FIDELL, L. S. (2007). *Using multivariate statistics*. Allyn & Bacon/Pearson Education.

TASHMAN, P., (2011). *Corporate climate change adaptation, vulnerability and environmental performance in the united states ski resort industry*, PhD thesis, The George Washington University

TASHMAN, P. & RIVERA, J., (2016). Ecological uncertainty, adaptation, and mitigation in the US ski resort industry: Managing resource dependence and institutional pressures. *Strategic Management Journal* 37(7), 1507-1525.

THE LEAD SOUTH AUSTRALIA. (2017). Leak detecting system is a dam good idea, June 26 2017, available at: http://theleadsouthaustralia.com.au/mining-resources/leak-detecting-system-is-dam-good-idea/

TINGEY-HOLYOAK, J. & PISANIELLO, J.D., (2015). The challenge of balanced policy and law for socially responsible water storage management. *Social Responsibility Journal* 11(4), 764-779.

TINGEY-HOLYOAK, J.L. & PISANIELLO, J.D. (2017). Strategic responses to resource management pressures in agriculture: institutional, gender and location effects. *Journal of Business Ethics* 144(2), 381-400

TINGEY-HOLYOAK, J. (2014a). Water sharing risk in agriculture: perceptions of farm dam management accountability in Australia. *Agricultural Water Management* 145, 123-133.

TINGEY-HOLYOAK, J. (2014b). Sustainable water storage by agricultural businesses: strategic responses to institutional pressures. *Journal of Business Research* 67(12), 2590-2602.

TINGEY-HOLYOAK, J.l., PISANIELLOW, J.D., BUSS, P., & WERSEIMA, B. (2019, in press). Development of a cost-effective water productivity accounting tool for agriculture. 22nd *International Farm Management Conference (IFMA22)*, Launceston 3-8 March 2019.

TOLBERT, P.S. & ZUCKER, L.G. (1983). Institutional sources of change in the formal structure of organizations: The diffusion of civil service reform, 1880–1935. *Administrative science quarterly,* 22-39.

UPRS. (2016). *Limestone Coast regional climate change adaptation plan, a report prepared for Regional Development Australia Limestone Coast,* Limestone Coast Local Government Association and the South East Natural Resources Management Board.

VARELA-ORTEGA, C., SUMPSI, J. M., GARRIDO, A., BLANCO, M., & IGLESIAS, E. (1998). Water pricing policies, public decision making and farmers' response: implications for water policy. *Agricultural Economics* 19(1-2), 193-202.

VEJVAR, M., LAI, K.H., LO, C.K. & FÜRST, E.W. (2017). Strategic responses to institutional forces pressuring sustainability practice adoption: Case-based evidence from inland port operations. *Transportation Research Part D: Transport and Environment* 61, 274-288.

WARD, F. A. (2016). Policy Nook: Policy Challenges Facing Agricultural Water Use: An International Look. *Water Economics and Policy* 2(03), 1671003.

WARD, F. A., & MICHELSEN, A. (2002). The economic value of water in agriculture: concepts and policy applications. *Water policy* (5), 423-446.

Water Resources Act (1997) (South Australia)

WEAVER, G.R., TREVINO, L.K. & COCHRAN, P.L. (1999). Integrated and decoupled corporate social performance: Management commitment, external pressures, and corporate ethics practices. *Academy of Management Journal* 42(5), 539-552

WESTBROOK, C. J., D. J. COOPER, AND B. W. BAKER (2006), Beaver dams and overbank floods influence groundwater – surface water interactions of a Rocky Mountain riparian area, *Water Resour. Res*. 42, W06404, doi:10.1029/2005WR004560.

WHEELER, S., ZUO, A., & BJORNLUND, H. (2013). Farmers' climate change beliefs and adaptation strategies for a water scarce future in Australia. *Global Environmental Change* 23(2), 537-547.

WHETTEN, D.A. (1978). Coping with incompatible expectations: An integrated view of role conflict. *Administrative Science Quarterly* 254-271.

WHYALLA NEWS. (2018). Call for farm support, 8 August, Available at: https://www.whyallanewsonline.com.au/story/5573895/call-for-farm-support/.

