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Interactive Land use Strategic Assessment (ILSA) Tool:

Scientific Methods and Tool Design

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The Water for a Healthy Country Flagship aims to provide Australia with solutions for water resource management, creating economic gains of $3 billion per annum by 2030, while protecting or restoring our major water ecosystems. The work contained in this report is collaboration between CSIRO, The University of Adelaide, Department of Agriculture, Fisheries and Forestry, Loxton to Bookpurnong Local Action Planning Group, South Australian Murray-Darling Basin Natural Resource Management Board and FieldObs.

For more information about Water for a Healthy Country Flagship or the National Research Flagship Initiative visit www.csiro.au/org/HealthyCountry.html

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Recently established vineyard in Riverland with in-row, drip line irrigation.
Photographer: Jeremy Nelson

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EXECUTIVE SUMMARY

During the first decade of the 20th century two key changes led to much more challenging times for regional irrigators

- The protracted “millennium drought” eroded the reliability of water allocations. The millennium drought produced 3 consecutive years with allocations below 50% of entitlements with the last two of those years requiring special changes to the allocation rules just to ensure some water was available to irrigators.
- Prices for key commodities, especially wine grapes imploded with the growth in domestic supply and international competition and unfavourable changes in the relative value of the Australian dollar

Results of declining water supply and low commodity prices were:

- A decline in area under irrigation, and financial distress for many regional irrigators EBC et al. (2011).
- Interviews, aerial survey data and anecdotal information suggests that in many instances, less productive blocks and blocks in varieties out of market favour were abandoned or fallowed.
- Whilst an ability to buy temporary water on allocation markets allowed many farms to maintain fruit and vine plantings, the cost of that water was high during the drought
- For many irrigators who stayed in production, ‘weathering the storm”, returns were below costs

This report describes the interactive demonstration software developed for use by the community to understand implications of adaptation strategy options under alternative climate change assumptions.

The main tool developed to facilitate this outcome is a computer based user interface Interactive Land use Strategic Assessment (ILSA) for enterprise scale planning with combined scientific and individual production circumstance information in an easy to use and practical format.

Given current levels of development and water allocation rules, the decadal averages in allocations exhibit little variation under the historical climate record.
Intra-decade allocations demonstrate greater variability. In this model this variability is represented as states of nature or years in a decade with similarly classified levels of allocations.

- Normal states of nature represent the most frequent levels of annual allocations in the historical record occurring in 94% of all years. Allocations in the normal state of nature have an average allocation equal to 96% of entitlements and a very small standard deviation of just 5% of entitlement. Normal states of nature are therefore characterised by a consistency and stability of allocations over the historical record.

- The drought state of nature represents years where allocations fall to a level that, if they were to occur in a long enough sequence, they are anticipated to affect changes in the structural mix of irrigation activities such as capital investment decisions and water investments. Drought states of nature have the potential to have considerable impacts on irrigation activities, but only occur in 5.5% of all years in the historical record.

- The dry state represents the more common type of drought situation where allocations fall to approximately 70% of entitlements although the range of variance in this state is quite considerable, from between 60% of entitlement and 80% of entitlement. These types of droughts occur in slightly less than 3% of the 110 years modelled.

- The very dry state represents a drought similar to the millennium drought. Allocations fall to between 25 and 60% of entitlement and occur in less than 2% of the years. Irrigation management activities in this state would include actions such as mothballing crops, exiting the industry or conversion to dryland/annuals, and expensive purchases of water in the market.

- The extremely dry state of nature represents rare dry events. This state is characterised by extremely low levels of allocations equivalent to less than 25% of entitlements. This level of allocation, if sustained, is unlikely to support current levels of irrigation activities in the region. Only one year in the 110 year record would have experienced this level of allocation without policy intervention.

Under the millennium drought scenario, the sample farm experiences a demand for irrigation water even though it had sufficient entitlement capacity in most of the less severe scenarios. The sample farm entitlement falls 29% short of demand under the very dry state of nature allocations and 64% short under the extremely dry state of nature allocation.

The impact of the additional water demand is a small reduction in net returns in the very dry and extremely dry states of nature. Water cost reduces net returns by -$106/ha in the very dry state and -$485/ha in the extreme state. This equates to a 0.25% and 1.2% reduction in returns for the best performing varieties and a 15% to 58% reduction for the worst performing.

Without water trade in the millennium drought losses are incurred in the very worst state of nature for all varieties with a minimum loss of -$11,563/ha to the default variety and a maximum loss of -$21,313/ha the traditionally best performing variety "August Red". On average over the decade, all varieties suffer from the loss of irrigation water with between 15% decrease in average annual net return down to a significant negative net return expressed as a 182% reduction over the decade when compared with the normal historical decade.

The model also considered a decade from a possible future climate scenario with a warmer and drier climate and lower overall allocations. Under this scenario the frequency of years with severe cuts to the levels of allocations occur much more frequently. While the state of nature impact of this scenario is no different to the millennium drought the real impact (although small) is revealed in the ten year average returns and in the varieties with marginal returns.

In this scenario the average annual returns are between 1 and 5% lower than in the normal historical decade for most varieties reflecting the additional cost of water in the drier future decade. However the marginal varieties show a 42% decline in returns as water cost grows and make up a larger share of the total cost of production.

Overall, the impact of the warmer drier climate without water trade was between a 30% reduction in net return to a very significant financial loss of 364% lower net returns. This represents approximately 50% greater reduction in net returns than occurred in the millennium drought.

1. INTRODUCTION

The Farm Ready Climate Change Research Program

The Commonwealth Farm Ready Program is an initiative to assist Australian Agriculture in adapting to climatic variation and change. It includes a Climate Change Research Program fund to support research projects with a farm demonstration emphasis on building agricultural sector resilience to future climate change. It supports large scale and collaborative projects to provide Australian farmers and food industries with practical climate impact mitigation adaptation management solutions

Developing Landholder Capacity to adapt to Climate Risks and Variable Resource Availability in the Bookpurnong and Pyap to Kingston On Murray Regions of the Riverland South Australia Project.

South Australian Murray Darling Basin horticulture and viticulture are a key contributor to both National and State food production with additional key export markets being serviced by its annual production. It is well known that the region is facing a number of challenges; arguably the most significant are River Murray water availability, and allocation reliability, sharing and usage for irrigation purposes. The region recently experienced a severe drought with historically unprecedented reductions in water available for irrigation and the environment. Available prediction (CSIRO, 2008), suggest severe droughts have occurred on intervals of something like 50 years over the historic record and that with climate change even more severe water shortage and allocation variability in the region are a possibility.

This project was motivated by the Riverland irrigation industry's desire to understand potential implications of climate change including strategies to adapt their businesses and management practices. Its overall objectives were to increase the irrigation industries' self reliance and preparedness to adapt to climate change and climate variability by:

- Promoting increased awareness of options and uptake of strategies for dealing with climate change and climate variability.
- Accelerating the uptake of climate change adaptation and mitigation education and training activities.
- Encouraging the uptake of best practice management techniques and strategies to reduce the gap between climate change research and farm practices.

About this report

This report describes the interactive demonstration software developed for use by the community to understand implications of adaptation strategy options under alternative climate change assumptions. A further report (forthcoming) describes the process and outcomes of real farm data used to test scenarios and report on the adaptation response of irrigators to the drought using the ISLA tool (Interactive Strategic Land use Assessment) and comparison of outcomes with those modelled using regional defaults values focussing on experience during the recent millennium drought.

Also included as appendices to this report are copies of:

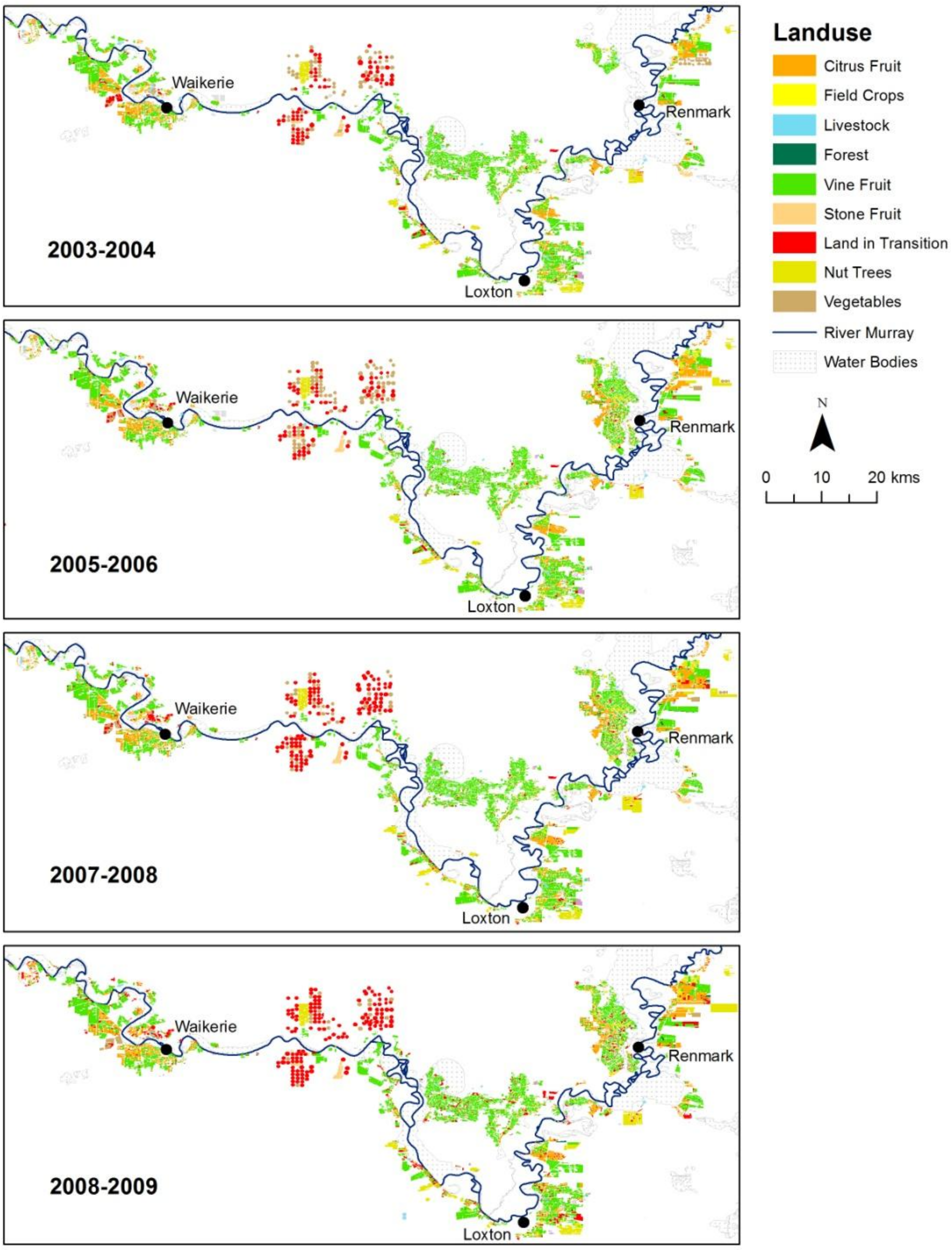
- The instructional users guide for the model (Appendix - Instructional Guide for use of the ILSA tool)
- The one page fact sheet used to promote its use (Appendix - Draft Fact Sheet for promoting the ILSA tool)

2. BACKGROUND

For many irrigators the process of planning for future scenarios relies on previous experience within a relatively stable long term climate. Decisions around crop, irrigation system and, water price were made using farm economics and tacit knowledge of climate based on years of experience. Following years of relative certainty in supply the recent millennium drought sharpened the focus of irrigating with increasingly scarce water supplies. Planning future farm management activities in the face of uncertain and potentially scarce supplies presents a considerable challenge. The science surrounding future climate change impacts are complex, difficult and time consuming to understand. Irrigators have expressed a desire for a simple planning tool to provide some insights and assist them

The geographic focus of this project (Figure 1) is the irrigation regions around Bookpurnong and between Pyap and Kingston on Murray in the South Australian Riverland, on the banks of the Murray River about 255km northeast of the capital of South Australia (Adelaide).

Figure 1 Land Use and location



As shown in Figure 1, the region is dominated by irrigated agriculture, primarily wine grapes and tree fruits such as citrus and stone fruits, with a large portion of the approximate population of 35,000 people involved in this sector. It has experienced considerable expansion of irrigated agriculture over the recent decades. This expansion continued into the 2000's but total irrigated area declined a little throughout the millennium drought period.

- Historically (prior to the mid 2000s) the region experienced very even and predictable levels of water availability for irrigation
- This and high prices for the main products from the region (especially wine grapes), resulted in strong economic returns to regional irrigators
- During the first decade of the 20th century two key changes led to much more challenging times for regional irrigators
    - The protracted "millennium drought" eroded the reliability of water allocations. The millennium drought produced 3 consecutive years with allocations below 50% of entitlements with the last two of those years requiring special changes to the allocation rules just to ensure some water was available to irrigators.

    - Prices for key commodities, especially wine grapes imploded with growth in domestic supply and increased international competition as well as unfavourable changes in the relative value of the Australian dollar
- Results of declining water supply and low commodity prices were:
    - A decline in area under irrigation, and financial distress for many regional irrigators EBC et al. (2011).
    - Interviews, aerial survey data and anecdotal information suggests that in many instances, less productive blocks and blocks in varieties out of market favour were abandoned or fallowed.
    - Whilst an ability to buy temporary water on allocation markets allowed many farms to maintain fruit and wine plantings, the cost of that water was high during the drought
    - For many irrigators who stayed in production, 'weathering the storm", returns were below costs

As a result of this experience, considerable additional uncertainty has been introduced to the process for local irrigators. While future climate change and its uncertainty is well understood by the science community, translations between the hard science and farm level decision processes are required to deepen the understanding of its impact for individual farm level decision makers.

2.1. Interactive Adaptation Strategy Model for Local Irrigators

2.1.1. Introduction

The recent experience with drought and low commodity prices outlined above increased local irrigators understanding of how their production environment now involves considerably greater financial risks than it had previously. Available climate science and hydrologic evaluation suggests that whilst water availability futures are uncertain, there is some probability of future droughts even more severe than the recent millennium drought and this could obviously introduce additional risks.

