**D1 PROJECT DESCRIPTION**

**PROJECT TITLE: Optimising the national benefits from restoring environmental water flows**

**Summary of research proposal:** $20 billion has been allocated to improve water security in the Murray-Darling Basin (MDB) by transferring up to 3200 gigalitres (GL) of water to the environment (Loch & McIver 2013). Considerable national benefits will accrue when environmental flows are restored (Quiggin 2001). However, the question remains, what is the *best* way to restore environmental flows to optimise economic, social and environmental benefits? The most recent strategy for implementing the Murray-Darling Basin Plan (Basin Plan) for restoring environmental flows proposes to purchase 1300GL of water rights from irrigators and obtain 1900GL of water by subsidising private investment in water-use efficient technology. However, no economic modelling of the Basin Plan's implementation exists (ACF, 2014). Without a model an informed debate of the feasibility of the strategy and the economic, social and environmental trade-offs from alternative Basin Plan implementation strategies cannot occur.

Loch, Adamson & Mallawaarachchi (2014) noted that evidence-based policy is required to optimise the national benefits (welfare) of a water management strategy within the MDB. When developing evidence-based, decision makers must understand that water supply variability: is not uniform within a landscape; alters the reliability of water rights; adjusts the trade-offs between all water users; changes the behaviour of all water users; is not a consistent distribution; and that climate change may alter all known information about past water supply. This research project aims to use such evidence to examine, how the national benefits from returning water to the environment in Australia's MDB could be optimised. The project will enable an economic, social and environmental evaluation of the proposed implementation of the Basin Plan using a variety of economic models, importantly with the capacity to incorporate behavioural response to water supply risk and uncertainty. This research can then contribute significantly to any the reviews of the Basin Plan due in 2016 and in 2019.

**AIMS AND BACKGROUND**

**Background:** Water crises emerge when policy makers fail to provide long term water security for economic, social and environmental users (water users) (OECD 2013). Water is a vital input for all users but the supply of water can be highly variable due to a cycle of droughts and floods. When water resources are inequitably shared, those with poor water security can be irreversibly harmed (Adamson 2015). Climate change is expected to decrease total rainfall and increase the severity and longevity of drought periods in areas where water security has been compromised (Garrick & Hall 2014). The restoration of environmental flows can counter welfare losses derived from an over allocation of natural resources toward private consumptive use (Quiggin 1991). Restoring the natural flow can then offset future climate shocks to water supply, but what is the best way to reallocate water resources (water reform) for society's benefit?

Any policy change involves potentially irreversible unintended private and public costs. To develop sustainable and cost-effective water security policy for society's benefit, decision makers must design governance systems (institutions and organisations) taking account of the facts that the supply of water is uncertain, and that demand for water by all users changes in response to supply (Pittock 2013). Evidence-based policy (Loch, Adamson & Mallawaarachchi 2014) helps institutions to: equitably define and share water resources between all users; design laws and rights that allocate water shares in response to climatic short-term variability and/or long-term change; and implement, monitor and enforce good governance rules for society's benefit (Crase, O'Keefe & Dollery 2013). Economics should also illustrate how individual behaviour responds to the new governance structures, the inducements designed to facilitate water reform (Pérez-Blanco & Gómez 2014), and new information about water supply. Behavioural responses are not uniform within a landscape (Garrick & Hall 2014). The dynamics of these responses alter not only the individuals' demand for water, but the downstream supply and quality of water available for all other users (OECD 2013). While these are complex problems, Chavas, Chambers & Pope (2010) suggest that an outstanding knowledge gap for economics remains in how we predict behavioural responses to rare events (e.g. intense floods and severe droughts), or new events that have not been experienced by the decision maker, in order to inform policy. In other words, how do we predict a move from A to B, when we don't have a roadmap?