WIJETHILAKE, C., MUNIR, R. & APPUHAMI, R., (2017). Strategic responses to institutional pressures for sustainability: The role of management control systems. *Accounting, Auditing & Accountability Journal* 30(8), 1677-1710.

WILSON, A. (2014). *Update on PA DEP financial requirements for private dams*, RKRHESS, available at: https://www.rkrhess.com/update-pa-dep-financial-requirements-private-dams/

WISHART, M., S. UEDA, PISANIELLO, J.D., TINGEY-HOLYOAK, J.L., LYON, K. & BOJ GARCIA, E. (2018). Legal and institutional frameworks for dam safety: A comparative global assessment. Key findings and recommendations. *Parallel Workshop of the Technical Committee on Dam Safety (CODS), International Commission on Large Dams (ICOLD) 26th World Congress and 86th Annual Meeting,* Vienna, 2 July 2018.

WOOD G. & WAY D. (2011). *Development of the Technical Basis for a Regional Flow Management Strategy for the South East of South Australia,* DFW Report 2011/21, Department for Water, Government of South Australia. Available at: https://www.waterconnect.sa.gov.au/Content/Publications/DEW/DFW_TR_2011_21.pdf

WOOLCOCK, M. (2009). Toward a Plurality of Methods in Project Evaluation: A Contextualized Approach to Understanding Impact Trajectories and Efficacy. *Journal of Development Effectiveness* 1(1), 1-14.

ZHENG, Q., LUO, Y. AND MAKSIMOV, V., 2015. Achieving legitimacy through corporate social responsibility: The case of emerging economy firms. Journal of World Business, 50(3), pp.389-403.

ZUCKER, L.G. (1987). Institutional theories of organization. *Annual Review of Sociology* 13, . 443-464.

7. Appendices

APPENDIX 7A – KEY EXPERT INTERVIEW GENERAL GUIDANCE

University of South Australia | Business School

ACHIEVING WATER SECURITY FOR SUSTAINABLE FARMING FAMILIES AND COMMUNITIES PROJECT

Key Expert Interview

General Question Guide Only

Ethics Protocol # 200856

(i) **General**[18]

1. What is the biggest threat to water security for your farmer stakeholders?
2. What role do farm dams play in enhancing threats to water security and personal safety for your farming stakeholders?
    3. Do you believe the policies and programs in place to face these threats is currently adequate? If not, how do you think this could be improved?

(ii) **Policy uncertainty (state; effect and response; perception of influence)**[19]

1. In your experience do you believe it is difficult for farmers to determine what the government's position on water management and security in regions is and how it will implement policy?
2. In your experience do you believe that farmers cannot accurately assess the relative impact of various water management and security policy alternatives?
3. Do you think that your farming stakeholders feel confident with the government's response to water management and security generally?
4. Do your farming stakeholders feel confident with the government's response to farm dam policy?

(iii) **Pressures on farmers**[20]

1. Context (industry/community/climate)

(a) Do you believe that your farmer stakeholders are under pressure from their industry to maximize their water stored in dams? For example competitive pressure from other growers, or supply chain pressure from big supermarkets?

(b) Do you believe that your farmer stakeholders are under pressure from their local community to maximize their water stored in dams? For example farmers upstream storing more and so there is a pressure to make sure everyone gets their 'share'?

(c) Do you believe that your farmer stakeholders are under pressure from climate factors to maximize their water stored in dams? For example increasingly long dry periods followed by sudden rains?

(d) Have any of your farmer stakeholders reported dam failure or other dam issues related to climate pressures?

2. Control (policy)

(a) Do you believe that your farmer stakeholders voluntarily manage their dams in a way that improves water security in their regions?

(b) Do you believe that improved farm dam policy would improve regional water security?

(c) If so, can you indicate what elements of water management policy most urgently require improvement?