Going forward, regional irrigators face difficult decisions about:

- whether to continue irrigating given uncertain future water availability,
- whether to remove certain blocks from production,
- whether to update with new varieties, or to abandon the block
- expected returns to future irrigation on average across possible future water availability and market price years, and
- the downside economic risks of possible future droughts

The science community involved in climate and hydrology futures modelling has an understanding of the nature of the possible future climate change, its uncertainty and implications for water availability. However, this information isn't often translated into forms that are suitable for communication to the irrigators. Nor is there much effort to make the linkages between scientific projection and outcomes most important to irrigators in their strategic business planning.

The motivation for this project was a need for translations of this hard science information into a format that facilitates deeper understanding by irrigators of the science and its impact for individual farm level decision making. Irrigation, like other farming enterprises, is characterised by very large variation across enterprises in soils, crops and varieties, marketing arrangement, physical and financial capital, management skill, and risk preferences. Planning for generic "representative enterprises" not accounting for this variation is unlikely to provide truly useful insights to most irrigators. Consequently, this project focussed on developing a framework to:

- present climate, water availability information that is valid across the region and
- allow farmers to add information about production circumstances specific to their individual circumstances
- produce reporting on likely financial outcomes of strategy options that the growers choose to explore, given the climate and water information and their individual enterprise characteristics.

2.1.2. Interactive program overview

The main tool developed to facilitate this outcome is a computer based user interface Interactive Land use Strategic Assessment (ILSA) for enterprise scale planning with combined scientific and individual production circumstance information in an easy to use and practical format.

A detailed user's guide reproduced as an Appendix (36) to this report describes the program and its use in detail. Here we outline it briefly. The user is first provided with information about historic and future climate in decadal sequences. As perennial crop and capital decisions are longer term investments, it is important to consider the longer term influences as well as the annual ones. Irrigators often suggest that they are able to cope with the odd dry year but extended droughts are tough. They are presented with the likely impacts of each scenario and decade on water available to them in the form of allocations and water prices likely to result given those allocation levels. This information is presented both graphically and numerically in a simplified format for ease of understanding. The user is shown a time series of water that would have been available on average by decade over the past 11 decades, <u>had current development and water sharing rules been in place for the entire period</u>. They are also shown how allocation would have varied by year within decades and likely implications for water price. This information is also presented for a climate change scenario.

Each climate change scenario is represented as a 110 year timeline in decadal sequences. Each decade is then classified according the expected/predicted level of allocations. Years with allocations of 95% or greater are not expected to have any impact in irrigation, years with 80-95% allocation are expected to have very little impact on irrigation, years with 60-80% allocation are expected to exert some stress possibly forcing radical change, while years with 25-60% allocation represents extreme drought conditions similar to those experienced in the millennium drought. Any less than 25% allocations and irrigated agriculture at or near current levels would be considered infeasible

Further detail of presentation of this information as it appears to program users is presented in Appendix 7.1 to this report, whilst the scientific basis for the information is described in the next section of this chapter.

Based on this information the user chooses a climate decade as the basis for their planning. A risk adverse farmer might choose a very dry decade under a future with climate change, whereas an optimist might choose an average or wet decade from the historic climate series. The point of the model is to allow exploration of alternative wet to dry decade impacts.

Next, the user provides details about their total entitlement, the area by crop(s), and irrigation system that they would like to consider. The model provides default starting values for crop production budgets, water prices, water allocations based on widely accepted regional sources including Primary Industries and Resources South Australia (PIRSA), the

Australian Bureau of Statistics (ABS) and, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) . The scientific basis for this information is described in the next section. The user can choose to accept these default values or adjust them to suit more farm specific data.

The model output is a graphic and tabular presentation of modelled outcomes that could be expected over the chosen planning decade. This includes expected: costs, returns, water use, opportunities to sell water or need to buy water to meet a gap between available allocations and planned application rates. The information is presented for different types of allocation years (wet normal, dry normal, dry, and very dry). The probabilities of each type of year are also presented as is the expected economic returns (or losses) over the decade as a whole.

The model generates results for the whole farm enterprise as well as for each individual irrigation activity described. For farms with just one activity the whole farm and individual crop will both be the same.

The example used below shows the whole of farm results and the results for a crop (citrus) grown on that farm. The first figure describes the whole of farm outcomes in graphical representations under each state of nature for both profit and water use. The water use graphic also displays the breakdown of the water account in terms of water used, allocated and surplus/deficit under each state of nature (type of water allocation year). Farmers are able to use the whole of farm results to maximise returns and observe overall levels of water use and understand possible financial risks in low water availability years. The water account provides an indication of how water is being used on the farm and is a starting point for further investigations into improving the returns to water.

Figure 2 describes the individual crop accounts in both graphical and numerical formats to allow the farmer to conduct deeper investigations into all elements of the costs and efficiencies associated with each crop. The two graphical outputs follow the same format as the whole of farm outputs while the numerical table shows a much higher level of detail. The numerical table contains all of the input data used to generate the results but also includes volumes of water that were used and purchased and the total profit for that crop. It is important to note that the proportion of total available farm water assigned to each crop in a multi crop farm will be equally assigned if there is insufficient water available. The ability to conduct more detailed investigations at the individual crop level within the context of the whole of farm, allows the farmer to identify how and where improvements can be made to increase the profitability of the whole farm.

State Of Nature	Years/10	Alloc (%)	Applied (ML/ha)	Yield (t/ha)	Crop ($/t)	Irrig ($/ha)	Op Costs ($/ha)	Fixed ($/ha)	Price ($/ML)	Used (ML)	Bought (ML)	Profit ($Total)
Wet	7	100.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 17.30	95	27	$ 24627
Normal	0	0.00	0.0	0.0	$ 0	$ 0	$ 0	$ 0	$ 60.00	0	0	$ 0
Dry	1	70.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 100.06	95	48	$ 20344
Very Dry	1	40.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 245.74	95	68	$ 8422
Extremely Dry	1	20.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 501.24	95	81	$ -15718
Ten year average	10	83.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 96.81	95	0	$ 18544

Figure 2 Example results outputs showing whole of farm and one of the crops grown

3. SCIENTIFIC BASIS FOR THE ILSA INTERACTIVE PROGRAM

3.1. Climate Data

The ILSA tools scientific basis is predicated on the influence of the prevailing climate conditions on the expected level of water allocation for irrigation activities under multiple climate scenarios. As the prevailing conditions become hotter and drier and the water storage levels fall the level of allocations also tend to fall. This model considers the impact historical climate conditions would have had on historical allocations under the current levels of irrigated development. It then also considers the impact that we might expect under future climate change conditions again with current levels of irrigated development.
The Loxton district is characterised by a hot and dry climate with annual temperatures averaging just below the 30^{0}C mark and can spike to as much as 47^{0}C. Overnight low temperatures average around the 5-6^{0}C mark but have fallen as low as -5.6^{0}C. Rainfall is fairly limited, with the majority falling in the non-growing season months. Loxton has received on average around 270mm of annual rainfall, although generally as little as 25% of this falls in the months from December to April.

The long term historical climate records for Loxton were obtained from the Bureau of Meteorology and analysed to identify long term trends in rainfall and temperature. Historically the Loxton region has seen a drying trend in climate as well as an increase in maximum temperatures and a decrease in minimum temperatures. The trend in winter rainfall reflects the overall trend with decreasing rainfall, increasing evaporation, higher maximum temperatures and lower minimum temperatures.

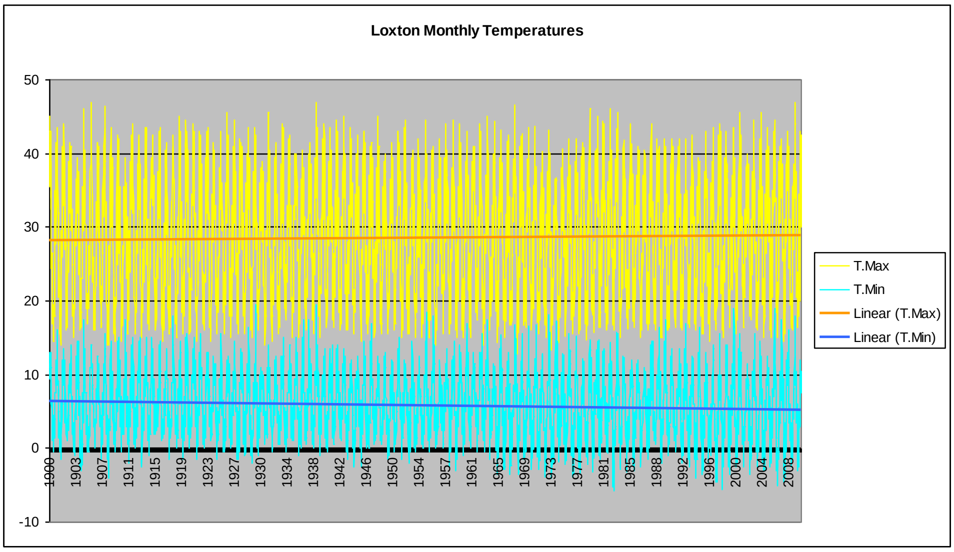


Figure 3 – Average annual temperatures for Loxton from the historical record

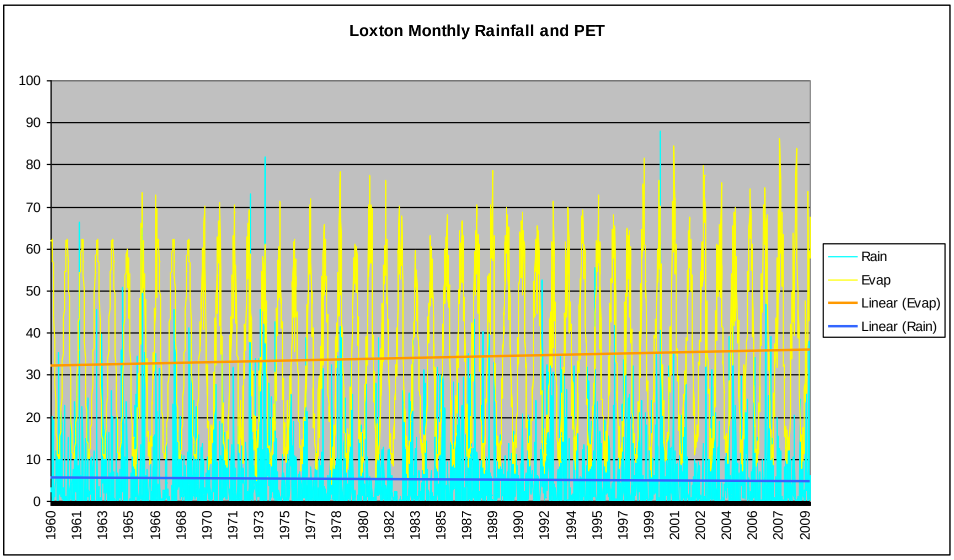


Figure 4 - Average annual rainfall and Potential evapotranspiration for Loxton from the historical record

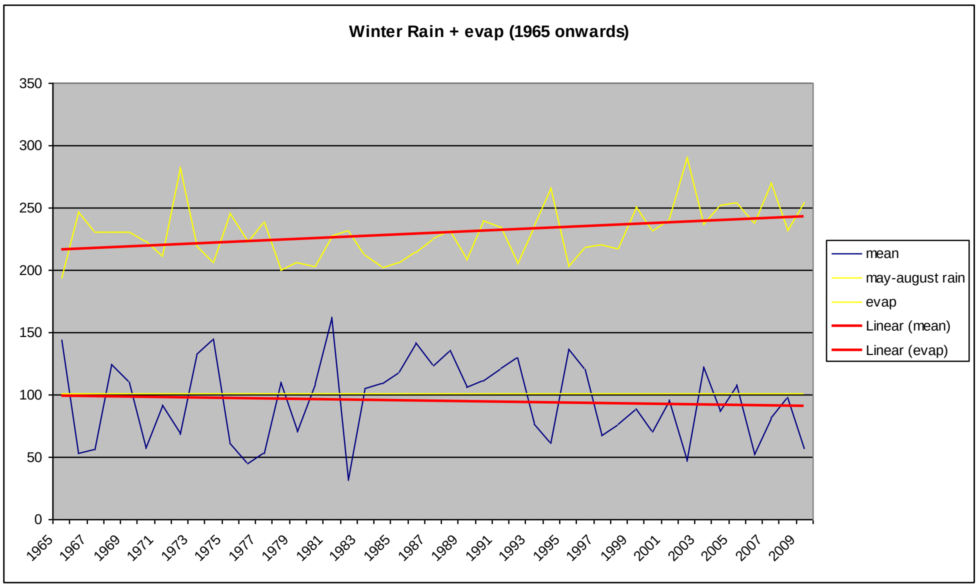


Figure 5 Average winter rainfall and Potential evapotranspiration for Loxton from the historical record (1965 onwards only)

3.2. Scientific Basis for Climate Change Scenarios

To provide an indication of the likely impacts of a feasible future change in climatic conditions, the water use account developed as part of the Lower Murray Landscape Futures project was used (Connor et al 2007). This model predicts the inflows into the upstream reaches of the Murray-Darling Basin that supplies South Australian irrigators under various climate change conditions. The climate change scenarios used in this study were chosen because they represent the best available modelling of climate change impacts on inflows for the basin and represent scenarios that are consistent with those used by the IPCC.

In total, the Connor et al 2007 study investigated three possible future climate change scenarios. A mild climate change scenario characterised by a 1^0C increase in average annual temperature, a 4% increase in average annual potential evapotranspiration and, a 5% decrease in average annual rainfall. A moderate climate change scenario characterised by a 2^0C increase in average annual temperature, a 8% increase in average annual potential evapotranspiration and, a 15% decrease in average annual rainfall. A severe climate change scenario characterised by a 4^0C increase in average annual temperature, a 15% increase in average annual potential evapotranspiration and, a 25% decrease in average annual rainfall.

Importantly, this modelling was conducted in late 2006 and therefore does not include the Millennium drought experience within its outputs. The Millennium drought represents the most significant drought on the historical record and as such it was considered vital to include in the study. Climate change modelling for the millennium drought does not currently exists and therefore outputs for this decade were generated separately using inputs from other studies.

3.3. Allocations

Without adequate levels of allocation, irrigation agriculture cannot produce economically viable crop yields. Therefore as far as irrigated agriculture businesses is concerned, allocations represent their lifeblood. The base allocation database used in this study (hereafter historical allocation) is derived from MSN BigMod which calculates expected allocations throughout the historical climate record assuming current levels of irrigated development and water allocation rules existed throughout the historical record. The advantage of using this dataset is that it provides an indication of the variance in allocations we might expect to be represented in the historical climate record. The model calculates expected annual allocations from 1900 through to 2009. South Australia has a basic entitlement for irrigation of 550GL per year. The historical allocation record contains 27 years in the record where allocations exceed the base level of entitlement (over allocation years).