The Basin Plan provides a global test-case for examining such prediction issues in the context of future water security challenges (Pittock 2013) for three reasons. First, by transferring up to 3200GL of water from irrigators to the environment, the Basin Plan is a world-leading example of water reform to address water insecurity. The 3200GL estimate was obtained from the difference between current water allocated to irrigators and a new Sustainable Diversion Limit (SDL); that is, the level of extraction at which ecological problems such as algal blooms or hyper salinity might be managed, if not mitigated (ACF, 2014). Second, while the MDB is regarded as having the second most variable flows in the world (McMahon & Finlayson 1991), the Basin Plan was primarily developed during the Millennium Drought. The severity and duration of the Millennium Drought challenged all preconceptions about water security and, it provided a natural experiment for how individuals adapt to rare events, thus a potential roadmap for climate change adaptation (Adamson 2015). Third, to promote a rebalance in water allocations between consumptive and environmental use, two competing programs were introduced: the *Restore the Balance* (RtB) program was allocated AUD$3.1 billion to purchase water rights from irrigators; while AUD$7.44 billion was provided to the *Sustainable Rural Water Use Investment Program* (SRWUIP) to obtain water by subsidising on- and off-farm water-efficiency investments. Adamson's thesis (2015) argues that the SRWUIP has unintended irreversible consequences on national welfare. The program encourages irrigators to adopt unsustainable levels of debt; there is a lack of accountability on what property rights[1] are obtained for the environment; and the policy appears to misunderstand that irrigation return flows[2] can be an environmental asset (Crase and O'Keefe 2009). Adamson (2015) suggested that in given circumstances the current SRWUIP program may decrease rather than increase environment flows. Adamson (2015) also noted that the RtB strategy provided a much clearer transfer of property rights from (willing) irrigators to the environment, and that from its existing budget the RtB could have been optimised to purchase a portfolio of water rights[3] that not only achieved the Basin Plan's objectives but could have been designed to offset known and future climatic outcomes (i.e. an accommodation of uncertainty and risk into the implementation strategy).

Adamson (2015) used a constrained welfare optimisation approach to model the design of the Basin Plan from the national perspective. The model was set up to maximise economic returns from irrigation subject to the institutional goals of achieving a minimum flow to the Coorong wetland[4] and water quality standards. However, Adamson (2015) concluded that the absence of complete spatial representation of environmental goals and a subsequent inability to examine the stochastic reliability of water property rights through the landscape prevented the model from identifying the welfare risks to the economy, society, the environment, and public expenditure.

The Basin Plan implementation strategy was finalised in 2014, Figure 1 summarises both the progress towards the SDL objectives and the current strategy for obtaining the environment's share of water resources (Department of the Environment 2014). To date, 1900GL of water has been recovered for the environments[5]. This includes 1142GL of water from the RtB, 543GL from the SRWUIP and 215GL from past investments in water security. By capping the RtB at 1300GL in the current strategy only a further 158GL can be purchased from willing irrigators, while an additional 57GL is estimated to be available from the SRWUIP. This would provide the environment with a total of 2100GL. However, the implementation strategy includes a proviso to revise environmental water requirements in two ways. In 2016, if equivalent ecological outcomes can be achieved with strategic supply measures[6] then up to 650GL of water may not have to be obtained for the environment. The developers of the framework designed to assess the ecological impacts of strategic supply measures caution against using only the results from their model, as adverse outcomes are possible (Brookes et al. 2014). The strategic supply measure assessment framework does not have an economic component, preventing an understanding of the trade-offs from alternative supply adjustment strategies such as water trade. In 2019, if it is identified that future investment in water-efficient technology may create adverse social or economic harm then a further 450GL of water may not have to be returned to the environment. The policy reviews in 2016 and 2019 may then occur in the absence of a bio-economic model. Such bio-economic modelling is important for examining if the current implementation strategy can achieve the Basin Plan goals, how the environmental water could be optimised to obtain maximum national welfare benefits, or whether a redesigned implementation strategy could provide alternative cost-effective long term solutions.