3. Cause (budgets, financial, networks, social)

[18] Pisaniello & Tingey-Holyoak (2017a; 2017b)
[19] Clemens et al. (2008)
[20] Tingey-Holyoak & Pisaniello (2015)

(a) How do you think that farmers could better be financial supported to and rewarded for improving water security in their regions? For example, incentives for better maintaining dams or government subsidies?
(b) Do you think there is enough awareness amongst farmers about the need to budget for farm dam maintenance?
(c) How do you think that neighbouring farmers could better help each other with their farm dams operations and maintenance to improve regional water security?

4. Constituents (social, institutional dependencies)

(a) Do you believe there are too many farmers in regions who are doing the wrong thing with their water stored in dams to overcome threats to water security?
(b) Do you believe that farmers depend on you to help them with their issues with water policy?

5. Content (decision power, goals)

(a) Do you think the changes in climate are removing farmer water decision making power?
(b) Do you think that farmers believe water management policy at the moment takes away some or all of their decision making power?
(c) Do you believe that farmers who are better connected to the environment make better water management decisions on farm? Do you have any examples?

(iv) Farmer response variables including attitudes and behaviours[21]

1. Do you believe that if farmers are most likely to manipulate or defy pressures from policy makers, such as by trying to actively influence policy or to just dismiss it?
2. Do your farmer stakeholders actively bargain with regulators to try to achieve optimal policy outcomes for their own water management? What about for that of their region?

[21] Tingey-Holyoak (2014b)

APPENDIX 7B – FARMER SURVEY INSTRUMENT

University of South Australia | Business School

ACHIEVING WATER SECURITY FOR SUSTAINABLE FARMING FAMILIES AND COMMUNITIES PROJECT

Farmer Survey

UniSA Ethics Protocol # 200856

Participants need to be

1. landholder,
2. growing agricultural produce of any variety at any commercial scale,
3. owner of at least 1 farm dam.

See recruitment script also

(v) Water security generally[22]

1. What do you think is the biggest threat to water security in your region?
2. What role do farm dams play in enhancing any threats to water security or safety for your farm and family?
3. Do you believe the policies and programs in place to face these threats are adequate? If not, how do you think this could be improved?

(vi) Policy uncertainty (state; effect and response; perception of influence)[23]

PLEASE INDICATE WHETHER YOU AGREE OR DISAGREE WITH THE FOLLOWING STATEMENTS REGARDING YOUR REACTION TO WATER SECURITY POLICY AND FARM DAMS. PLEASE USE THE FOLLOWING 7-POINT SCALE:
1-VERY STRONGLY DISAGREE; 2-STRONGLY DISAGREE; 3-DISAGREE; 4-DON'T KNOW/NOT SURE; 5-AGREE; 6-STRONGLY AGREE
7-VERY STRONGLY AGREE

4. The government's position on water and dam management in my region and how it will implement policy is clear.
5. The policies mean I can control my own water and dam management which has positive benefits for water security in my region.
6. The laws require me to provide too much water for the environment.
7. Water and dam management policy in my region changes too frequently.
8. When water and dam management policy change this is communicated to me clearly.
9. I feel confident with the government's position on water and dam management to ensure water security.
10. I have a say in co-designing policy that suits my farm and the farmers around me.
11. I am satisfied with the conditions of my water license and water access entitlements.
12. I am fearful of enforcement of water and dam management policy by regulators.

(vii) Environmental uncertainty (climate, regional etc)[24]

PLEASE INDICATE WHETHER YOU AGREE OR DISAGREE WITH THE FOLLOWING STATEMENTS REGARDING YOUR REACTION TO ENVIRONMENTAL UNCERTAINTY AND FARM DAMS. PLEASE USE THE FOLLOWING 7-POINT SCALE:
1-VERY STRONGLY DISAGREE; 2-STRONGLY DISAGREE; 3-DISAGREE; 4-DON'T KNOW/NOT SURE; 5-AGREE; 6-STRONGLY AGREE
7-VERY STRONGLY AGREE

13. Rapidly changing climate factors are a significant threat to water management and security in my region.
14. I understand the concept of environmental flows and why low flow bypasses would be needed on dams.
15. I am worried about the future of water availability to continue my farming operations.
16. I am under pressure to be more productive with my water use on farm.

[22] Pisaniello & Tingey-Holyoak (2017a; 2017b)
[23] Clemens et al. (2008)
[24] Ibid.