While inter-annual variations in allocations exert an influence on irrigated farm management decisions, most irrigators make economic planning decisions that are robust enough to survive short term fluctuations in water supply. Management approaches such as deficit irrigation or mothballing allow irrigators to wait out short term shortfalls in water supply while some of the more “savy” farm managers have benefited from trading in the water markets to mitigate losses from allocation shortfalls. More important to irrigators are the long run allocation shortfalls. Long term or decadal sequences of allocations provide irrigators with the necessary information for longer term planning decisions including capital asset investment, crop choice and opting out of irrigation altogether. However this does not exonerate irrigators from the burden of extreme events such as those experienced in the millennium drought. Low frequency high impact events can be potentially as damaging as longer term less severe events.

3.3.1. Allocation Modelling Results

In response to this multi-temporal decision matrix we have analysed the historical allocation record at both the decadal time step as well as annually. When considering the decadal time step we assessed the average annual allocation over the decade to determine the expected dryness of the decade. Results of sorting historical decades in order of ten year average allocation level are shown in Figure 6.

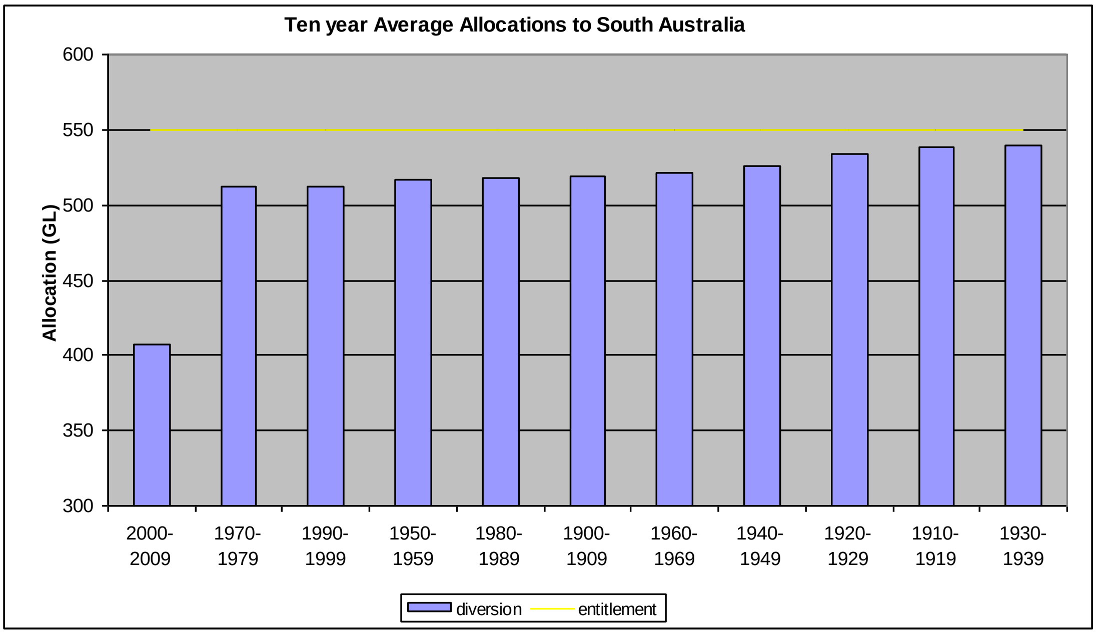


Figure 6 – Ten year average allocations based on historical inflows and current levels of development and allocation rules.

As shown in Figure 6, within the historical record, annual allocations have generally fluctuated (with little deviation from the mean) around the long term average. If we exclude the last two very dry years in the record then the standard deviation about the mean is only 9% of entitlements and across all years this rises to 14% of entitlements.

Notably, the millennium drought which occurred through the latter half of the 2000’s produced an average annual allocation over the 2000’s equal to roughly half of the next driest decade. No decade produced an average annual allocation level equal to or in excess of the states irrigation sector entitlements suggesting that SA is unlikely to ever receive its full entitlement consistently over an entire decade. Over the entire historical record the average decade receives allocations equal to approximately 93% of full entitlement.

As can be seen in Figure 7, despite relatively even, decadal average water availability, current allocation rules and development would have led to some individual years of quite low allocation. For example 1904 and 1946 would have been very low allocation years under the current rules.

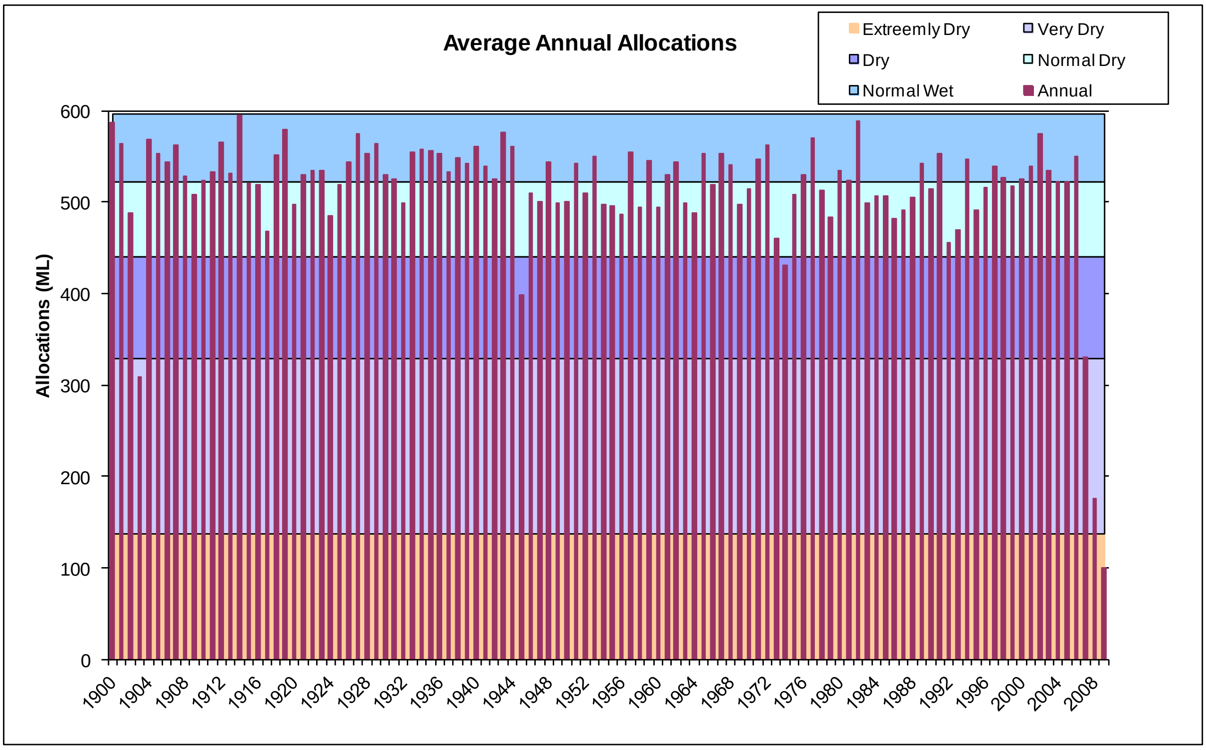


Figure 7 – Modelled average annual allocations using the historical climate dataset. Horizontal bands indicate how states of nature were classified.

3.3.2. States of Nature

For the purpose of modelling and ease of understanding we have characterised annual allocations into states of nature. These states of nature represent probabilities of certain levels of allocations occurring throughout time. The states of nature do not define exact levels of allocations in volumetric measures but rather define specific proportions of allocation that represent the likely average for that state. This study represents states of nature with five different allocation levels.

- Normal wet years with allocations of 95% or greater
- Normal dry years with 80-95% allocation
- Dry years with 60-80% allocation
- Very dry years with 25-60% allocation
- Extremely dry years with less than 25% allocations

The frequency of types of allocations by decade for the historical climate scenario are shown in Table 1.

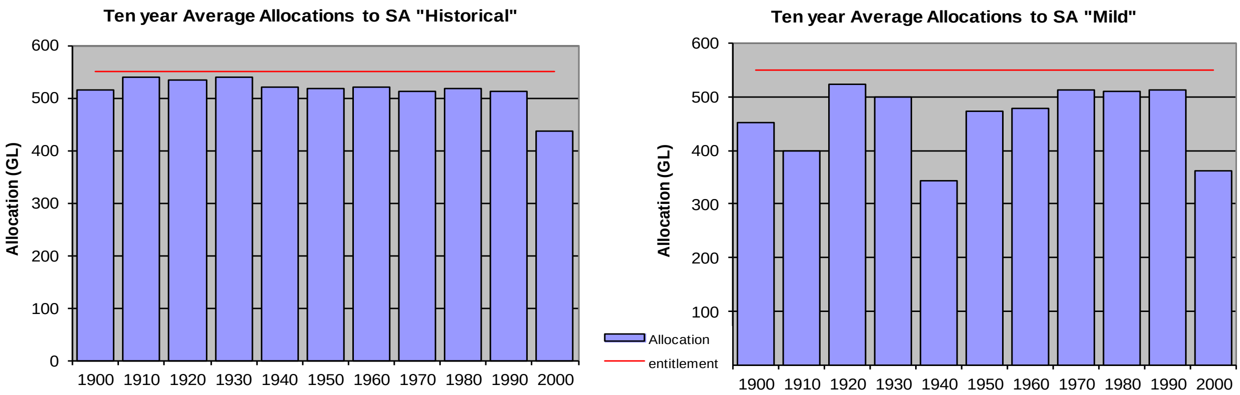
	Normal		Drought		
decade	Wet (>95%)	Dry (80 - 95%)	Dry (60 - 80%)	Very Dry (25 - 60%)	Extremely Dry (<25%)
1900-1909	7	2	0	1	0
1910-1919	7	3	0	0	0
1920-1929	7	3	0	0	0
1930-1939	9	1	0	0	0
1940-1949	6	3	1	0	0
1950-1959	4	6	0	0	0
1960-1969	5	5	0	0	0
1970-1979	4	5	1	0	0
1980-1989	4	6	0	0	0
1990-1999	4	6	0	0	0
2000-2009	7	0	1	1	1

Table 1 – Number and level of allocation years in ten for each of the decades in the historical time period.

Normal states of nature represent the most frequent levels of annual allocations in the historical record occurring in 95% of all years. Allocations in the normal state of nature have an average allocation equal to 96% of entitlements and a very small standard deviation of just 5% of entitlement. Normal states of nature are therefore characterised by a consistency and stability of allocations over the historical record. Normal states of nature are broken into two separate states, the normal wet and the normal dry. Normal wet states of nature are defined as the probability of allocations exceeding 95% of entitlements and this state occurs in 58% of all years. Normal dry states of nature are defined as years where the allocations exceed 80% of entitlements but not 95%. Normal dry states of nature occur in approximately 36% of all years in the historical record.

In contrast to the normal state is the drought state of nature. The drought state of nature represents years where allocations fall to a level that if they were to occur in a long enough sequence they are anticipated to affect changes in the structural mix of irrigation activities such as capital investment decisions and water investments. Drought states of nature have the potential to have considerable impacts on irrigation activities but only occur in 5.5% of all years in the historical record. Drought states are broken into three categories; the dry, the very dry state and the extremely dry state.

The dry state represents the more common type of drought situation where allocations fall to approximately 70% of entitlements although the range of variance in this state is quite considerable from between 60% of entitlement and 80% of entitlement. The very dry state represents a drought similar to the millennium drought. Allocations fall between 25% and 60% of entitlement. . Irrigation management activities in this state would include actions such as mothballing crops, exiting the industry or conversion to dryland/annuals, and expensive purchases of water in the market. The extremely dry state of nature represents rare dry events. This state is characterised by extremely low levels of allocations, equivalent to less than 25% of entitlements. This level of allocation, if sustained, is unlikely to support current levels of irrigation activities in the region.



	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Wet	7	7	7	9	6	4	5	4	4	4	7
Normal	2	3	3	1	3	6	5	5	6	6	0
Dry	0	0	0	0	1	0	0	1	0	0	1
Very Dry	1	0	0	0	0	0	0	0	0	0	1
Extremely	0	0	0	0	0	0	0	0	0	0	1

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Wet	3	2	7	6	0	2	3	4	4	4	2
Normal	1	3	2	1	4	7	5	5	5	6	4
Dry	1	2	1	3	2	0	1	1	1	0	1
Very Dry	4	3	0	0	2	1	1	0	0	0	0
Extremely	1	0	0	0	2	0	0	0	0	0	3

Figure 8 The ten year average allocations by decade and the corresponding frequency of years within each decade as defined by the states of nature for the historical (left) and mild climate change scenario (right).

Figure 8 (above left) presents a modelled representation of expected allocations under the current (2010) water allocation rules and levels of development given historical climatic conditions. It does not consider abnormal scenarios such as out of context negotiated water carry over for exceptional years nor is it intended to present a true representation of actual historical allocations. The graph present the average annual allocations for each decade while the table describes the number of individual years that meet the allocation criteria for each defined state of nature. Figure 8 (above right) presents the expected allocations under a mild warming and drying climate change scenario. Allocations are modelled under the same rules and conditions as the historical dataset with reductions generated by modelled contractions in basin inflows resulting from a mild warming and drying climate. The graph (Figure 8) shows the increased likelihood frequency of decade with low average annual allocations while the corresponding table (Table 1 – Number and level of allocation years in ten for each of the decades in the historical time period.) details the increased frequency of drought years within the decades.