Central to the cost-effective solution is an understanding that the supply of water and its security in a landscape is determined by the "spatial mix of use and non-uses of water given the actual inflows, evaporation and the quality

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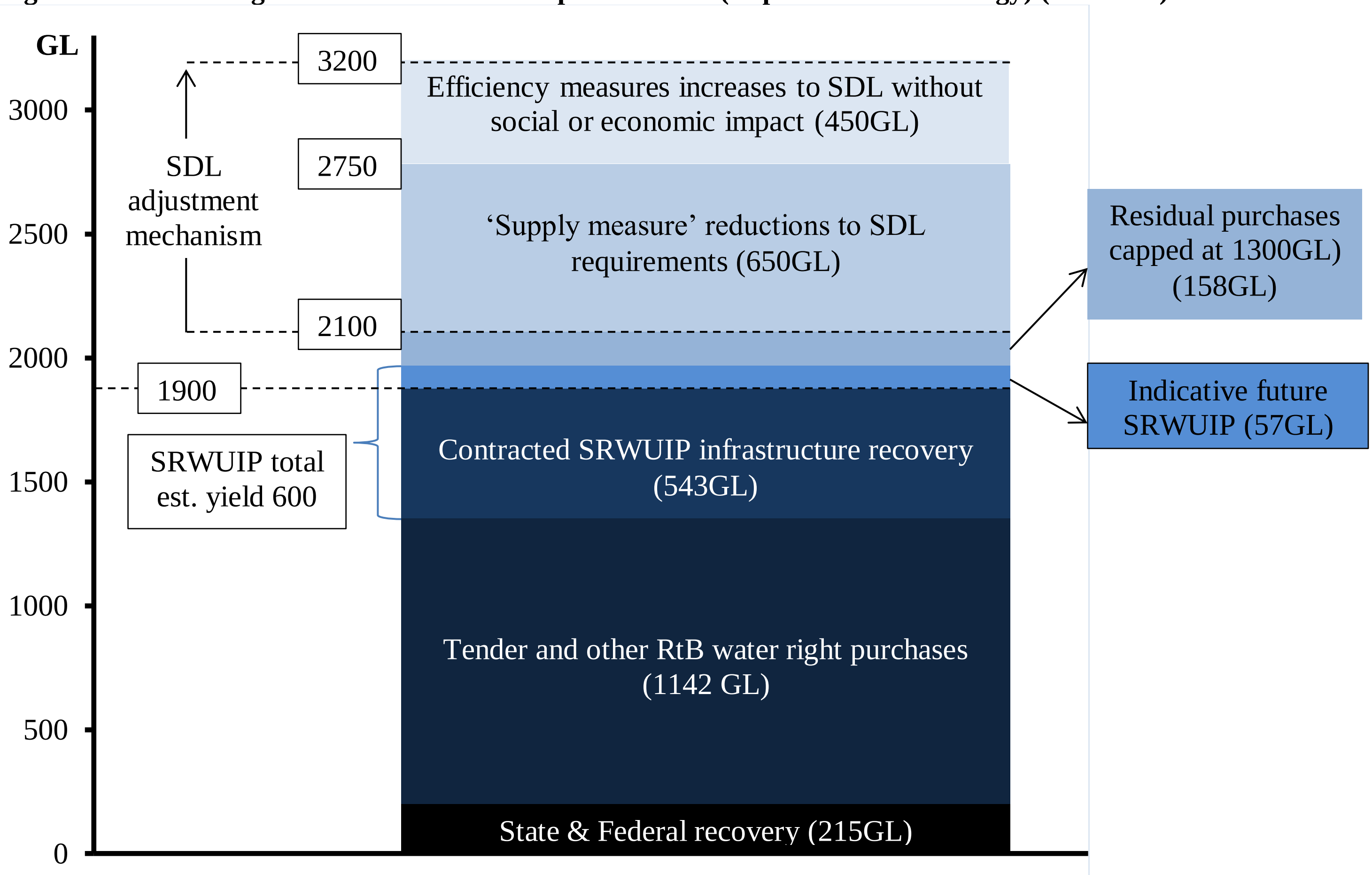
[1] Water property rights in the MDB are designed to reflect the security they provide by location. In each location there are a set of alternative property rights, and each right provides a different level of water security determined by the total supply of water available at a given point in time.
[2] A return flow is the unused proportion of water that returns to the river after it has been used by its owner.
[3] A portfolio of rights is a bundle of alternative rights that provides a given level of water security.
[4] The Coorong wetlands are the terminal point of the river system before it discharges into the sea.
[5] The Commonwealth Entitlement Water Holder (CEWH) purchases the water rights, while the Commonwealth Entitlement Water Office (CEWO) manages the water in the national interest.
[6] Supply measures include water supply management rules and/or infrastructure options that can create win-win solutions for achieving similar SDL environmental outcomes with less total recovered water.