(viii) Responses to water security pressure and uncertainty[25]

AS A FARMER, YOU HAVE A NUMBER OF OPTIONS AVAILABLE TO MEET ANY POSSIBLE WATER MANAGEMENT POLICY OR ENVIRONMENTAL UNCERTAINTY IN YOUR REGION, RELATED TO YOUR WATER USE AND STORAGE.
BASED ON YOUR PERCEPTION OF THE CURRENT WATER POLICY IN YOUR REGION AND YOUR RESPONSES ABOVE, PLEASE RATE THE DEGREE TO WHICH YOU WOULD CONSIDER ADOPTING THE FOLLOWING TACTICS ON A 7 POINT SCALE:
1-WOULD NEVER CONSIDER; 2-WOULD HARDLY EVER CONSIDER; 3-WOULD SOMETIMES CONSIDER; 4-DON'T KNOW/NOT SURE; 5-WOULD OFTEN CONSIDER; 6-WOULD NEARLY ALWAYS CONSIDER; 7-WOULD ALWAYS CONSIDER

17. I follow the water and dam management approach most commonly used in the past on this farm.
18. I follow the water and dam management approach used by other successful farmers in the area.
19. I choose to comply with all of the specific water and dam management regulatory requirements in my region.
20. I negotiate openly with the water regulators in my region to obtain a mutually agreeable solution.
21. I appear to comply with water and dam management regulations but intentionally avoid certain aspects of the requirements.
22. I avoid communicating with the regulator regarding water and dam management.
23. I ignore the water and dam management regulatory requirements and continue with business as usual.
24. I try to reduce the extent to which regulators inspect my water and dam management activities.
25. I would challenge the water and dam management requirements in court.
26. I attempt to form an alliance with the water and dam management regulators in my region.
27. I meet with elected officials about the water and dam management regulations in my region.
28. I use lobbyists and industry groups to influence water and dam management policy makers.
29. I allow for an annual maintenance spend on my dam to ensure it brings positive benefits to my production.
30. If at any time I do not have enough water in my dam or it fails, I can easily use a different water source.
31. If at any time I do not have enough water in my dam or it fails, I can easily diversify into new farming opportunities.
32. I have been ordered to have low flow bypasses on my dams.
33. I have been ordered to improve the size or condition of my spillway.
34. I voluntarily installed low flow bypasses on my dams.
35. I have voluntarily improved the size or condition of my spillway.

(ix) Attitudinal questions related to water security and farming[26]

PLEASE INDICATE WHETHER YOU AGREE OR DISAGREE WITH THE FOLLOWING STATEMENTS REGARDING YOUR REACTION TO WATER MANAGEMENT AND FARM. PLEASE USE THE FOLLOWING 7-POINT SCALE:
1-VERY STRONGLY DISAGREE; 2-STRONGLY DISAGREE; 3-DISAGREE; 4-DON'T KNOW/NOT SURE; 5-AGREE; 6-STRONGLY AGREE; 7-VERY STRONGLY AGREE

Regional factors

36. Most of the farmers in my region manage their water and dams the same way.
37. Farmers around me use and store their water fairly.

Environmental factors

38. Managing environmental problems on my farm is a very high priority.
39. I am more environmentally responsive than other farmers in the region.
40. I believe in climate change.

Commercial factors

41. I have a successor for this farm in place.
42. In the last 5 years this farm has had a positive productivity change.
43. In the past 5 years me or a member of my family have had to take off-farm work to subsidize/support on-farm activities.
44. A maximum annual return from my property is my most important aim.
45. Compared to other farmers in my region, my growth in profit has been positive.
46. I include water and dam management in my overall farm planning.
47. My general health is good.

[25] Tingey-Holyoak & Pisaniello (2015)
[26] Ibid; Wheeler et al. (2013)

48. My health has suffered due to water insecurity in my region.

Production factors

49. I am open to new ideas and technologies for water and dam management.
50. I have adopted irrigation efficiency improvements on my farm.

Financing factors

51. I obtain funding for my activities from government.
52. It would help me to obtain water management funding from government.
53. Financial policy incentives or subsidies would encourage me to improve my water and dam management.