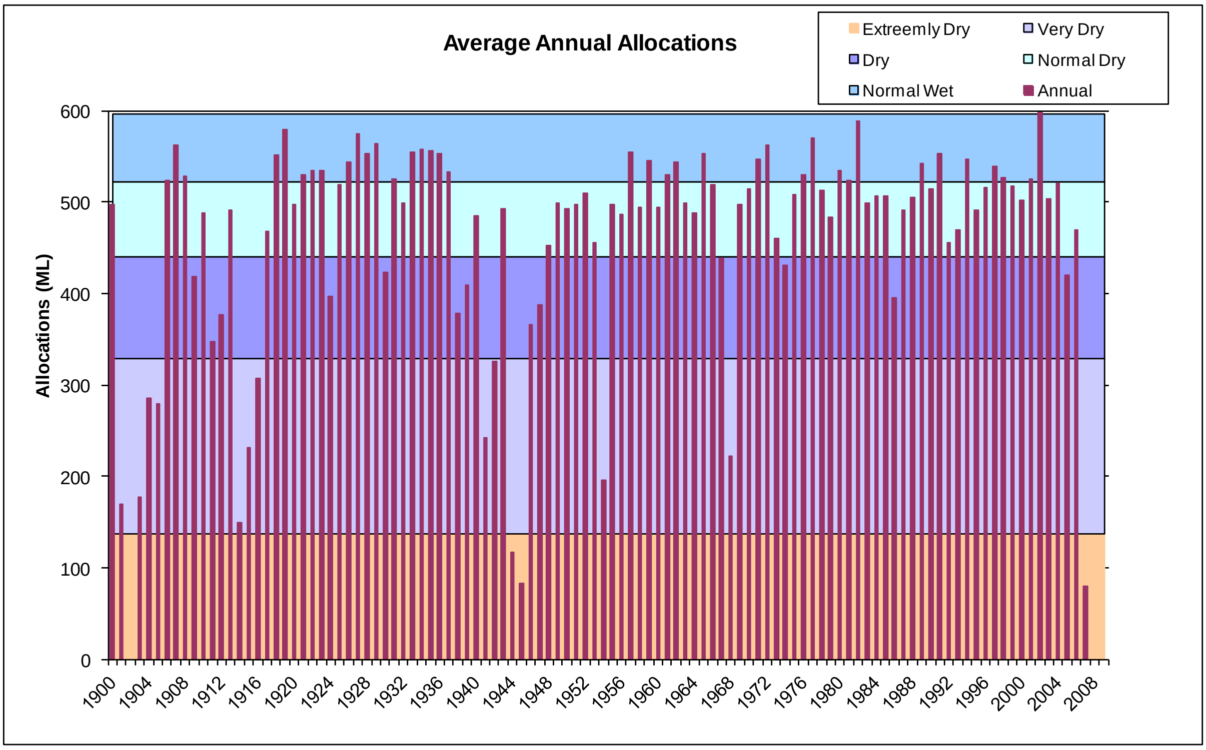
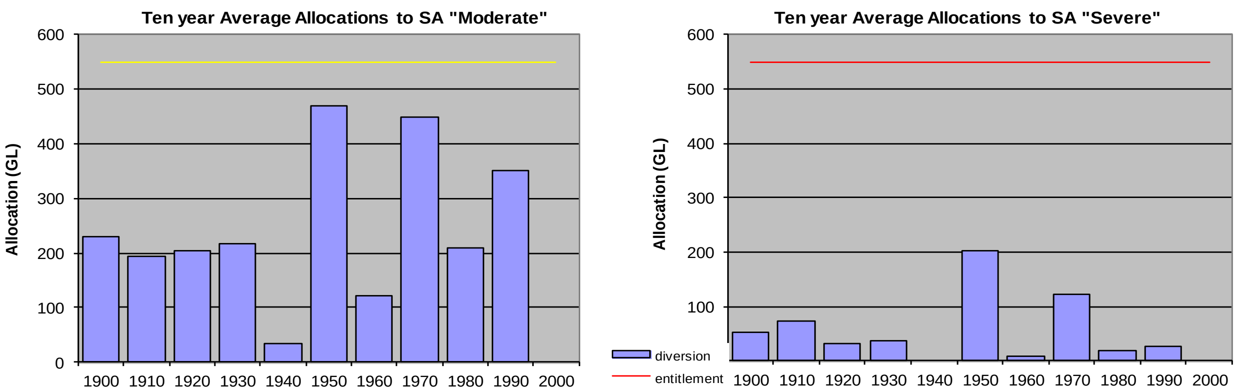


Figure 9 Modelled average annual allocations with states of nature thresholds for the “mild” climate change scenario

Figure 9 above presents the expected average annual allocations under the “mild” climate change scenario. When compared with the historical scenario, the mild scenario presents a higher frequency of years with low levels of allocations including a number of years with extremely dry states where irrigation activities are likely to experience considerable stress.



	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Wet	0	2	1	1	0	2	0	4	0	0	0
Normal	0	1	0	1	0	7	0	2	2	4	0
Dry	0	0	1	0	0	0	1	3	0	1	0
Very Dry	1	1	3	5	0	1	3	0	4	4	0
Extremely	9	6	5	3	10	0	6	1	4	1	10

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Wet	0	1	0	0	0	0	0	0	0	0	0
Normal	0	0	0	0	0	1	0	0	0	0	0
Dry	0	0	0	1	0	2	0	1	0	0	0
Very Dry	0	1	1	0	0	3	0	2	0	1	0
Extremely	10	8	9	9	10	4	10	7	10	9	10

Figure 10 The ten year average allocations by decade and the subsequent years in ten that describe the annual distributions of allocations with each decade for the moderate (left) and severe climate change scenarios (right).

Figure 10 presents the expect allocations under a moderate warming and drying (above left) and a severe (above right) warming and drying climate change scenario. Allocations are modelled under the same rules and conditions as the historical dataset with reductions generated by the modelled contractions in basin inflows resulting from a moderate or a severe warming and drying climate. No allocations were able to be generated for the millennium drought and no figures are presented for the 2000's. In both of these scenarios the frequency of severe drought conditions would place irrigated agriculture in considerable stress and probable decline. Given the modelled prevailing conditions and the poor quality of the millennium drought period these two scenarios were not included in the ILSA tool itself.

3.4. Model Inputs

3.4.1. Crops

Six major crop/commodity groups are provided as a starting point. These crop classes broadly represent most of what is grown in the Loxton region and provide sufficient separation to the modelled outputs. Crop groups include;

Citrus-	based on Navel oranges but versatile input parameters allows most form of citrus fruits and varieties to be covered.
Grapes –	Based on a generic high volume wine grape, this commodity class is expected to express considerable variation in input parameters.
Nuts –	based on almonds
Stone fruit –	based on Apricots
Vegetables –	based on potatoes
Field crops –	based on irrigated wheat

Table 2 Crop commodity classes used in the model

3.4.2. Irrigation Activity

Like the crop/commodity classes irrigation methods are wide and varied depending on the irrigator's level of skill, financial capability, preference and access to pressurised water supplies. This model groups irrigation methods into five classes:

Pivot.
Flood.
Overhead.
Drip.
Under Canopy.

3.4.3. Economic Variables

Economic data for the region is fairly limited and reasonably simple, equating to price of commodity, and costs of production. We do not have any change over costs (i.e. the cost to change from one system to another), capital costs are defined by crop and irrigation system type while operating costs are only those not relating to irrigation and are defined by crop type.

Crop prices – determined as default values from PIRSA

Production costs

- irrigation costs - irrigators consider this the cost of irrigation only and do not consider this to include any capital costs or the cost of water

- Operating costs are the variable operating costs aside from those considered irrigation costs
- Fixed costs include all fixed capital (including irrigation capital), fixed labour and fixed operating costs.

Importantly it is difficult to present economic data (particularly cost data) that all users will find suitable. Variations in the level of skill, experience, approach and preference all serve to shift the expected cost of production between farms and in some cases even between paddocks. All of the price and cost data is presented as a default value by crop. For each of the cost parameters the default values are also presented by irrigation method used. Users may choose to modify these defaults to suit their own circumstances.

	yield (t/ha)	price ($)	ML/ha	irrigation ($)	Operating ($)
citrus	45	300	9.5	586	5284
grapes	9	1400	4.45	286	3650
nuts	2.45	7000	12	486	4413
field crops	5	290	8.75	180	345
stone fruit					6285
vegetables	37	370	5.3	236	4062

Table 3 Principle economic inputs, used as default values in the model

	citrus	wine	Nuts	fc	Apricot	Veg
flood	2856.974	2882.357	2731.687	566	2735.288	1585.255
overhead	3620.304	3645.687	3495.017	766	3498.618	2348.585
under canopy	3620.304	3645.687	3495.017	1787.74	3498.618	2348.585
drip	3710.844	3736.227	3385.557	7660	3389.158	1326.845
pivot	2598.564	2623.947	2473.277	1992.09	2476.878	2552.935

Table 4 Fixed capital costs per hectare of irrigation infrastructure by crop commodity class

3.4.4. Water price

To characterise the relationship between water scarcity and the price that growers are likely to experience in the water market we used a regression analysis approach. Adopted from, and more completely documented in, Connor et al (2011), the approach follows Brennan (2006) who estimated the relationship (equation 1) between water allocation and water prices using actual allocations and water prices experienced from 1998 to 2004.

$$\ln(P_w) = 7.84 - 1.308A - 0.00718R \quad (1)$$

where P_w is the price of water ($/ML) and A is allocation as a percentage of entitlement.

The predicted water prices by state of nature used in this study as default prices are reported in Table 5

State of Nature	Normal Wet >95%	Normal Dry 80 - 95%	Dry 60 - 80%	Very Dry 25 - 60%	Extremely Dry <25%
Water Price ($)	17.29	60.00	100.06	245.74	501.24

Table 5 Estimated water price by state of nature for purchases in the water market.

3.4.5. Crop water production function

The relationship between water and crop or plant productivity is of high importance for optimising operations on an irrigated agricultural enterprise. Our model has evolved through a consultative process with irrigators to a default function that has been derived from previous functions and empirical data. We begin by following the approach of Connor et al 2011 by using a quadratic crop water production function of the form as displayed in equation #

$$Y = \alpha 1 + \alpha 2 \cdot W + \alpha 3 \cdot W \quad (3)$$

While it is common to estimate the parameter values for such production functions through agronomic approaches using crop water trials. Here we derive the parameters using an economic calibration approach. Starting with the assumption that irrigators have the objective of applying water at a rate that maximises profit per hectare we solve for the three unknowns α1, α2, and α3. From information entered on observed yields and water application rates together with the choice of water application we derive an equation where water is applied until the marginal return to water is equal to the marginal cost per unit water.

				Crop (t/ha)		
Water Application Rate		**grapes**	**stone fruit**	**nuts**	**citrus**	**pasture**
ML/ha	**2.5**					**5.5**
	3					**6.29**
	3.5					**6.96**
	4	**23.93**				**7.53**
	4.5	**24.7**				**7.99**
	5	**25.1**				**8.35**
	5.5	**25.11**				**8.59**
	6		**17.01**	**2.84**	**47.25**	**8.74**
	6.5		**17.32**	**2.89**	**48.11**	**8.77**
	7		**17.59**	**2.93**	**48.87**	
	7.5		**17.82**	**2.97**	**49.51**	
	8		**18.02**	**3**	**50.05**	
	8.5		**18.17**	**3.03**	**50.48**	
	9		**18.29**	**3.05**	**50.8**	

Table 6 empirically derived estimates of crop water production values.

The crop water production figures produced through this process provide only a small portion of the production function curve. Complete curves were fitted to the data that mimicked as closely as possible the original curve (Figure 11).

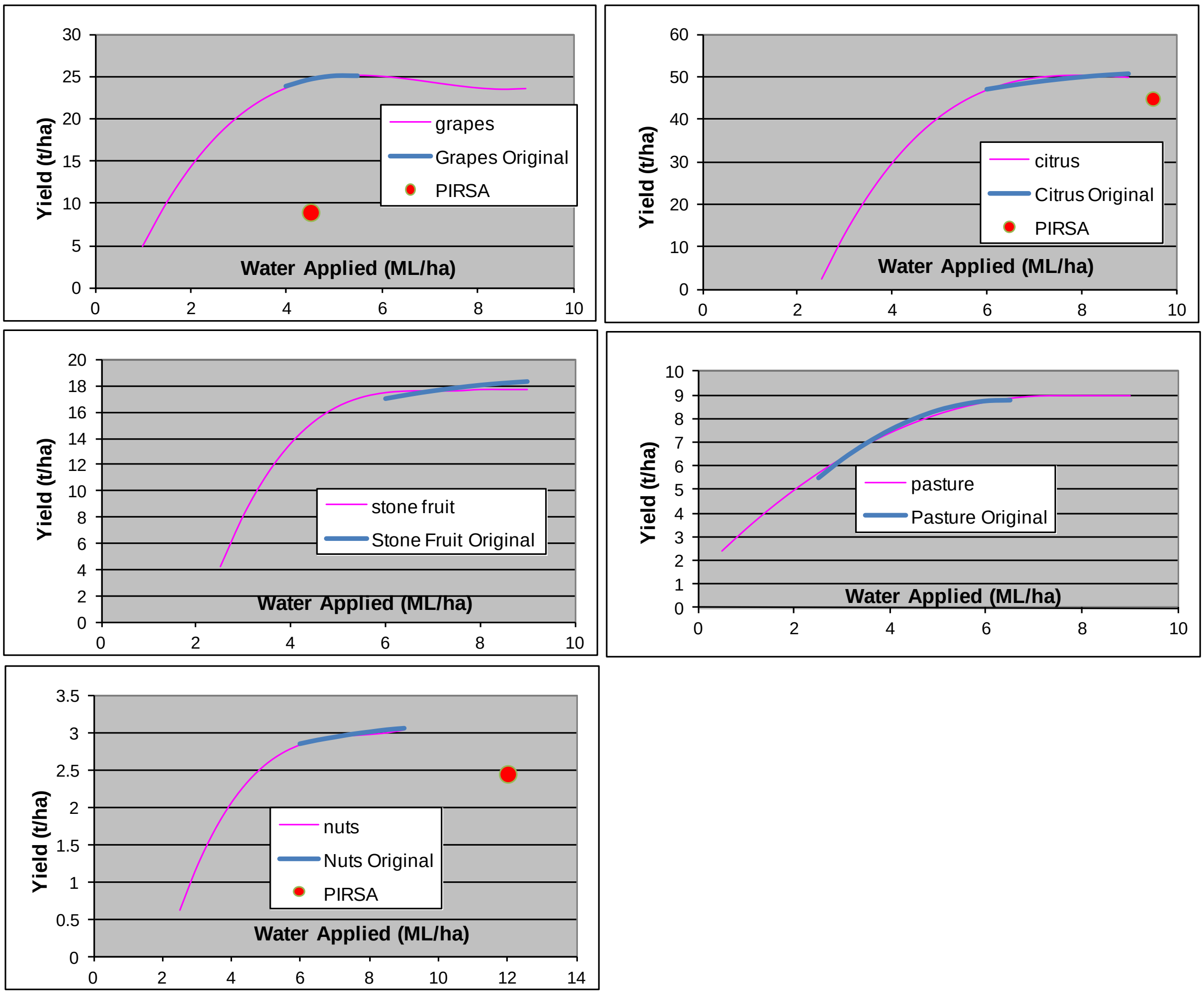


Figure 11 Crop water production curves including empirically derived, fitted and PIRSA point values.