of existing environmental assets" (Connell & Grafton 2008, p. 72). In the MDB, the share of water supply in the landscape can be divided into a set of property rights designed for private use, and a river system maintenance flow that is used to transport private rights and supply water to urban centres and environmental assets. However, the river maintenance flow has no legal rights, and during drought events this maintenance flow has been penalised to provide greater water security for private right-holders; but as droughts progress, the reliability of those private rights decline. As water supply is uncertain, this balance between the water security provided to water rights and maintenance flows becomes a critical issue on which to evaluate the Basin Plan's implementation stage. In other words, to assess the Basin Plan implementation strategy, the supply of water and the reliability of water property rights should be described in stochastic terms.

**Figure 1 Current Progress of the Basin Plan Implementation (Implementation Strategy) (Nov 2014)**




This raises several issues when obtaining water for the environment:

- If the security of all water rights remains constant, then the volume of water allocated to maintenance flows may decrease, reducing national welfare and Basin Plan cost–effectiveness, on average. But when droughts occur, the future security of entitlements may be reduced downwards to new extremes of water insecurity,
- If supply measures also include not penalising the maintenance flow, then the water security provided by each class of right must decrease. As the security of water rights decreases, how might irrigators adjust and what would be the implications for meeting the environmental and water quality objectives of the Basin Plan?
- What is the true value of water rights, and the trade-offs between all water users?
- What role will trade play in the CEWO's role for managing surplus, and deficit water requirements?
- How does climate change alter the prior identified issues?

**Aim of the Project:** To optimise national welfare from the recovery of water for environmental flows. To do this, the major research questions that will be investigated by the project include:

1. Does the lack of a stochastic description of alternative property rights misallocate resources?
2. What is the environment's current portfolio of water rights by region, and what could the final portfolio of rights look like?
3. Can 3200GL of water be feasibly returned to the environment? How does the current implementation strategy alter the river maintenance flows, and what are the welfare outcomes?
    a. Will the reliability of rights need to be altered to provide maintenance flows in the system?
    b. Can the Basin Plan goals be achieved?
    c. How could climate change impact on the reliability of water share in the MDB?

4. If the CEWO actively engages in trading will it be feasible/realistic to adopt counter cyclical trade (i.e. CEWO sale of water in drought, and purchasing during wet, periods) as predicted by Ancev (2015)?
   a. What are the welfare impacts for irrigators who sold or purchased water in droughts?00
   b. Could national welfare be maximised if the CEWO purchased allocation[7] water in drought period?
5. What are the lessons to be learned from alternative behavioural economic approaches that have been used to reallocate water resources internationally?
   a. What can these behavioural approaches contribute to understanding how decision makers reallocate resources in response to rare or new water supply events, so that policy can be redesigned to reduce the costs of moving from A to B?

**PROJECT QUALITY AND INOVATION**

**Quality:** In 2016, the review of the supply measure strategies will occur, as discussed above, possibly in the absence of an independent behavioural bio-economic model to challenge any attempt to reduce the quantity of water provided to the environment. Qualitative economic debate will undoubtedly occur around how and why changes to the quantity of water returned to the environment may alter national welfare. But the fundamental power of an economic model is that it can clarity what is known and unknown, and it can quantify changes in national welfare. Quantifying the economic, social and environmental trade-offs will be vital in 2016 and 2019 when major reviews of the Basin Plan are scheduled to take place. These timeframes align well with this DECRA proposal, and potentially making the DECRA's outputs an important part of the decision making process by helping clarify the consequences from alternative policy settings.

