Department of Planning and Environment

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Economic base case

Lachlan region

October 2023

Acknowledging First Nations people

The NSW Government acknowledges First Nations people as the first Australian people and the traditional owners and custodians of the country's lands and water. First Nations people have lived in NSW for over 60,000 years and have formed significant spiritual, cultural, and economic connections with its lands and waters.

Today, they practice the oldest living culture on earth.

The NSW Government acknowledges the Nari Nari, Ngiyampaa, Wiradjuri, Barkandji, Maljangapa and Yita Yita people as having an intrinsic connection with the lands and waters of the Lachlan Regional Water Strategy area. The landscape and its waters provide the First Nations people with essential links to their history and help them maintain and practice their traditional culture and lifestyle.

We recognise the Traditional Owners as the first managers of Country. Incorporating their culture and knowledge into management of water in the region is a significant step towards closing the gap.

Under this regional water strategy, we seek to establish meaningful and collaborative relationships with First Nations people. We will seek to shift our focus to a Country-centred approach; respecting, recognising and empowering cultural and traditional Aboriginal knowledge in water management processes at a strategic level.

We show our respect for Elders past and present through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places where First Nations people are included socially, culturally and economically.

As we refine and implement the regional water strategy, we commit to helping support the health and wellbeing of waterways and Country by valuing, respecting and being guided by First Nations people, who know that if we care for Country, it will care for us.

We acknowledge that further work is required under this regional water strategy to inform how we care for Country and ensure First Nations people hold a strong voice in shaping the future for all communities.

Artwork by Nikita Ridgeway.

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Lachlan Economic Base Case

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Executive summary

This report details the economic base case used for the hydrologic and economic modelling undertaken to support the assessment of the long list of options for the draft Lachlan Regional Water Strategy. It includes both the Lachlan and Belubula catchments within the Lachlan region.

The Lachlan Regional Water Strategy is not a business case, and this economic base case analysis has not been undertaken at the level of detail required for a business case. However, it is the first step in strategically analysing alternate options being considered for the Lachlan. The analysis still needs to be robust and sufficiently specific to compare the merits of different options. The approach outlined in this document aims to strike the right balance between a high level, strategic assessment and region-specific information. It aims to determine an economic base case that represents a robust estimate of future surface water availability and the economic value of that availability.

The first step in any economic analysis is to understand what the future could look like and the potential consequences of doing nothing. This is known as the 'base case'. The economic base case used for the regional water strategies represents what the future could look like for towns and water-based industries if nothing is done to address issues related to the supply, demand or allocation of water over the next four decades.

For the purposes of the regional water strategies, three plausible futures have been examined. All of these futures are referred to as the base case. Portfolios of options considered in the Lachlan Regional Water Strategy that can be hydrologically modelled will be assessed against these three futures:

1. Historical data — this scenario assumes that future climate will be similar to the climate data that has been recorded over the last 130 years.
2. Stochastic data — long-term historic climate projections — this scenario assumes our future climate will be similar to what the science indicates our long-term paleoclimate was like and is based on a 10,000-year dataset.
3. NARCliM[1] data — a dry climate change scenario — this scenario assumes a dry, worst-case climate change in the future and is also based on a 10,000-year dataset.

[1] NARCliM (NSW and ACT Regional Climate Modelling) is a partnership between the NSW, ACT and South Australian governments and the Climate Change Research Centre at the University of NSW. NARCliM produces robust regional climate projections that can be used to plan for the range of likely climate futures. Further information about NARCliM modelling can be found at: climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARCliM.

In the past, water infrastructure and policy changes in the region have only been assessed against historical data (records of rainfall, temperature and other climate conditions going back to the 1890s). However, the stochastic and NARCliM data give a much better understanding of the water risks that could be faced by the region.

The economic base case presented in this report assumes existing infrastructure and policy settings, based on growth projections for the region from the NSW Government's Common Planning Assumptions[2].

To understand the consequences for the Lachlan region of doing nothing, we have modelled the three most significant water user groups within the region:

- town water supply (as water shortfall) — Forbes, Parkes, Condobolin, Lake Cargelligo, Hillston, Cowra, and the communities serviced by Central Tablelands Water
- annual crop producers (as water supplied) — assumed to be cotton and wheat among other crops
- permanent crop producers (as water supplied and as shortfalls) — assumed to be oranges, almonds, and olives

The first step in developing the economic base case is to understand how water availability changes for these water users under the future scenarios, also referred to as hydrologic modelling. The modelling results show that towns and agricultural producers in the Lachlan are, on average, likely to have access to water less often (or have decreased water supply reliability) under the dry climate change scenario. A summary of the average amount of water usage (or shortfall in the case of towns) for each aggregated water user group under the plausible futures is shown in Table A.

Table A. Average yearly water provided to different water user groups- combined Belubula and Lachlan

Water users	Stochastic scenario: long-term historical climate projections	NARCliM scenario: dry climate change
Town water supply (shortfall, ML/year)	293	1372
Annual crops (supplied, GL/year)	170	118
Permanent crops (supplied, GL/year)	12	10

The second step in developing the economic base case is to undertake an economic analysis to understand how this change in water availability translates into dollar values and impacts on the economy. Economic analysis was undertaken in accordance with the framework set out in Regional

[2] Common Planning Assumption (CPA) refers to the median population prediction in NSW 2022 Population Projections ASGS LGS Dataset.

Water Value Function.[3] The evaluation period for each analysis was 40 years with a discount rate of 7%. Economic valuations per megalitre of water for each water user group were:

- towns water supply — escalating cost is dependent on the size of the town and the length of the shortfall as this value is applied to the volume of water not supplied — that is, the shortfall
- annual crop producers (assumed to be the highest value crop — cotton) — $250/ML
- permanent crop producers (assumed to be oranges) — $450/ML or $2,300/ML in shortfall.