Irrigators in the region and the project partners expressed concerns that these values might not be considered accurate given that they are figures published by Primary Industries and Resources South Australia (PIRSA) in their irrigated agriculture fact sheets (a resource commonly referred to by irrigators in the region). Inspection of the PIRSA fact sheet published indicated that their figures were very broad regional estimates with a single water application values and a single corresponding yield estimate. In the case of grapes two distinctly different commodity classes are produced (wine grapes vs. table grapes) both requiring vastly different water application rates to optimise returns. It is clear that in the future production functions will need to be derived for both wine and table grapes separately. In all cases (except grapes) the PIRSA figures present a much less efficient use of water than the empirically derived estimates. This may be a result of the age of the facts sheets and the improved efficiency of irrigators since their original publication. As a result the model itself provides the derived functions as its first estimate for crop water production values but retains the flexibility to allow irrigators to input their own values.

3.4.6. Profit function

The primary decision variable in the model is total farm profit. Within this modelling framework profit is considered on two planning horizons. Firstly the annual farm profit presented both at a crop and a farm level. And secondly in order for farmers to make longer term capital investment and planning decisions we consider farm profit over the longer (10 year) time frame.

Annual outcomes are expected to vary by individual states of nature, for example lower returns are expected in very low allocation states. Equation X describes returns for any given year as the commodity price times yield as a function of water application rate less costs not associated with water. Any water bought or sold on the water market is captured in the function as a additional cost or revenue to the operation.

$$(p_{s\ j} * Y_{s,j}(W_{s,j}) - pw_s * (W_{s,j} - wa_{s,j}) - vc_{s,\ j} - fc_{s,\ j}) * AI_{s,j}$$

The parameters and variables in the model are indexed by crop j (grapes, citrus, stone fruits, nuts, vegetables, and field crops) and state of nature s (States 1−5). These states of nature represent the frequency of allocations estimated to be available for irrigation diversion as categorised into five allocation percentage classes. These states of nature are described in detail in section 3.3.2. Each state of nature has a representative frequency (pr_s) that describes how often that level of allocation class could be expected to appear in a given decade.
$AI_{s,j}$ is area (hectares) available for crop j that is irrigated in state of nature s. $Y_{s,j}$ is yield (tonnes) and $W_{s,j}$, is the water applied (ML/ha). The production function characterising yield as a function of water is described below.

Parameters are represented by lower case letters where fc_j represents the crop establishment and irrigation establishment costs treated as an annual cost;
$p_{s,j}$ is the crop price per tonne of yield;
pw_s is the market equilibrium price per unit water traded on the market and $wa_{s,j}$ represents the allocation of water in state of nature s for crop j;
vc_j represents variable costs of production for crop j not related to irrigation. Table 3 and Table 4 summarise the values of economic parameters fc_j; p_j; and; vc_j assumed in the analysis.

The long run average profit over the 10 year planning horizon is also considered in the equation

$$\Pi = \sum_s pr_s * \left(\sum_j (p_j * Y_{s,j}(W_{s,j}) - pw_s * (W_{s,j} - wa_{s,j}) - vc_j - fc_j *) \right) * AI_{s,j}$$

Profits from each individual state of nature are averaged over the decade by calculating the state of nature probability weighted average of all states in the decade.

4. APPLYING THE ILSA TOOL TO LOCAL IRRIGATOR DATA

In this section we include real farm and test data scenarios to report on the adaptation response of irrigators to drought using the ISLA tool. We compare modelled outcomes with actual farm data inputs and see how it compares with regional defaults focussing on experience during the recent millennium drought and possible future droughts.

4.1. Default parameter results

As the model allows the user complete autonomous control of almost all input parameters it results in an almost limitless number of combinations for any one farm scenario. It is not realistic to represent all possible scenarios. Given the large degree of uncertainty surrounding many of the input parameters the model was initially run using default data only across a limited set of climate decades and input parameters. This simulation run is simply for demonstration purposes rather than for analytical interrogation. We model using the default values for all crops under drip irrigation with an intended application rate of 6 ML/ha. The simulation assumes there are no impediments to trade and water can be freely bought but not sold (water is not sold to reflect the risk adverse nature of many irrigators and to remain consistent with the behaviour of irrigator behaviour used in the real data assessment). This simulation is modelled at one hectare only and assumes the irrigator has an irrigation entitlement of 8ML to allocate to that hectare. Each state of nature recalculates to entitlement based on the specific allocation percentage for that state and subsequently assigns the appropriate level of irrigation allocation in ML.

Climate scenario one is based on the 1940's decade within the historical climate dataset. It is representative of a majority of years in the dataset with 9 out of 10 years producing normal levels of allocations. The result is that irrigators only experience one year where the level of allocation is below their demand for water. Table 7 below shows the expected annual profit under each commodity using the default settings by climate state of nature.

	Normal Wet	Normal Dry	Dry	Very Dry	Extremely Dry	average
Grapes	$6,775.19	$6,775.19	$6,735.17	N/A	N/A	$6,771.19
Stone Fruit	$7,287.89	$7,287.89	$7,247.86	N/A	N/A	$7,283.89
Nuts	$8,461.51	$8,461.51	$8,421.49	N/A	N/A	$8,457.51
Citrus	$8,998.27	$8,998.27	$8,958.25	N/A	N/A	$8,994.27
Field Crops	$2,223.12	$2,223.12	$2,183.10	N/A	N/A	$2,219.12
Vegetables	$4,738.17	$4,738.17	$4,698.15	N/A	N/A	$4,734.17

Table 7 Net returns to irrigation as modelled using default settings under the historical normal scenario

As is evident in Table 7 above the expected annual profit under each state of nature is largely unaffected by the state apart from a very small demand for water in the dry state. This demand equates to just $40.00 worth of water on the market (0.4 ML at $100/ML). This small cost represents less than 1% of annual profit for the state of nature in which it is incurred with the exception of field crops where it is just less than 2%.

Climate scenario two is based on the millennium drought experienced in the late 2000's. This decade is the worst on record for irrigation in the region and is characterised by 7 years in 10 with normal levels of allocations and 3 years in 10 with increasingly severe allocations. Irrigators in this decade are exposed to allocation levels below their demand for water in 3 of the 10 years.

	Normal Wet	Normal Dry	Dry	Very Dry	Extremely Dry	average	% change from climate scenario one
Grapes	$6,775.19	N/A	$6,735.17	$6,087.12	$4,569.74	$6,481.84	-4.27
Stone Fruit	$7,287.89	N/A	$7,247.86	$6,599.82	$5,082.43	$6,994.53	-3.97

Nuts	$8,461.51	N/A	$8,421.49	$7,773.44	$6,256.05	$8,168.15	-3.42
Citrus	$8,998.27	N/A	$8,958.25	$8,310.20	$6,792.81	$8,704.91	-3.22
Field Crops	$2,223.12	N/A	$2,183.10	$1,535.05	$17.66	$1,929.77	-13.04
Vegetables	$4,738.17	N/A	$4,698.15	$4,050.10	$2,532.72	$4,444.82	-6.11

Table 8 Net returns to irrigation as modelled using default settings under the historic drought scenario.

Table 8 shows the annual profits under each state of nature in the 2000's decade. The reduced allocation produces an increased demand for water with the average annual cost of water rising from approximately $4.00/ha/yr to $293.35/ha/yr or a 73 fold increase in water costs. The additional water cost translates to between 3 and 13% reduction in average annual returns in the millennium drought decade.

Climate scenario three represents a future drought scenario where irrigators are faced with a warmer and drier climate and subsequently fewer full allocation years and more drought years. This decade is characterised by drought in 6 of the 10 years of increasing severity and just 4 years in 10 with the normal dry state of nature. This decade contains no years with full allocations.

	Normal Wet	Normal Dry	Dry	Very Dry	Extremely Dry	average	% change from climate scenario one
Grapes	N/A	$6,775.19	$6,735.17	$6,087.12	$4,569.74	$6,188.48	-8.61
Stone Fruit	N/A	$7,287.89	$7,247.86	$6,599.82	$5,082.43	$6,701.18	-8.00
Nuts	N/A	$8,461.51	$8,421.49	$7,773.44	$6,256.05	$7,874.80	-6.89
Citrus	N/A	$8,998.27	$8,958.25	$8,310.20	$6,792.81	$8,411.56	-6.48
Field Crops	N/A	$2,223.12	$2,183.10	$1,535.05	$17.66	$1,636.41	-26.26
Vegetables	N/A	$4,738.17	$4,698.15	$4,050.10	$2,532.72	$4,151.46	-12.31

Table 9 Net returns to irrigation as modelled using default settings under the future drought scenario

Table 9 above shows the expected annual profits under each state of nature in the future drought scenario. In this scenario the additional average annual cost of water increases again to $586.71. This represents a doubling of the cost in the millennium drought and a near 150 fold increase from a normal year in the historic climate dataset. The effect of the reduced water allocation would equate to between 6.5 and 26% decrease in returns. It is improbable that all the water demanded would be available to trade under this scenario. Assuming that no water is available for trade the scarcity impact would equate to an additional 40 to 90% reduction in returns.

It would be possible to observe greater adaptation capabilities with an increase in the water application decisions that irrigators would be likely to make and ability to trade water out. Changes in the mix of crops, the price of commodities and water and the costs of irrigation activities are all factors in the likely adaptation response. These options have not been modelled for this report.

4.2. Real farm data results

Farm data from a local stone fruit grower was used to test the model under multiple climate decades, water prices and commodity prices. The data provided was for stone fruit production over three recent years and included, up to 33 varieties, yields, costs associated with production, prices received and total returns. The total water use data on farm and the grower's entitlement was also provided. However information on crop water production functions and or the rates of water application by variety were not provided. During the three years of records the grower expanded his operation slightly and traded some water entitlements for infrastructure upgrades. As a result it was decided to use an average of the three years as inputs to test the model.

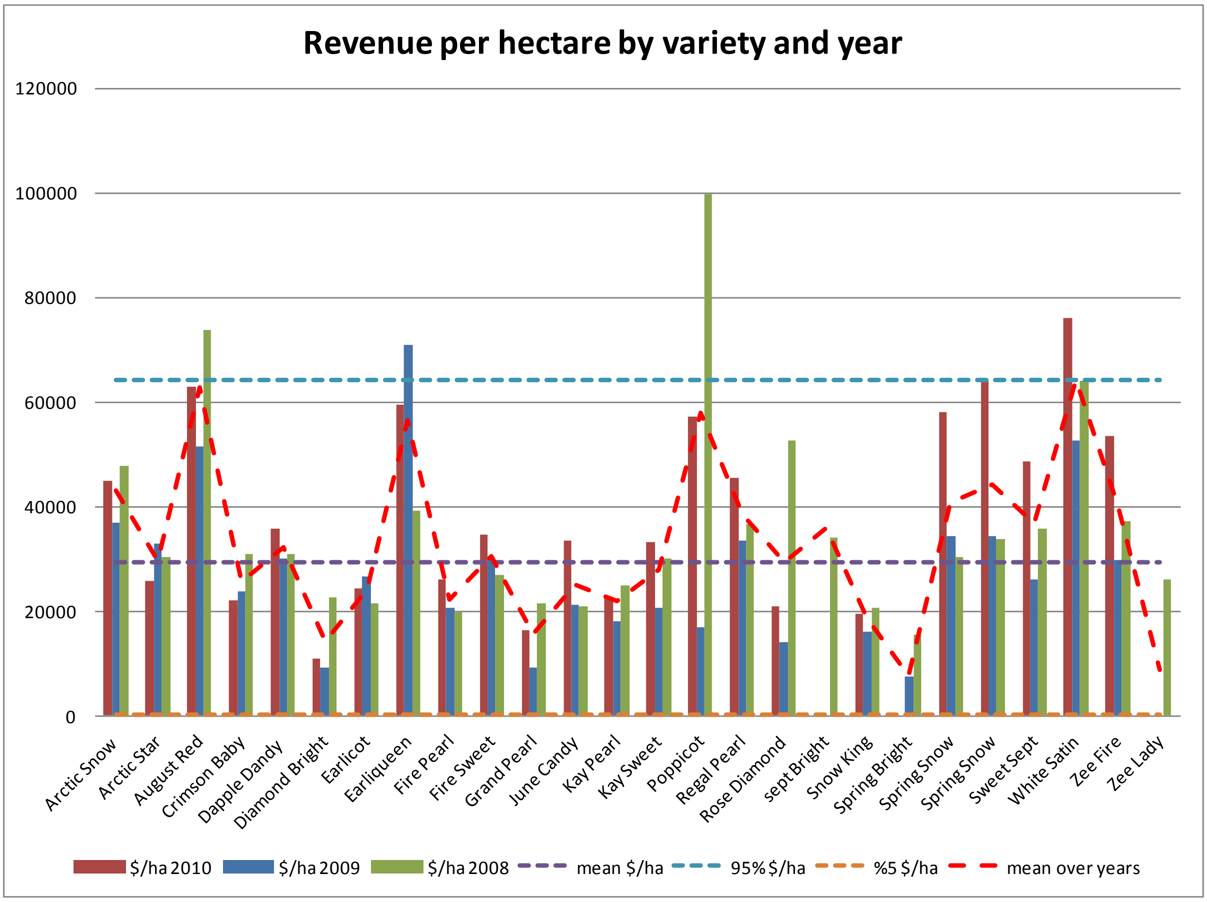


Figure 12 Revenue per hectare and variety

With 33 varieties, the potential for information overload is clear, so four specific varieties were chosen to test. A consistently strong performer over the three years was "August Red", and consistently poor performer was "Diamond Bright", "Dapple Dandy" performed consistently close to the average for all varieties and "Poppicot" exhibited considerable variation in revenue performance. In order to capture some of that variance expressed by the "Poppicot" variety a separate analysis of this variety was conducted. In addition the same analysis was concurrently undertaken using the default values in the model.

The subject farm had an irrigation entitlement well in excess of their annual irrigation need that provides insurance in times of water scarcity and low allocation. Generally, the prospect of purchasing water in the market has historically been relatively cheap when compared with the marginal cost of that water in lost production. So in times of great water scarcity where water is not available in the market at any price a buffer between entitlement and allocation serves to cover the gap. Our analysis considers this situation as well as one where an irrigator might have no or very little buffer in their entitlement.

4.2.1. Historical Normal Climate

With the benefit of a buffer in the entitlement, the sample farm does not experience any shortages in allocated water for irrigation under the historic normal scenario unlike the default options examined earlier in section 4.1. For the irrigator, certain varieties perform much better than others. Analysis of the “Poppicot” variety under best case and worst case scenarios, with no variation in price, show that returns for this variety could range from $9,845 to as much as $65,582/ha/yr.