(x) Demographics

60. Production type
61. Any change in production type in past 5 years
62. Size of farm (Acres/Hectares)
63. Number of irrigated acres/hectares
64. Change in irrigated acres/hectares over last 5 years
65. Number of farm dams
66. Size of largest dam
67. Postcode
68. Years farming
69. Number of full-time employees
70. Age
71. Gender
72. Are you a member of an industry body – name
73. Are you a member of a landcare group
74. Are you a member of a water or environmental group - name

APPENDIX 7C - KEY VARIABLES AND RELATIONSHIPS

Hypothesis	Variable	Construct	**Measure** (Likert 1-7 scale)	Literature / source	Scale reliability (Cronbach's alpha)
All (lowest resistance to water sharing equity pressure)	DV1	Acquiescence[27]	17 I follow the water and dam management approach most commonly used in the past on this farm	Meyer & Rowan, 1977; Pfeffer & Salancik, 1978; Scott, 1987; Oliver 1991; Etherington & Richardson, 1994; Ingram & Simons, 1995; Goodstein, 1994; Bansal, 2005; Clemens and Douglas, 2005; Pisaniello & McKay, 2007; Pisaniello *et al.*, 2012; Tingey-Holyoak, 2014; Tashman & Rivera, 2016	0.39
			18 I follow the water and dam management approach used by other successful farmers in the area		
			19 I choose to comply with all of the specific water and dam management regulatory requirements in my region		
All (low resistance to water sharing equity pressure)	DV2	Compromise[28]	20 I negotiate openly with the water regulators in my region to obtain a mutually agreeable solution		0.22
			51 I include water and dam management in my overall farm planning		

[27] Acquiescence is the dependent variable that represents the lowest farmer resistance to sustainable farm dam management institutional pressure. Three items were designed to capture the underlying meaning and all were found to measure the underlying construct and thus all three items were retained for the final analysis. The skew and kurtosis were within the normal range. There was limited evidence of outliers among items because communalities were all around 0.3 and above – this is not highly strong but does indicate that items have qualities in common with each other. Factorability of the matrix was confirmed by KMO's test of sampling adequacy at 0.51 and a significant Bartlett's test of sphericity ($X2$=26.83, p<0.001). The inter-item correlations also confirmed this with values around or over 0.3 which is still not extremely high but it was decided to retain all items as they measure different dimensions of the same construct in line with the theory – namely 'habit', and 'compliance' (see Clemens & Douglas, 2005). None were 0.8 or above which would indicate the presence of multicollinearity or singularity. The initial single factor solution had eigenvalues explaining 47.24% of the variable, supported visually by the scree plot showing one factor above the elbow. The total variance explained was 27.35%. Cronbach's alpha was 0.39 showing adequate reliability of the scale and no item if deleted would improve the alpha score so in line with reference to literature, all items were decided to be retained and their means computed to create the new variable 'Acquiescence' for inclusion in the final analysis.

[28] Compromise is the dependent variable that represents low farmer resistance to sustainable farm dam management institutional pressure. Two items were designed to capture the underlying meaning and both were found to measure the underlying construct and thus both items were retained for the final analysis. The skew and kurtosis were within the normal range. There was limited evidence of outliers among items because communalities were all around 0.6 and above indicating the items all had a lot in common with each other. Factorability of the matrix was confirmed by KMO's test of sampling adequacy at 0.50 and a significant Bartlett's test of sphericity ($X2$=2.55, p<0.01). The inter-item correlations also confirmed this with values around or over 0.2, but not at 0.8 or above which could indicate the presence of multicollinearity or singularity. The initial single factor solution had eigenvalues explaining 56.46% of the variable, supported visually by the scree plot showing one factor above the elbow. The total variance explained was 56.46%. Cronbach's alpha was 0.22 showing adequate reliability of the scale and no item if deleted would improve the alpha score so all items were decided to be retained and their means computed to create the new variable 'Compromise' for inclusion in the final analysis.