To debate the trade-offs in the design of the implementation stage of the Basin Plan, the economic impacts on irrigators and the environmental and social benefits must be known in this time period (A) and the future (B). However, theoretical gaps remain in our understanding of how decision makers respond to risk and uncertainty. One behavioural economic approach used in the MDB to investigate how decision makers adapt to water supply risk and uncertainty is the state-contingent approach (SCA) (Adamson, Mallawaarachchi & Quiggin 2009).

By separating the environmental signal (e.g. droughts, floods and periods of average water supply) from the decision maker's response to the environmental signal, SCA can illustrate how decision makers might actively reallocate resources to maximise returns over time (Chambers and Quiggin 2000). This theoretical breakthrough helped Adamson, Mallawaarachchi and Quiggin (2009) illustrate how MDB resources (land, labour, capital and water) were reallocated by alternative water states of nature (drought, flood and normal). For example, producers who irrigate cotton in a normal year, may not plant a crop during a drought, and when water is not a binding constraint, producers will opportunistically irrigate farm land to maximise profits. These insights helped to illustrate how decision makers adopted new management strategies to deal with climate variability and climate change. However, every model has design limitations that can leave model predictions vulnerable to rare or new events (Taleb 2007). The existing SCA model of the MDB used: discrete parameters, assumed perfect knowledge about all future states of nature, and allowed all resources in a region (or across the entire MDB) to be allocated by a benevolent profit maximising agent who wanted to ensure the Basin Plan objectives could be achieved. This DECRA project wants to challenge these assumptions, and ask what will *individuals* do across a landscape?

By adopting stochastic parameters, the SCA approach provides new opportunities to examine how and why decision makers respond to rare or new levels of water insecurity. As new events are revealed, individuals have to adapt to the water security challenges within their system (Byerlee & Anderson 1982). However, an individual's ability to respond is constrained by: their prior relevant experience to the event (Goldstein & Gigerenzer 2002); their ability to recognize or predict the event (Lindner & Gibbs 1990; Makeham & Malcolm 1981); their past management success in dealing with the event; any biophysical, financial and capital investment constraints on the farming enterprise; and factors outside of their control which constrain their choice sets (Wilson 2014). Additionally the research also needs to examine what other behavioural approaches could be used to represent heterogeneity (diversity) within a landscape.

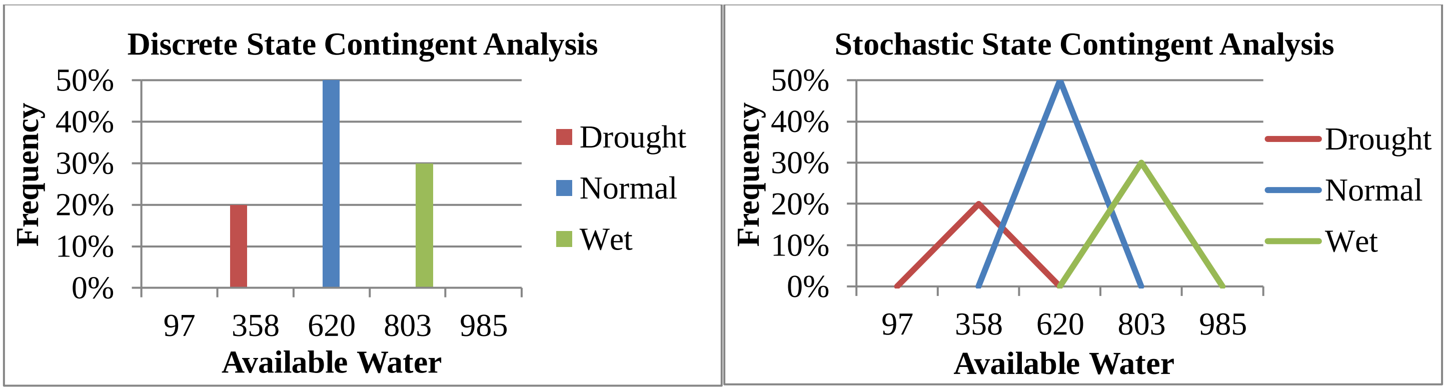
***Innovation:*** By reconsidering the above decision via an SCA analysis, a manager's bounds (e.g. experience and management response) may reduce their awareness about all outcomes in different states of nature (e.g. solutions to deal with a lack of water availability) and the description of each state (e.g. just how extreme can a drought be). Changes to the problem set (e.g. water availability in a drought or climate change) can result in resource