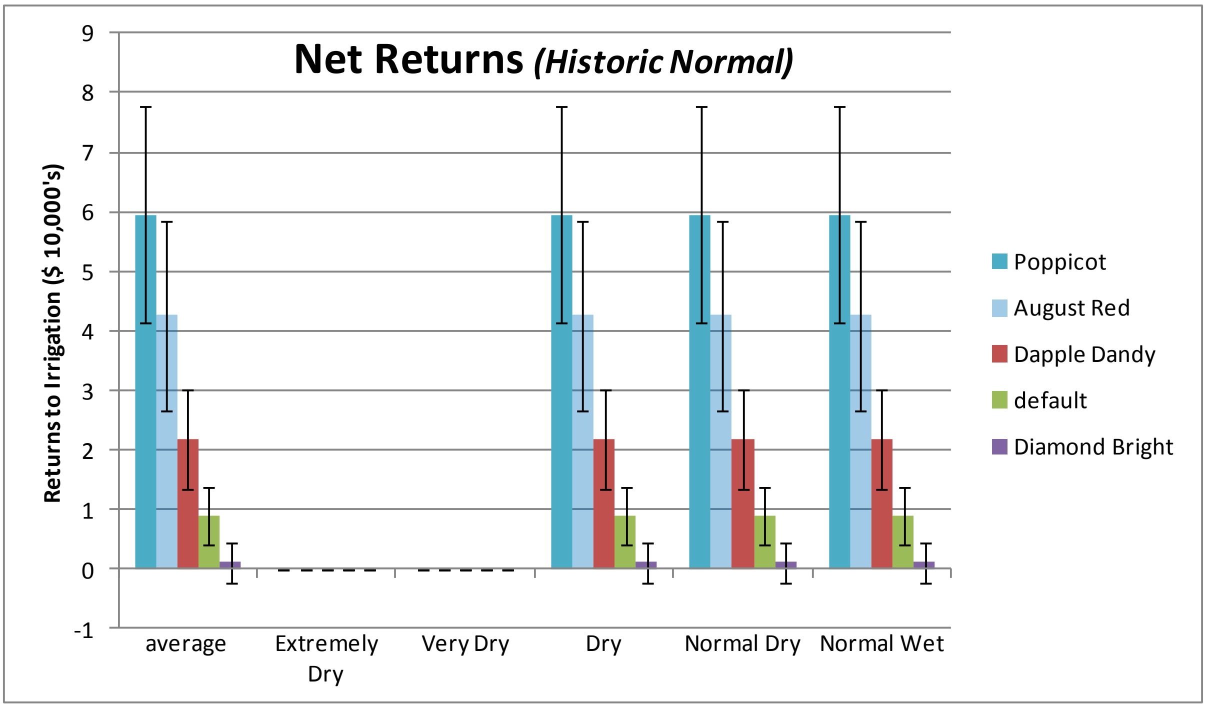


Figure 13 Net returns to irrigation under the “historic normal” climate

Figure 13 above shows the net returns to irrigation under the historic normal climate decade for four crop varieties in the sample data and the default values for that commodity. With no demand for water in excess of the irrigator’s entitlements the impact of low allocation years is mitigated and no costs incurred. The error bars on the graph represent the upper and lower bounds of a 25% change in commodity price. As is evident in Figure 13, strong performing varieties can absorb the effect of a commodity price shift while the poorer performers can experience a loss as their costs of production begin to exceed their revenues. As this scenario has no demand for additional water any change in the price of water will have no effect on returns.

We also consider a situation where water becomes so scarce that trade is not possible and the grower simply suffers the production decline. In this climate scenario the sample irrigator does not experience an irrigation demand deficit and therefore does not suffer from reduced allocations.

4.2.2. Historical Drought Climate (Millennium Drought)

Under the millennium drought scenario the sample farm experiences a small additional demand for water despite the extra capacity in the entitlement. The sample farm entitlement falls 29% short of demand under the very dry state of nature allocations and 64% short under the extremely dry state of nature allocation. This shortfall in water can be met through purchasing water in the market, adding costs to the commodities production function and reducing net returns.

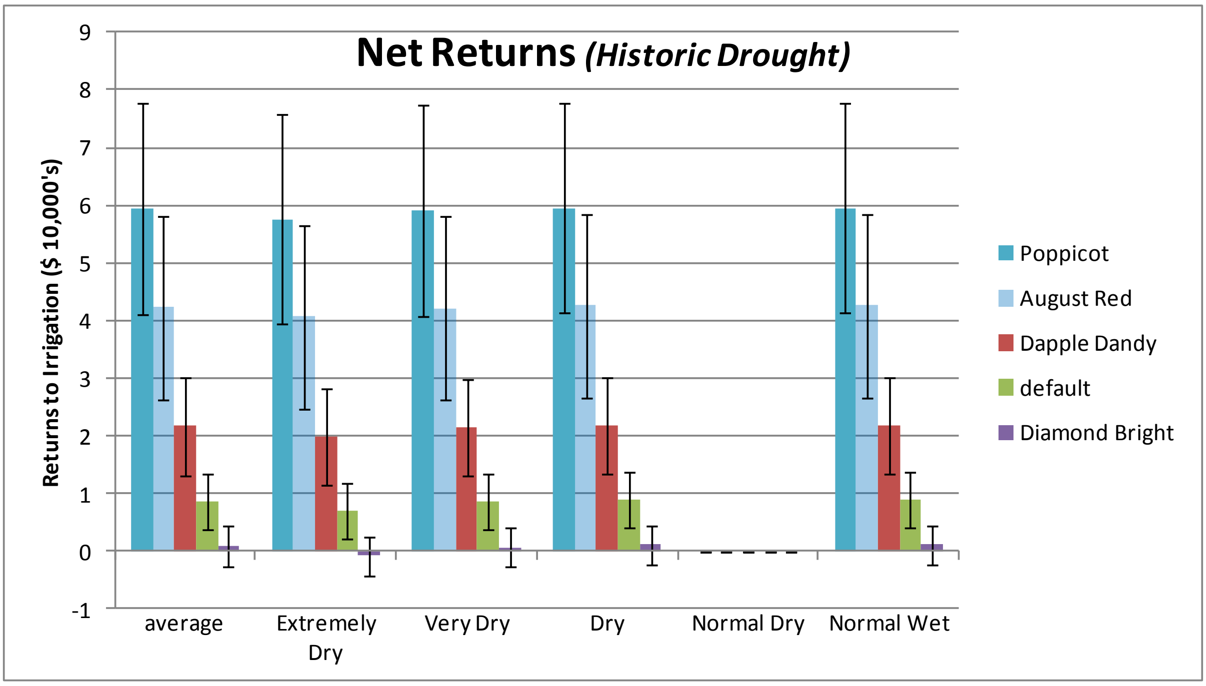


Figure 14 Net returns to irrigated agriculture under the "historic drought" climate

The impact of the additional water demand is a small reduction in net returns in the very dry and extremely dry states of nature. Water cost reduces net returns by -$106 in the very dry state and -$485 in the extreme state. This equates to a 0.25% and 1.2% reduction in returns for the best performing varieties and a 15% to 58% reduction for the worst performing. The more marginal the operation the greater the impact of additional water demand. The error bars on the graph again represent the upper and lower bounds of a 25% change in commodity price. As is evident in the Figure 14, strong performing varieties can absorb the effect of a commodity price shift while the poorer performers can experience a loss as their costs of production begin to exceed their revenues. In the drought years this loss can be further exacerbated by the additional cost of water.

Without water trade the millennium drought looks a lot worse for the sample irrigator with considerable declines in net returns and in some varieties and states of nature an economic loss.

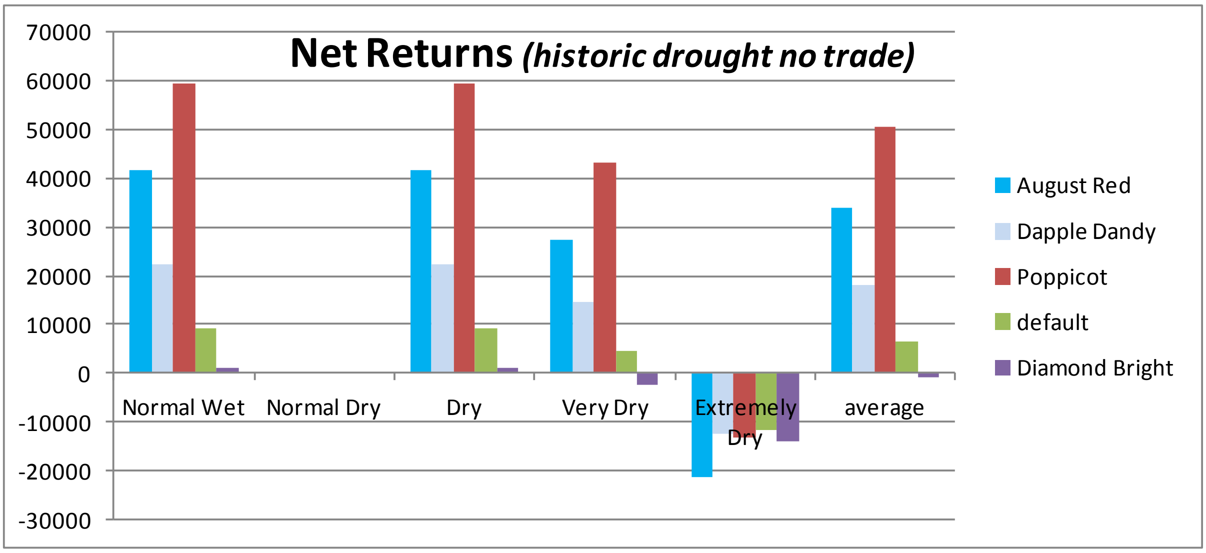


Figure 15 Net returns without the capacity to trade water under the millennium drought

Figure 15 shows that losses are incurred in the very worst state of nature for all varieties with a minimum loss of -$11,563 to the default variety and a maximum loss of -$21,313 to the traditionally best performing variety, “August Red”. On average over the decade all varieties suffer from the loss of irrigation water with between 15 and 182% reductions in average annual net returns when compared with the normal historical decade.

4.2.3. Future Drought Climate

The model also considered a decade from a possible future climate scenario with a warmer and drier climate and lower overall allocations. Under this scenario, the frequency of years with severe cuts to the levels of allocations occur much more frequently. While the state of nature specific impact of this scenario is no different to the millennium drought - the real impact (although small) is revealed in the ten year average returns and in the marginal varieties.

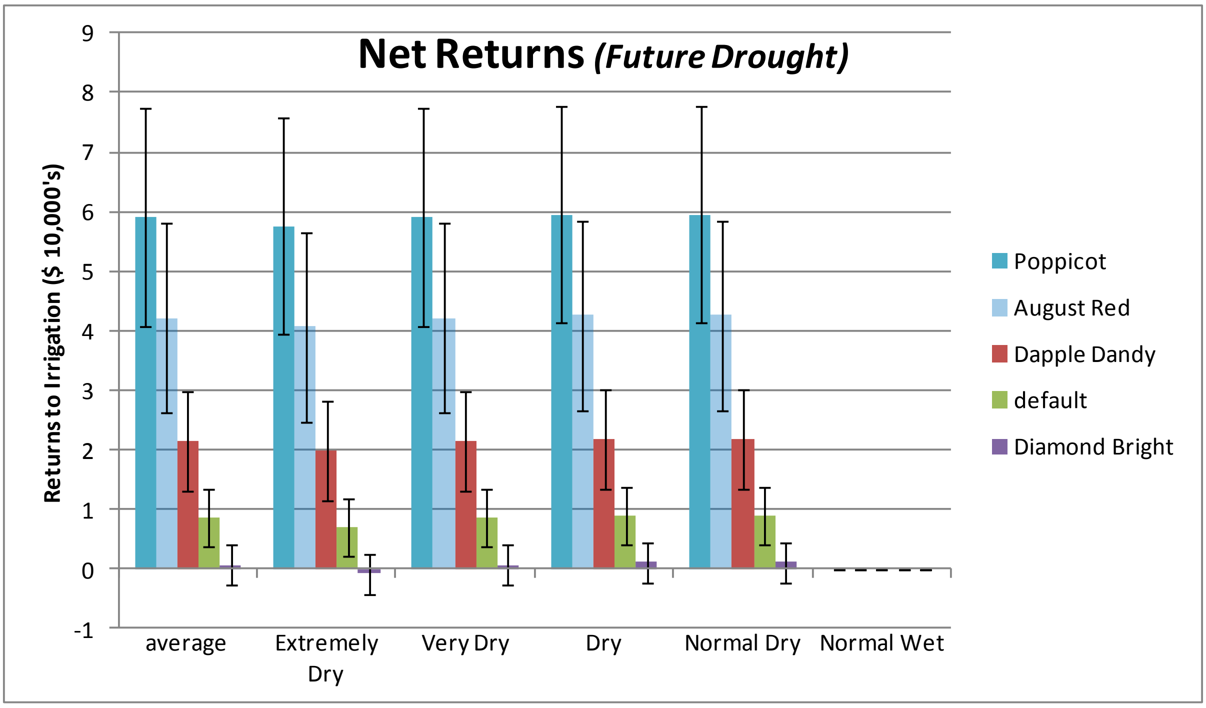


Figure 16 Net returns to irrigated agriculture under the "future drought" climate

The results in Figure 16 above show the annual net returns under a warmer/drier future drought decade. In this scenario the average annual returns are between 1 and 5% lower than in the normal historical decade for most varieties reflecting the additional cost of water in the drier future decade. However the marginal varieties show a 42% decline in returns as water cost grows and make up a larger share of the total cost of production.

The importance of the ability to trade water becomes clearer in the future drought scenario where considerable economic losses are possible for the sample farm.