All (mid-point of resistance to water sharing equity pressure)	DV3	Avoidance[29]	21 I appear to comply with water and dam management regulations but intentionally avoid certain aspects of the requirements		0.75
			22 I avoid communicating with the regulator regarding water and dam management		
All (high resistance to water sharing equity pressure)	DV4	Defiance[30]	23 I ignore the water and dam management regulatory requirements and continue with business as usual		0.69
			24 I try to reduce the extent to which regulators inspect my water and dam management activities		
			25 I would challenge the water and dam management requirements in court		
All (highest resistance to water sharing equity pressure)	DV5	Manipulation[31]	26 I attempt to form an alliance with the water and dam management regulators in my region		0.79
			27 I meet with elected officials about the water and dam management regulations in my region		
			28 I use lobbyists and industry groups to influence water and dam management policy makers		
All (mid-to-low range resistance to water sharing equity pressure)	DV6	Adaptation (diversification and substitution)[32]	29 I allow for an annual maintenance spend on my dam to ensure it brings positive benefits to my production	Tashman & Rivera, 2016, key expert interviews	0.65

[29] Avoidance is the original mid-point dependent variable measuring mid resistance with a tendency to reflect higher than low resistance (Meyer & Rowan, 1977). Two items were designed to capture the underlying meaning and all were found to measure the underlying construct and thus the items were retained for the final analysis. The skew and kurtosis were within the normal range. There was limited evidence of outliers among items because communalities were all around 0.40 and above indicating the items all had a lot in common with each other. Factorability of the matrix was confirmed by KMO's test of sampling adequacy at 0.50 and a significant Bartlett's test of sphericity ($X2$=67.87, p<0.001). The inter-item correlations also confirmed this with values around or over 0.6, but not at 0.8 or above which could indicate the presence of multicollinearity or singularity. The initial single factor solution had eigenvalues explaining 79.97% of the variable, supported visually by the scree plot showing one factor above the elbow. The total variance explained was 59.84%. Cronbach's alpha was 0.75 showing good reliability of the scale and no item if deleted would improve the alpha score so all items were decided to be retained and their means computed to create the new variable 'Avoidance' for inclusion in the final analysis.

[30] Defiance is the second highest level of resistance in strategic response models and 3 items were designed to capture the underlying meaning and all were found to measure the underlying construct and thus the items were retained for the final analysis. The skew and kurtosis were within the normal range. There was limited evidence of outliers among items because communalities were all around 0.30 and above indicating the items all had a lot in common with each other. Factorability of the matrix was confirmed by KMO's test of sampling adequacy at 0.67 and a significant Bartlett's test of sphericity ($X2$=77.81, p<0.001). The inter-item correlations also confirmed this with values around or over 0.5, but not at 0.8 or above which could indicate the presence of multicollinearity or singularity. The initial single factor solution had eigenvalues explaining 62.10% of the variable, supported visually by the scree plot showing one factor above the elbow. The total variance explained was 43.47%. Cronbach's alpha was 0.69 showing good reliability of the scale and no item if deleted would improve the alpha score so all items were decided to be retained and their means computed to create the new variable 'Defiance' for inclusion in the final analysis.

[31] Manipulation is the highest level of resistance in strategic response models and 3 items were designed to capture the underlying meaning and all were found to measure the underlying construct and thus the items were retained for the final analysis. The skew and kurtosis were within the normal range. There was limited evidence of outliers among items because communalities were all around 0.40 and above indicating the items all had a lot in common with each other. Factorability of the matrix was confirmed by KMO's test of sampling adequacy at 0.66 and a significant Bartlett's test of sphericity ($X2$=158.41, p<0.001). The inter-item correlations also confirmed this with values around or over 0.5, but not at 0.8 or above which could indicate the presence of multicollinearity or singularity. The initial single factor solution had eigenvalues explaining 71.36% of the variable, supported visually by the scree plot showing one factor above the elbow. The total variance explained was 59.43%. Cronbach's alpha was 0.79 showing good reliability of the scale and no item if deleted would improve the alpha score so all items were decided to be retained and their means computed to create the new variable 'Manipulation' for inclusion in the final analysis.