[7] There are two types of water trading. Permanent trading which is a transfer of a property right and allocation trade which is the purchase of water for a single use.

misallocation occurring until new successful solutions are determined by the decision maker. By defining the stochastic reliability of alterative property rights in each state of nature, it then allows the SCA to represent something approaching a normal distribution (Figure 2). This then helps explain why individuals may allocate resources in anticipation of a different state of nature being realised. As Grant and Quiggin (2013) discuss, when decision maker's experiences are ecologically rational (Goldstein & Gigerenzer 2002), cognitive heuristics rapidly improve their awareness, which increases their welfare. To this end, once a decision maker has experienced a state of nature (i.e. a drought) that decision maker is more likely to affect a better decision next time the state is experienced. However, if the time period between the adverse events occurring can be classified as the long-run, then changes to the irrigation property (e.g. new crop, new infrastructure and new management processes) may decrease the value of past experiences, as they may no longer provide suitable guidance.

This information then helps examine the hydrological realities of both the bio-physical limitations of a river system to delivering water and the security of the water rights to deliver water. If public investment in the SRWUIP is decreasing the river's maintenance flow, then the public funds are impairing welfare by degrading water security. If, as expected, climate change degrades water security, then the dual impact of climate change and misallocated resources could lead to irreversible outcomes for all water users.

**Figure 2 Comparing a discrete and stochastic SCA representation of state of nature**




***Conceptual Framework*****:** Society has incomplete knowledge about the future water supply and the set of management solutions required for optimal transformation towards a greater water security. In predicting the consequences of change, models provide a platform to test what we know and a framework for challenging preconceptions. The research program has three key objectives and the program's timelines are in Figure 3.

*Objective 1: Compare discrete versus stochastic version of the new SCA model*

*Rationale:* Examine the reallocation of resources and subsequent welfare implications from modelling water resources as discrete or stochastic parameters within a new SCA model that can analyse the implementation stage of the Basin Plan.

- Step 1: Redesign and rebuild the existing discrete SCA model so that it provides greater representation of the 53[8] environmental watering objectives as water flows along the river system. The current model has only 1 explicit environmental target, preventing a representation of the choices decision managers will face when allocating scare water resources between competing environmental assets or strategically using water trade to maximise environmental benefits. Update all data in the model and check that the validity of the assumptions.
- Step 2: Build a new stochastic version of the SCA model that defines the stochastic properties of water rights, states of nature, inputs required by state of nature and outputs obtained by state of nature.
- Step 3: Compare and contrast the results from the discrete and stochastic SCA models.

*Objective 2: Compare the stochastic SCA approach to other behavioural economics modelling approaches designed to reallocate water resources in a landscape under uncertainty.*

*Rationale:* The lessons learnt from the last 130 years of water reform in the MDB are regularly used to compare findings in other river basins (Pérez-Blanco & Gómez 2014), countries (Garrick et al. 2009) and to develop international best-practice guides (OECD 2013). But information is a two-way street. What can Australia learn from the institutional and economic applications in other countries? What can the candidate learn from challenging their preconceptions of alternative behavioural models by comparing and contrasting SCA with other approaches?