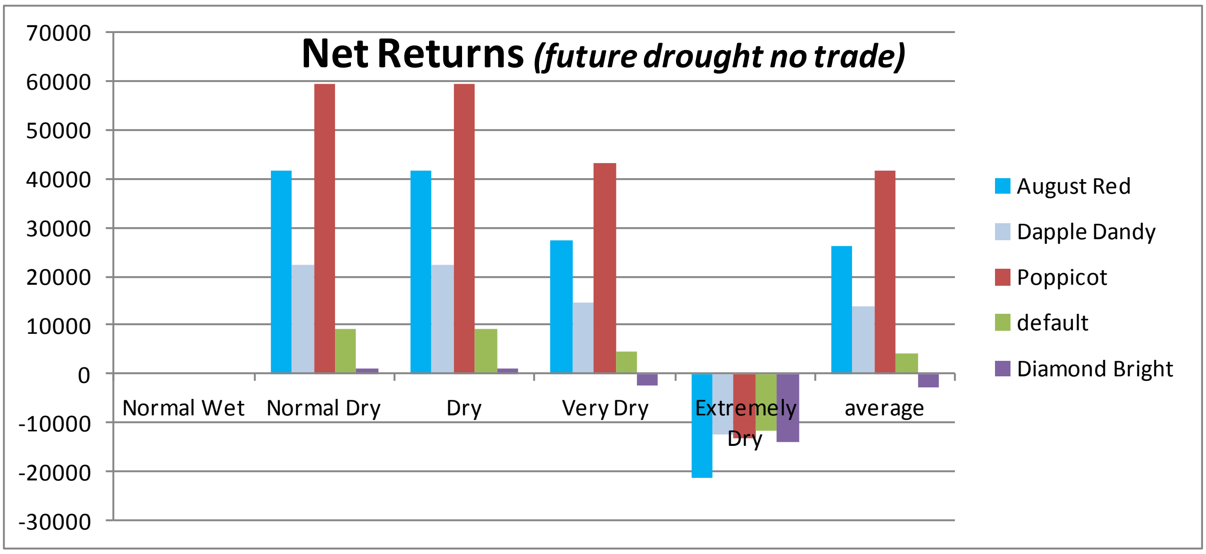


Figure 17 Net returns without the capacity to trade water under the future drought

Figure 17 above shows the same extent of losses in the extremely dry state as occurred in the millennium drought. The extent of the impact here is more clearly expressed in the average annual returns for the decade. Overall the impact of the warmer drier climate without water trade was between 30 and 364% lower net returns. This represents approximately 50% greater reduction in net returns than incurred in the millennium drought.

5. DISCUSSION

This report covers the design, construction and use of the Interactive Land use Strategic Assessment tool and is based on the best available science within the scope of the project boundaries. It is important to note that the future climate modelling used to determine allocations has been based on the Lower Murray Landscape Futures approach. More recent modelling undertaken by CSIRO may provide more robust estimates of future climate change in line with the predictions of the latest IPCC reports. Although based on older prediction modelling, the Lower Murray Landscape Futures approach produced predictions much closer to those experienced in the millennium drought and has had more time to earn credibility with local landholders which aligns with the project goal of maximising local engagement.

The model itself provides an open and malleable resource that contains enough adaptability to fit the needs of most irrigators. It does not however serve to provide a single comprehensive overview of all possible outcomes. In the sample data used several limitations in the quality and quantity of the data prevent the model from producing a clear estimation of outcomes under various circumstances. Nuance in the management mix, water application rates and in particular the timings of allocation announcement and water applications are not able to be represented in the model.

An overall analysis of the sample data indicates that provided an effective water market is operational and that the market has water to trade, crops and varieties that are productive and well managed are resilient to reductions in allocations. This resilience is produced when the cost of additional water is a small part of the total cost structure. Additionally the sample data indicates that having surplus entitlement provides insurance against low allocation years at a fairly modest rate. With the price of water in high allocation years so low the benefits of selling surplus in those years in considerably less than the cost of purchase in low allocation years which is also much less than the cost of lost production.

6. REFERENCES

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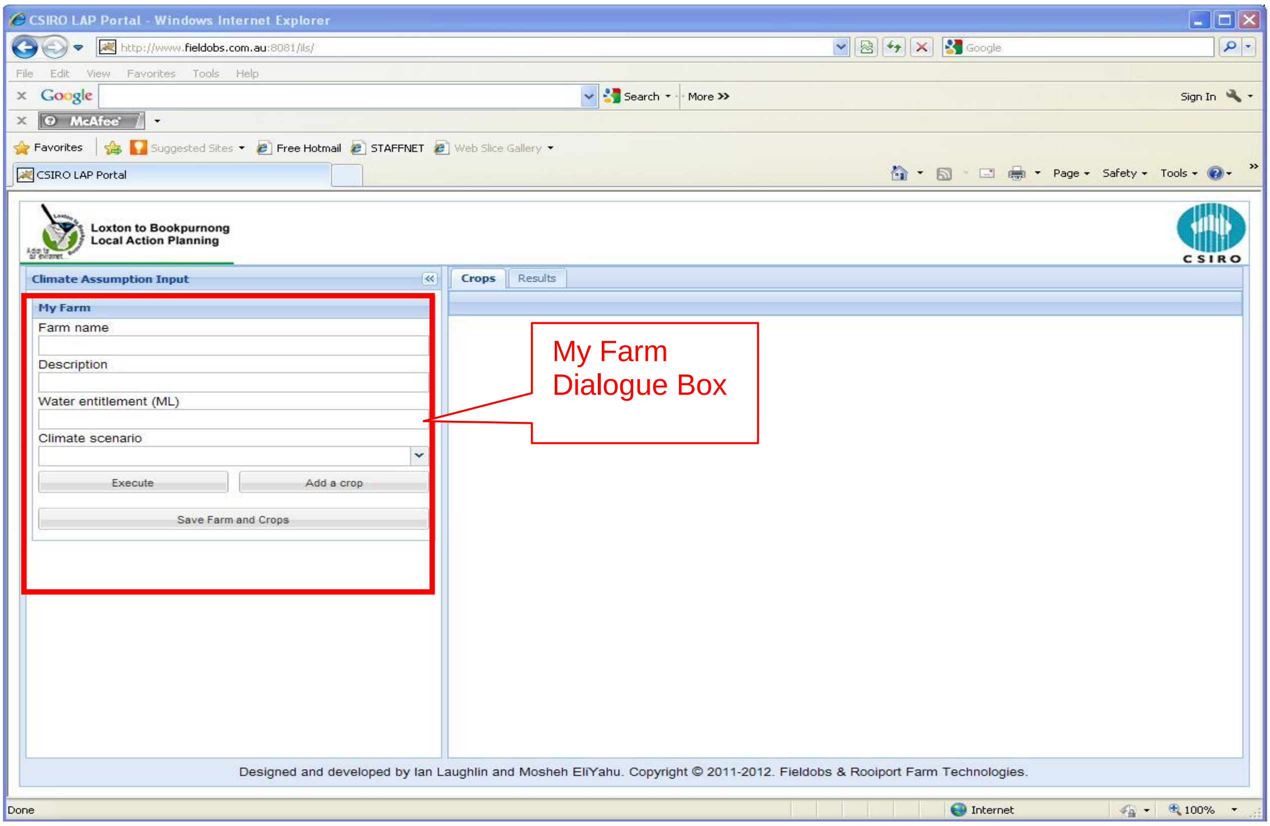
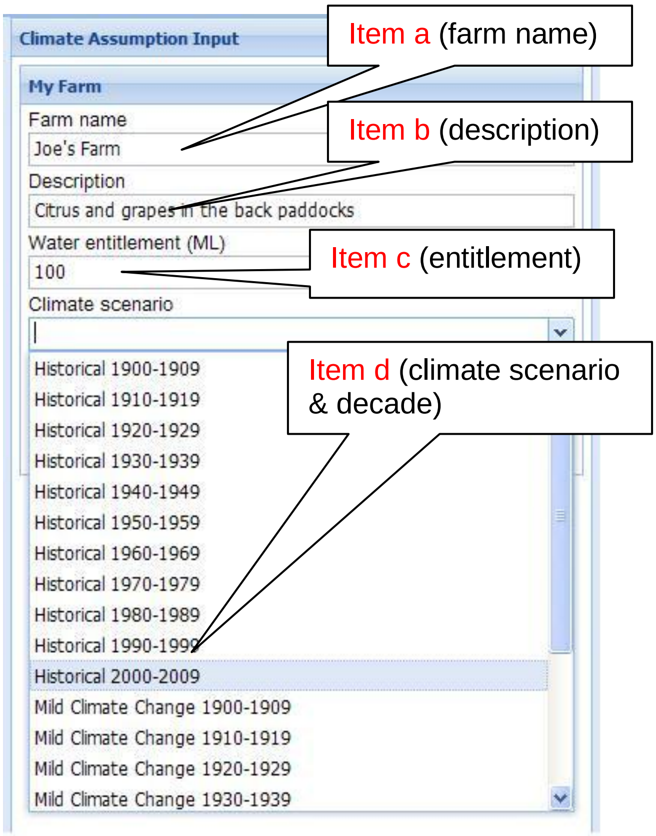
7. APPENDICES

7.1. Instructional Guide for use of the ILSA tool

1. Open a web browser and type the following url - http://www.fieldobs.com.au:8081/ils/
2. This will open the Tool interface and allow you to start adding details of your farm and the scenarios you would like to examine.



3. To begin the process the user should enter details about their farm in the left hand box titled "MY Farm".

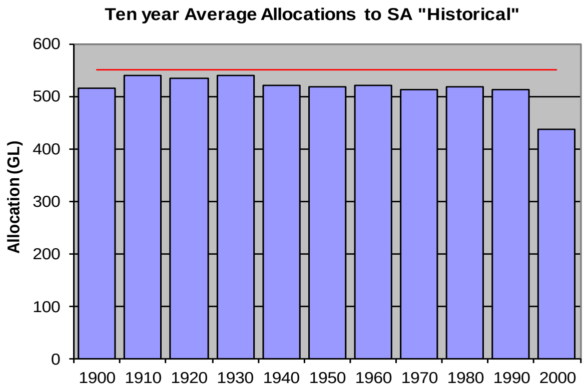


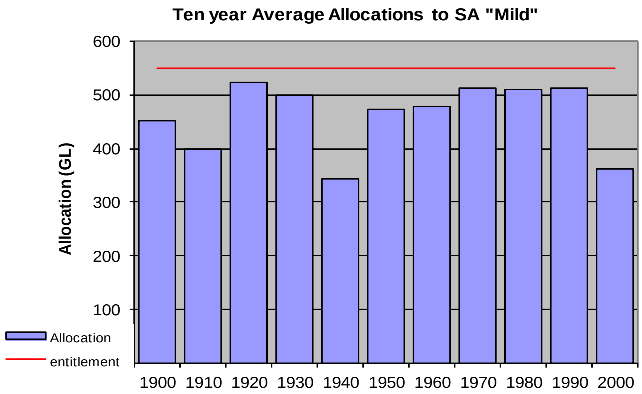
4. Start with a name for the farm (Item a) something simple yet informative will do
5. A descriptive name for the particular option you intend test (item b).
6. Your current level of water entitlement at Item c. This should be your entire water entitlement
7. Select a climate change scenario from the drop down list item d.

8. Two climate change scenarios are available to choose from including ***historical*** and ***mild*** future warming and drying. Within each scenario are decadal sequences to select.

NOTE: As perennial crop decisions are longer term investments, it is important to consider the longer term influences as well as the annual ones. Irrigators often suggest that they are able to cope with the odd dry year but extended droughts are tough. Use the graphical display below to help inform your choice. Allocations used are based on historical and projected climates with the current levels of development and allocation rules.

The graphs and tables below display **average annual allocations** for each decade. They are provided to help you identify wetter and drier decades in both the Historical climate and future climate. While the table shows the number of years in the corresponding decades that are classified as wet, normal, dry, very dry or extremely dry.



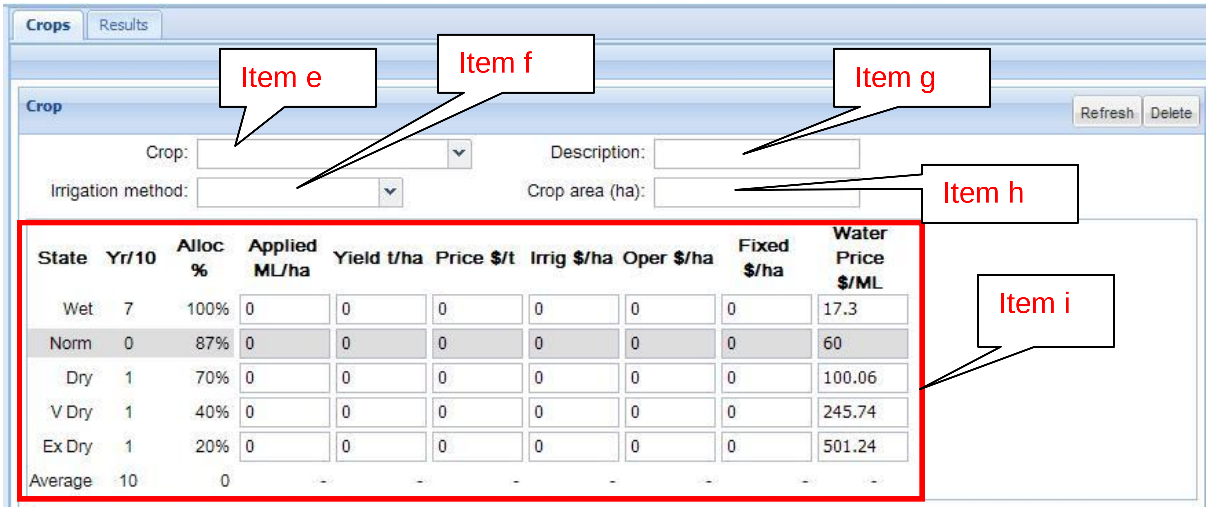


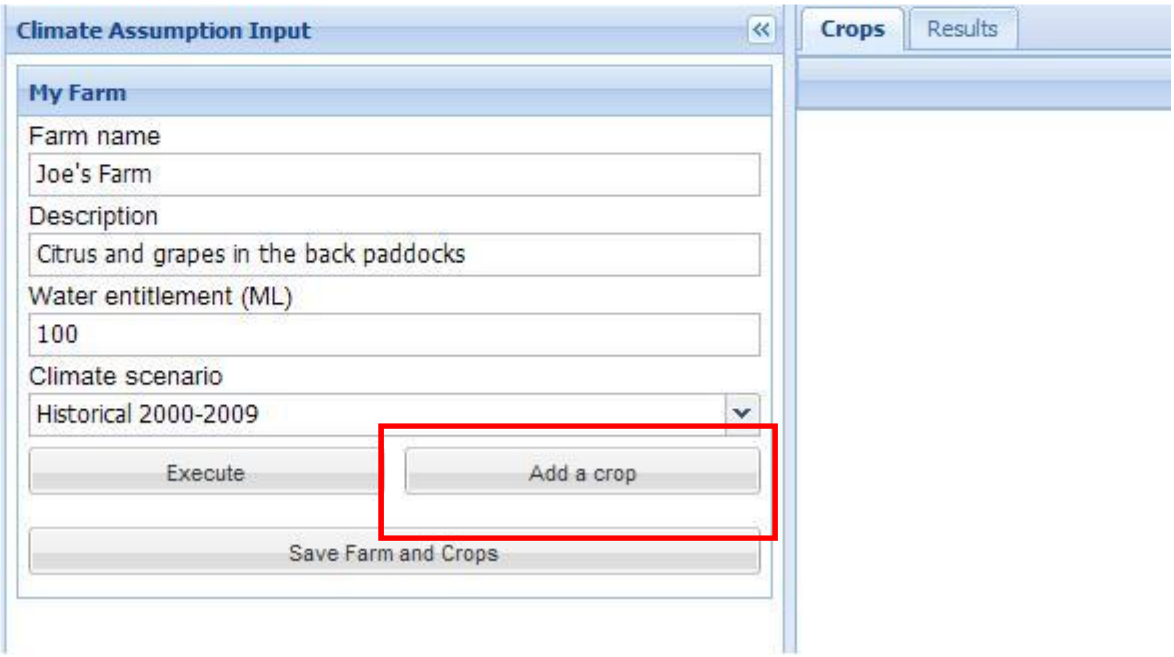
Wet	7	7	7	9	6	4	5	4	4	4	7
Normal	2	3	3	1	3	6	5	5	6	6	0
Dry	0	0	0	0	1	0	0	1	0	0	1
Very Dry	1	0	0	0	0	0	0	0	0	0	1
Extremely	0	0	0	0	0	0	0	0	0	0	1