[32] Adaptation (diversification and substitution) is the mew possible mid-to-low level resistance in strategic response models and 2 items were designed to capture the underlying meaning and all were found to measure the underlying construct and thus the items were retained for the final analysis. The skew and kurtosis were within the normal range. There was limited evidence of outliers among items because communalities were all around 0.40 and above indicating the items all had a lot in common with each other. Factorability of the matrix was confirmed by KMO's test of sampling adequacy at 0.50 and a significant Bartlett's test of sphericity ($X2$=40.20, p<0.001). The inter-item correlations also confirmed this with values around or over 0.5, but not at 0.8 or above which could indicate the presence of multicollinearity or singularity. The initial single factor solution had eigenvalues explaining 74.28% of the

			32 If at any time I do not have enough water in my dam or it fails, I can easily diversify into new farming opportunities		
H1a: Farmer perceptions of ecological uncertainty relate to low resistance to pressures for equitable and safe water storage.	IV1a[33]	Context - Ecological uncertainty	15 I am worried about the future of water availability to continue my farming operations	Meyer & Rowan, 1977; Zucker, 1977; Pfeffer & Salanick 1978; DiMaggio & Powell, 1983; Meyer *et al.*, 1983; Oliver, 1991; Goodstein, 1994; Clemens et al., 2008; Tingey-Holyoak, 2014b; Tashman & Rivera, 2016	
H1b: Farmer perceptions of regional or industry interconnectedness relate to low resistance to pressures for equitable and safe water storage.	IV1b	Context - Interconnectedness	37 Most of the farmers in my region manage their water and dams the same way	DiMaggio and Powell, 1983; Oliver, 1991; Clemens & Douglas, 2005; Clemens et al., 2008	
H2a: Farmer perceptions of legal coercion relate to low resistance to pressures for equitable and safe water storage.	IV2a	Control – legal coercion	12 I am fearful of enforcement of water and dam management policy by regulators	DiMaggio & Powell, 1983; Oliver, 1991; Jennings & Zandbergen, 1995; Weaver *et al.*, 1999; Bansal, 2005; Pisaniello, 2010; Pisaniello *et al.*, 2011a; Tingey-Holyoak, 2014; Tashman & Rivera, 2016	
H2b: Farmer perceptions of voluntary diffusion relate to low resistance to pressures for equitable and safe water storage.	IV2b	Control – Voluntary diffusion	5 The policies mean I can control my own water and dam management which has positive benefits for water security in my region	Tolbert & Zucker, 1983; Fligstein, 1985; Oliver, 1991; Pisaniello *et al.*, 2011a; Tingey-Holyoak, 2014; Tashman & Rivera, 2016	
H3a Perceptions of a lack of decision making power relate to high resistance to pressures for equitable and safe water storage.	IV3a	Content - Lack of decision making power	6 The laws require me to provide too much water for the environment	Thomson, 1967; Cook, 1977; Pfeffer & Salancik, 1978; Meyer *et al.*, 1983; Oliver, 1991; Tashman & Rivera, 2016	
H3b Perceptions of inconsistency of pressure with business goals relate to high resistance to pressures for equitable and safe water storage.	IV3b	Content - Consistency of organisational goals	11 I am satisfied with the conditions of my water license and water access entitlements	Powell & Freidkin, 1986; Covaleski & Dirsmith, 1988; Ingram & Simon, 1995; Bansal & Roth, 2000; Pisaniello *et al.*, 2012	

variable, supported visually by the scree plot showing one factor above the elbow. The total variance explained was 48.46%. Cronbach's alpha was 0.65 showing good reliability of the scale and no item if deleted would improve the alpha score so all items were decided to be retained and their means computed to create the new variable 'Adaptation' for inclusion in the final analysis.

[33] Single item measures were employed for independent variables as these had concrete singular object attribute item measures which was deemed appropriate for the target audience in agriculture because they provide the comparable predictive validity and a lower risk of converging onto another attribute in this novel area (Bergkvist & Rossiter, 2007). Bergkvist and Rossiter (2007) demonstrate equal predictive validity for single item scales compared with multiple-items. The single items also have the practical advantage of lowering refusal rates and nonresponse bias (Patterson et al., 2014) and more recent studies continue to support this notion (Singhapakdi et al., 2014). Upon inspection of the items and the questions employed to represent the constructs by expert colleagues and also pretesting in the field, it was decided to retain the items for inclusion in the data analysis.