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[8] ttp://www.environment.gov.au/water/cewo/about/water-use, accessed 04/03/15

- Step 1: Collaborate with Dr Pérez-Blanco (a 2015 Marie Currie Fellow) who is merging revealed preference models (Pérez-Blanco & Gómez Gómez 2012) into agent-based models (ABM) (Iftekhar & Tisdell 2015) to determine the optimal private and social strategies for drought insurance. This research is located in the Segura River Basin in Spain, an area that meets the standards of absolute water scarcity[9] (EEA 2009) and compares well to Australian water supply conditions and constraints. The revealed preferences then provides a counter point to the SCA model, which use a profit maximisation strategy across states of nature, to examine if satisficing explains differences in adaptation strategies as society transitions from point A to B.
- Step 2: Collaborate with Professor Doole (Chair of Environmental Economics at the University of Waikato) to engage in the on-going debate about the use of positive mathematical programming (PMP) to represent the dairy impacts on water quality in New Zealand (Daigneault, Greenhalgh & Samarasinghe 2014; Doole & Marsh 2014). PMP is an ABM approach designed to calibrate optimisation results into a region providing greater representation of individual's actions. However, PMP has been challenged as the calibration may prevent the model seeing how decision makers adapt from A to B. This research will examine if there are benefits from merging PMP into a SCA framework to explain the necessary conditions that incentivise individuals to adapt through the landscape.

*Objective 3: Contribute to the policy debate. The new model and information learnt from reviewing other behavioural research methodologies to deal with adaptation to rare events needs to be applied to real issues*

Rationale: Understanding how to optimise the implementation stage of the Basin Plan allows for a greater discussion of the options available for decision makers to increase national welfare in 2016 and 2019.

**Figure 3 Work Plan**

| **Objective** | Step | 2016 | | 2017 | | 2018 | |
|---|---|---|---|---|---|---|---|
| | | Jan-June | July-Dec | Jan-June | July-Dec | Jan-June | July-Dec |
| **New Model** | 1 | | | | | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| **Compare Methodologies** | 1 | | | | | | |
| | 2 | | | | | | |
| **Policy Debate** | | | | | | | |

***Strategic Research Priorities*:** By representing the spatial and temporal water security of alternative entitlements the bio-economics aspects of model, helps identify the *current and future risks* to current water management strategies. The *behavioural response* to climatic variability and change is internalised within the stochastic SCA methodology approach which helps understand why decision makers alter inputs in response to a **'living and changing environment**'. The stochastic representation of nature states and inputs required by nature states to produce outputs within a bio-economic framework then helps identify the barriers to transformation and the subsequent management solution that exist to optimise '**food and water assets'** in the national interest.

***Advancement of knowledge:*** Dealing with individual adaptions through a landscape is complex but essential for policy development. To date there are no direct comparisons between these three behavioural approaches to dealing with allocating resources under risk and uncertainty. This research program should address that knowledge gap. Additionally the development of a new economic model to explore the reliability of property rights to deal with water reform then helps optimise welfare in Australia.

## RESEARCH ENVIRONMENT

The project will draw upon and sustain the research capacity built up in the RSMG at the School of Economics (SOE), at The University of Queensland (UQ), led by Professor Quiggin. RSMG was established precisely to facilitate projects of this kind that address large and complex policy problems. RSMG has a well-defined network of diverse collaborators within SOE, across UQ and internationally, who provide a comprehensive view of complex policy issues. The RePeC ranking lists RSMG in shared 11th place among all economic research institutions in Australia. While by sponsoring up to 3 seminars a week, the SOE attracts emerging and established domestic and international experts to debate cutting edge economic advancements. Additionally Dr Adamson is well integrated into the SOE who are offering generous support for this DECRA.

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- [9] Absolute water scarcity is defined as 500,000 litres of water per person a year (Garrick & Hall 2014)

*Communication of results:* While Dr Adamson will take full advantage of the opportunity the DECRA provides to disseminate research outputs at international and domestic conferences, workshops to engage in debate with peers, and where possible publish in open access journals, it will be Dr Adamson's past experiences writing for 'The Conversation' that will ensure that the research findings are debated in the public forum. 'The Conversation' provides a costless platform for research dissemination and the traditional media utilise 'The Conversation' to find experts for TV, radio and print interviews. The dissemination strategy has culminated in Dr Adamson being invited to provide a private briefing to a Federal Government Joint Standing Committee. This strategy then can directly influence the political debate at the highest levels.