Wet	3	2	7	6	0	2	3	4	4	4	2
Normal	1	3	2	1	4	7	5	5	5	6	4
Dry	1	2	1	3	2	0	1	1	1	0	1
Very Dry	4	3	0	0	2	1	1	0	0	0	0
Extremely	1	0	0	0	2	0	0	0	0	0	3

Wet	allocation greater than 95%
Normal	allocation greater than 80% less than 95%
Dry	allocation greater than 60% less than 80%
Very Dry	allocation greater than 25% less than 60%
Extremely Dry	allocation less than 25%

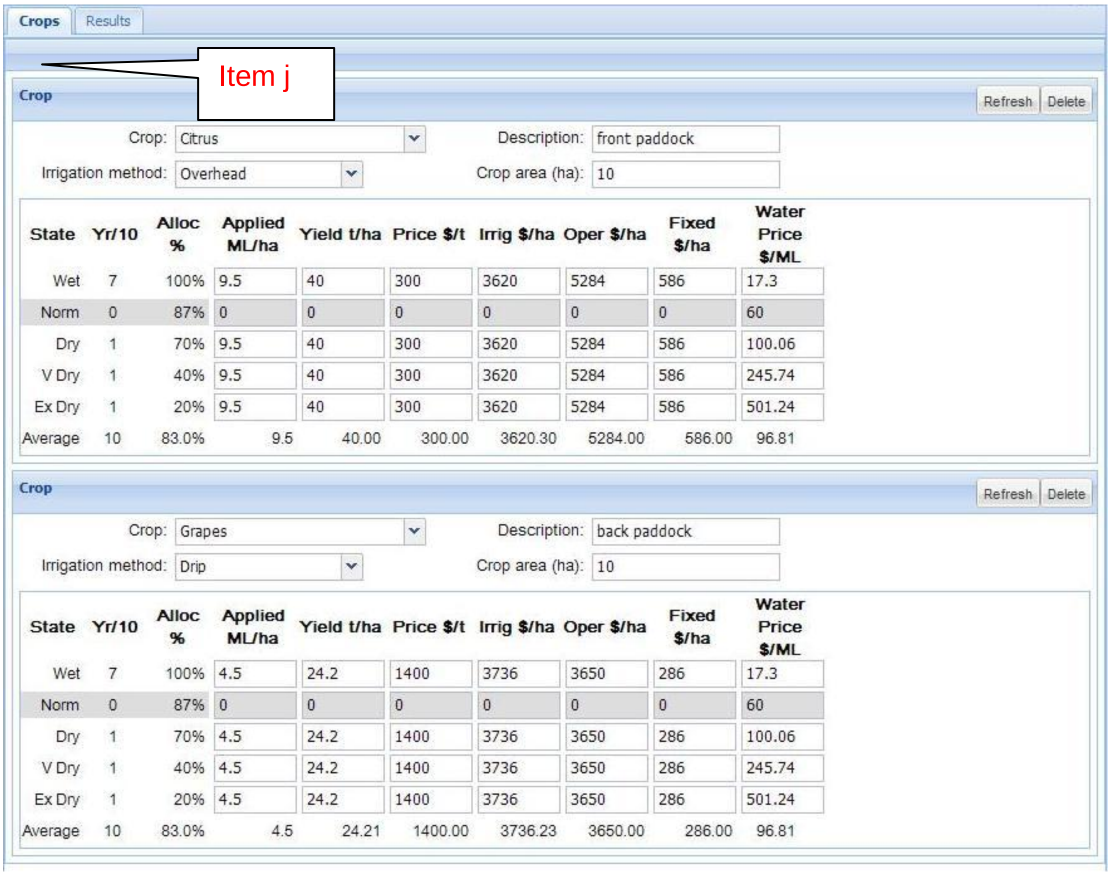
9. Once you have completed all the preliminary farm details it is time to begin adding crops





10. Click on the "Add a Crop" to add a new crop and begin specifying the details for that crop
11. Select a crop from the drop down list (item e
12. Select an irrigation method from the drop down list (item f)
13. Add a description to describe the block (i.e. old valencies or shiraz in the front block) (item g)
14. Indicate the number of hectares you wish to model (item h)
15. Once the four items above are entered the rest of the data (item i) will be populated automatically with default values
16. Users can choose to accept these defaults or edit them manually to something more representative of their circumstances. Note that the water applied/ yield relationship will be broken if you choose to edit the yield values.

17. Each time you select the “add a crop” button a new crop dialogue box will open



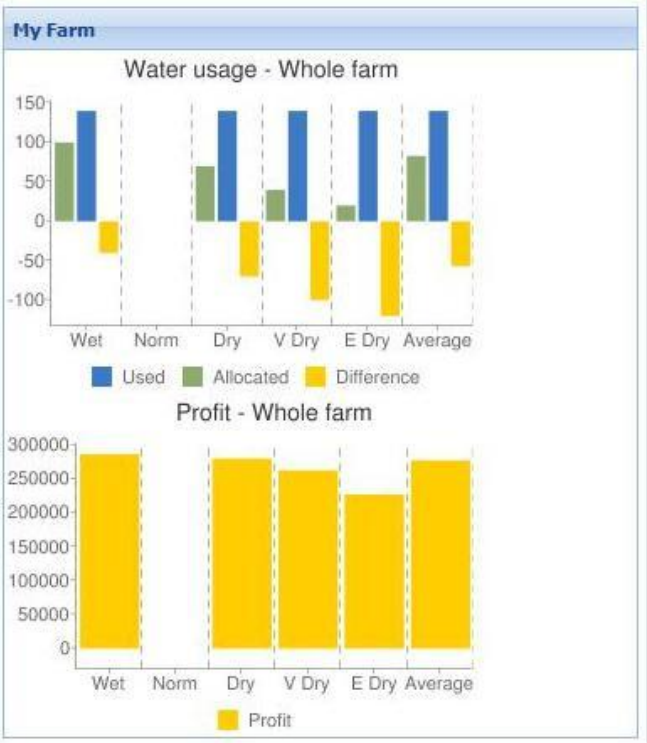
State	Yr/10	Alloc %	Applied ML/ha	Yield t/ha	Price $/t	Irrig $/ha	Oper $/ha	Fixed $/ha	Water Price $/ML
Wet	7	100%	9.5	40	300	3620	5284	586	17.3
Norm	0	87%	0	0	0	0	0	0	60
Dry	1	70%	9.5	40	300	3620	5284	586	100.06
V Dry	1	40%	9.5	40	300	3620	5284	586	245.74
Ex Dry	1	20%	9.5	40	300	3620	5284	586	501.24
Average	10	83.0%	9.5	40.00	300.00	3620.30	5284.00	586.00	96.81

State	Yr/10	Alloc %	Applied ML/ha	Yield t/ha	Price $/t	Irrig $/ha	Oper $/ha	Fixed $/ha	Water Price $/ML
Wet	7	100%	4.5	24.2	1400	3736	3650	286	17.3
Norm	0	87%	0	0	0	0	0	0	60
Dry	1	70%	4.5	24.2	1400	3736	3650	286	100.06
V Dry	1	40%	4.5	24.2	1400	3736	3650	286	245.74
Ex Dry	1	20%	4.5	24.2	1400	3736	3650	286	501.24
Average	10	83.0%	4.5	24.21	1400.00	3736.23	3650.00	286.00	96.81

18. The tool has two tabs in the right side window (item j) labelled “Crops” and “results”. Until you have entered details about the crop you wish to examine there will be no results to display.
19. When you are happy with your crop choices and selections click the “execute” button in the right hand “My Farm” box to calculate results

Note you do not have to enter every crop and irrigation system that you wish to examine all at once but you will need to compile a complete farm for each execution as the results display the whole farm outcomes.

20. Farm summary results will be presented below the right hand box, and will update each time you hit the execute button. The summary results provide an indication of the whole farms performance in terms of water and profit.



21. For full printable results outlined by crop select the results tab

State Of Nature	Years/10	Alloc (%)	Applied (ML/ha)	Yield (t/ha)	Crop ($/t)	Irrig ($/ha)	Op Costs ($/ha)	Fixed ($/ha)	Price ($/ML)	Used (ML)	Bought (ML)	Profit ($Total)
Wet	7	100.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 17.30	95	27	$ 24627
Normal	0	0.00	0.0	0.0	$ 0	$ 0	$ 0	$ 0	$ 60.00	0	0	$ 0
Dry	1	70.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 100.06	95	48	$ 20344
Very Dry	1	40.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 245.74	95	68	$ 8422
Extremely Dry	1	20.00	9.5	40.0	$ 300	$ 3620	[illegible]	[illegible]	[illegible]	95	81	$ -15718
Ten year average	10	83.00	9.5	40.0	$ 300	$ 3620	$ 5284	$ 586	$ 96.81	95	0	$ 18544

22. Complete simulation results are displayed in three rows.
23. The first row repeats the summary detail from the front page and displays the whole farm graphically.
24. The second row reflects the layout of the summary results but displays results for the first crop choice only. In cases where the user has only selected one crop then rows one and two will appear the same.
25. The third row shows the input data used to calculate the results for the first crop and includes a numerical representation of the water use and profit.
26. Second and subsequent crop results will follow the same format and are presented below the first crop. Simply use the scroll bars to view
27. Finally to print your results click the print button and follow the prompts associated with your printer.
28. Additionally you can save the results using a unique code for each run. These codes will be administered by the coordinators of the program to prevent any risk of doubling up.

29. To save your run simply select "Save Farm and Crops" from the "My Farm" dialogue box and follow the prompts.

7.2. Draft Fact Sheet for promoting the ILSA tool

Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

FACT SHEET

To access the ILSA tool go to:

http://lblap.fieldobs.com.au:8081/ilis/

To speak to a SA MDB NRM Board Field Officer
Phone: (08) 8580 1800

Better planning with better information

INTRODUCING A PLANNING TOOL THAT WILL HELP YOU UNDERSTAND THE EFFECTS OF VARIABLE CLIMATE, WATER AVAILABILITY AND PRICES ON YOUR IRRIGATED HORTICULTURAL FARM

The Loxton to Bookpurnong Local Action Planning Committee and the South Australian Murray-Darling Basin Natural Resources Management (SA MDB NRM) Board have worked with researchers at CSIRO and the University of Adelaide to develop a computer based tool called ILSA. ILSA stands for Interactive Land use Strategic Assessment. This tool allows users to enter details about their irrigated horticultural farm and to see what effects variable climate conditions, variable water availability and variable commodity prices have on financial returns. The idea is to play "what if" games with the important variables that affect farm profitability and production. You can look at the possible effect on the bottom line without the risk of experimenting with the real thing.

HOW DOES ILSA WORK?

ILSA is a computer based user interface for enterprise scale planning that combines scientific and individual production circumstances in an easy to use and practical way. Users enter information about their farm, choose climate conditions that they think will be applicable for a season and information about the crops they have and the returns they expect. The tool then calculates the feasibility of the combinations, the amount of water needed and the financial consequence. Lots of combinations can easily be tried so that it is possible to build an understanding of the sensitivity of the different effects on farm viability.

WHAT CAN I USE ILSA FOR?

ILSA is primarily a learning and planning tool. It can help growers better understand the interactions between climate, land, water, crops and prices. It is possible to enter your particular circumstances and see how they may be affected as water availability and prices change. ILSA is not a financial or a crop management tool. It is simply a tool to help understanding and improved planning in a complex and variable world.


Irrigating in a mature orchard


[illegible] grape vine

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Website:
www.samdbnrm.sa.gov.au

HOW DO I USE ILSA?

The tool can be accessed at:
http://lblap.fieldobs.com.au:8081/ils/
The user then follows a logical set of steps to set up the farm description and the variables they would like to experiment with.

- Start with a name for the farm
- Enter a descriptive name for the particular option you intend to test
- Enter your current level of your entire water entitlement
- Select a climate change scenario from the drop down list
- Select "Add a Crop" to add a new crop from the drop down list
- Select an irrigation method from the drop down list
- Enter the area (hectares) of each crop
- Then the tool will automatically add information on a usual amount of irrigation water per hectare, expected yields and a usual price per tonne. At this point you can choose to edit these values and add in what you think they should be.

Note: no information from ILSA is stored or available outside your use.

Precise, controlled irrigation is now the norm

WHY DO WE NEED ILSA?

Following years of relative certainty in water supply, the recent millennium drought sharpened the focus of irrigating with increasingly scarce water supplies. Planning future farm management activities in the face of uncertain and potentially scarce supplies presents a considerable challenge. Notably, the millennium drought of the 2000's resulted in annual allocations that had never been experienced before. With increased demands for water and the prospect of the climate becoming drier it is unlikely that SA will ever receive its full entitlement consistently over any future decade. Managing and adapting to this prospect along with variable markets and prices is not easy. ILSA is designed to assist with planning and understanding in this variable future.

ACKNOWLEDGEMENTS

The project that developed ILSA was commissioned by the Loxton to Bookpurnong Local Action Planning Committee. Funding was received from the Australian Government Farm Ready Program.

Below: Screen view of Tool

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