H3c Perceptions of high policy uncertainty relate to high resistance to pressures for equitable and safe water storage.	IV3C	Content - Policy uncertainty	7 Water and dam management policy in my region changes too frequently	Tingey-Holyoak, 2014; Tashman & Rivera, 2016; Rivera, 2016; Key expert interviews	
H3c Perceptions of high levels of institutional fragmentation relate to high resistance to pressures for equitable and safe water storage.		Content - Institutional fragmentation	9 I feel confident with the government's position on water and dam management to ensure water security	Tingey-Holyoak, 2014; Tashman & Rivera, 2016; Rivera, 2016; Key expert interviews	
H4a: Farmer perceptions of multiplicity of constituents relates to high resistance to pressures for equitable and safe water storage.	IV4a	Constituents – Multiplicity	4 The government's position on water and dam management in my region and how it will implement policy is clear	Whetten, 1978; Oliver, 1991; Cashore & Vertinsky, 2000; Pisaniello *et al.*, 2012; Tingey-Holyoke, 2014b; Tingey-Holyoak & Pisaniello, 2017	
H4b: Farmer perceptions of dependence constituents relates to low resistance to pressures for equitable and safe water storage.	IV4b	Constituents - Dependence	57 I obtain funding for my activities from government	Pfeffer & Salancik, 1978; DiMaggio & Powell, 1983; Oliver, 1991; Tingey-Holyoke, 2014b; Tingey-Holyoak & Pisaniello, 2017	
H5a: Farmer perceptions of social fitness and legitimacy relate to low resistance to pressures for equitable and safe water storage.	IV5a	Cause – Social fitness	10 I have a say in co-designing water and dam management policy that suits my farm and the farmers around me	Tolbert & Zucker, 1983; Etherington & Richardson, 1994; Fligstein, 1985; DiMaggio & Powell, 1991; Oliver, 1991; Pisaniello & McKay, 2007	
H5b: Farmer perceptions of economic fitness relate to low resistance to pressures for equitable and safe water storage.	IV5b	Cause – Economic fitness	29 I allow for an annual maintenance spend on my dam to ensure it brings positive benefits to my production	Oliver, 1991; Vogel, 1992; Albert, 1993; Dore, 2000; Roe, 2007 Campbell 2007; Pisaniello & McKay, 2007; Tingey-Holyoak & Pisaniello, 2017	
H5c: Farmer perceptions of environmental fitness relate to low resistance to pressures for equitable and safe water storage.	IV5c	Cause – Environmental fitness	41 I am more environmentally responsive than other farmers in the region	Oliver, 1991; Vogel, 1992; Albert, 1993; Dore, 2000; Roe, 2007 Campbell 2007; Pisaniello & McKay, 2007; Tingey-Holyoke, 2014b; Tingey-Holyoak & Pisaniello, 2017	
H5d: Farmer perceptions of competitive fitness relate to low resistance to pressures for equitable and safe water storage.	IV5d	Cause - Competitive fitness	50 Compared to other farmers in my region, my growth in profit has been positive	Tingey-Holyoak, 2014; Tashman & Rivera, 2016; Rivera, 2016; Key expert interviews	
H6a: Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in low income regions.	ObjV1	Household Income	Regional/postcode metric – ABS	ABS website	
H6b: Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in increasingly remote areas.	ObjV2	Remoteness	Regional/postcode metric – ABS	ABS website	

H6c Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in increasingly dry areas.	ObjV3	Mean annual precipitation	Regional/postcode metric – BoM	BoM website	
H6d Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in increasingly warm areas.	ObjV4	Mean annual temperature	Regional/postcode metric – BoM	BoM website	
H6e Resistance to perceptions of pressures for equitable and safe water storage will be increased for farmers in areas of low soil moisture.	ObjV5	Rootzone soil moisture	Regional/postcode metric – BoM	BoM website	

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