## FEASIBILITY AND BENEFIT

**Feasibility:** Dr Adamson brings 20 years of applied economic experience and a proven track record of delivering successful research outcomes to this DECRA proposal. Dr Adamson has well established links to world renowned and future research leaders who are supporting him to ensure that the proposal achieves its goals. This includes: Professor Quiggin who has received two ARC Federation Fellowships and an ARC Laureate and is internationally recognised for his work in risk and uncertainty; Dr Mallawaarachchi, a RSMG colleague, has worked extensively at the interface between risk, natural resource economics and policy development; and Dr Loch, a 2015 DECRA recipient, who is utilising expert surveys to review MDB water reform and associated transaction costs.

**Benefit:** Changing environmental contexts place private and public expenditure at risk. If policies incentivise the wrong adaptation path then national welfare is reduced and, in severe cases, public assets can be irreversibly lost and private debt increased. Australia is embarking on the largest known attempt to improve environmental flows and that should increase welfare. However, preliminary evaluations have highlighted risks with the implementation of this plan. To evaluate the risks to welfare, greater efforts are needed to understand the complex hydrological realities and the true impact alternative strategies (RtB & SRWUIP) will impact on the river's maintenance flow. By identifying the private and public risks from climate uncertainty and developing greater understanding of the hydrological realities of the Basin Plan implementation, comments on the review stage of the Basin Plan can be made in an attempt to guide society along a more optimal adaptation path.

**Value for money:** Adamson (2015) suggested that for $3.1 billion the RtB program could have provided sufficient water to achieve the Basin Plan goals. That strategy represented a cost saving of $7.44 billion, as the SRWUIP would not have been required; but that opportunity has been lost. The review of the implementation strategy provides another opportunity to prevent a misallocation of private and public funding. From a public perspective, assuming that half of the funds in the SRWUIP have been allocated, this research may drive a refocusing of the implementation strategy back towards purchasing water directly from irrigators. The cost savings to the public may then be in the order of $3.7 billion. From a private perspective, if this DECRA can prevent investments in farming systems that cannot adapt to climate change or are exposed to increased water inequality, then future pressures on private debt and the social problems that causes may be avoided.

## DECRA CANDIDATE

For the last 11 years, the Dr Adamson has been research water resource issues in the MDB. Over this timeframe, Dr Adamson has developed a substantial skill set from his mentoring and from the PhD training. However, this DECRA provides the opportunity for Dr Adamson to clearly illustrate why his is a researcher in their own right. The DECRA provides the opportunity for Dr Adamson to: spend 80% of his time on this research question, to refine his economic skills; develop new skills (the candidate has never used GAMS, PMP or revealed preference models); build a suite of new models; and collaborate with established and emerging international and domestic scholars. The candidate has already benefited from collaborating with Dr Loch by publishing two articles (Journal of Hydrology and Agricultural Water Management). These articles are not in top 10% of journals by SNIP, but both articles are within the top 10% of most cited publications worldwide (SciVal data, 17/03/15). The DECRA provides new opportunities for Dr Adamson to take everything he has learnt, apply it to an important complex problem, increase his knowledge and, expand his collaborative research network by including internationally recognised researchers. The opportunity will not be wasted.

## MANAGEMENT OF DATA

UQ has dedicated valuable resources to enable researchers to document, store and control access to data sets. However, all the resources utilised in developing these services are the responsibility of the individual. Data management is critical when building models. Critical to the success of a project such as this, the model needs to be continually refined and updated and the candidate will document the changes to both the model and its documentation. To assist in the cataloguing and preservation of data, the UQ templates will be modified and the UQ e-space data storage facilities will be utilised. E-space provides a secure service to preserve data and ensure that access, where legally possible, is available on-line via the UQ library via e-space. The e-space service then is able to track changes in data sets allowing for iteration of the model to be tracked. Additionally a description of the model and the public data sets will also be on a new dedicated section of the RSMG web site. All research outputs of the project will be made available on conditions as close as possible to public domain, subject to limitations imposed by the copyright policies of journal and book publishers.

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