As shown in Table B, the economic impacts, on average, are higher under the NARCliM scenario than under the stochastic scenario, reflecting the lower availability of water between the two estimates.

Table B. Average total (40 years) economic outcomes per water user group

Water users	Stochastic scenario: long-term historical climate projections	NARCliM scenario: dry climate change
Town water supply (cost to) ($m)	-22	-243
Annual crops ($m)	599	440
Permanent crops ($m)	46	-15

All modelled towns are predicted to experience increases in the economic costs of maintaining water supplies in the NARCliM scenarios. Agricultural producers would also experience a decline in economic outcomes under a NARCliM scenario, reflecting a reduction in agricultural production due to decreased water supply.

There is also other significant mining activity in the Lachlan region. The Regional Water Value function suggests that mines values water at $12,500/ML. However, it is difficult to accurately measure the value of water to a mine, as it depends on the exact production methods used. In addition, mines often have alternative production methods or sources of water that are not available to agricultural users of water. Consequentially, it is difficult to accurately estimate the value of a megalitre of water to a mine and they have not been included in the analysis.

[3] Marsden Jacobs Associates. 2020. *Regional Water Value Function.*

Introduction

Context

This report details the Economic Base Case (economic base case) used for the hydrologic and economic modelling undertaken to support the assessment of the long list options presented in the draft Lachlan Regional Water Strategy.

This report has been prepared to document the process used and support decision-making for the Lachlan Regional Water Strategy about options that may impact the supply, demand or allocation of water and that can be represented adequately within catchment-level hydrologic modelling. A range of other options in the regional water strategy do not impact on the supply, demand or allocation of water in the region. A separate assessment process has been undertaken for those options and detailed in the Options Assessment Process report. However, the information documented in this report may also support analysis of those other options.

The economic base case has been prepared in accordance with the requirements outlined in:

- NSW Treasury, NSW Government Business Case Guidelines[4]
- NSW Treasury, NSW Guide to Cost–Benefit Analysis.[5]

The economic base case and why it is important

The economic base case represents what the future could look like for towns and water-based industries if nothing changes over the next four decades to address the issues related to supply, demand and allocation of water. The economic base case is generated by combining the value different extractive water users place on water against the water availability forecasts for the region. It assumes current infrastructure and water policy settings but includes changes to population projections. The water demands of users are generally set as fixed, with some exceptions where population growth in towns is predicted. This approach allows all potential options to be compared consistently and any benefits, costs or other effects from an individual option to be assessed against their impact to the economic base case. The economic base case will be used as

[4] NSW Treasury. 2018. *TPP18-06: NSW Government Business Case Guidelines.*

[5] NSW Treasury. 2017. *TPP17-03: NSW Government Guide to Cost–Benefit Analysis.*

the central scenario in the cost–benefit analysis for the hydrologic modelling of portfolios of solutions developed for the regional water strategies.

The Regional Water Value function

The Regional Water Value function[6] places a value on the amount of water forecast to be available. The forecasts are developed through hydrologic modelling. These estimated values:

- focus on key water user groups — not every water user in a region is analysed because the hydrologic modelling only captures changes in water availability for key water users in each region
- reflect how users make decisions and how they use water in practice — this water user behaviour has been studied and included in the Department of Planning and Environment's water models.

The values produced in the Regional Water Value function are for key water users. In the Lachlan region, the users considered within the strategy are:

- town water supply
- annual crop producers — assumed to be cotton, as this is the primary crop grown in the region
- permanent crop producers — assumed to be oranges
- stock and domestic producers — assumed to be dairy farmers.

The Regional Water Value function values reflect how water is used in practice by the key water user groups. For example, irrigators of annual crops scale their operations each year depending on water availability, whereas irrigators of permanent crops change their operations following a sustained change in high reliability of water. As a result, producers with permanent plantings are more vulnerable in periods of supply shortfalls. This reflects how the economic value of water adjusts as forecast availability changes.

Using climate change modelling to create expectations of the amount of water available

The NSW Government has invested in new climate datasets and improved hydrologic modelling that provide a more sophisticated understanding of historic climate variability, as well as likely future climate risks. The draft Lachlan Regional Water Strategy's reliability assessments for towns and communities in the region are based on this new climate data, scaled down to the regional level and used in the modelling of surface water. This data and modelling include consideration of long-term

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[6] Marsden Jacob Associates. 2020. *Regional Water Value Function*

historic paleoclimate data, where available, and climate change impacts to develop scenarios of plausible extreme climate events.

Using the SOURCE streamflow modelling platform for the Belubula River and the IQQM streamflow model for the Lachlan River, the rainfall runoff — recorded at gauging stations across the catchment — is calibrated with historical streamflow data. The calibrated hydrologic model is then used to generate two series of streamflow sequences: one incorporating historic paleoclimate data and the other adding climate change scenario impacts. These two climate scenarios are referred to as the stochastic and the NARCliM models respectively.

The stochastic and NARCliM models are used to create expectations about the amount of water available in the future. The hydrologic modelling creates 1,000 replicates of 40-year duration daily climate inputs — sampled with a moving window of 10 years from the 10,000-year historic estimates — to create a broad range of feasible possibilities for the next four decades.[7]

Translating hydrologic modelling to user group outcomes

The hydrologic modelling estimates town surface water availability over the next 40 years. Town water availability was estimated by simulating extraction volumes and restrictions curves associated with the levels of storage in the Wyangala Dam as a proxy for town water restrictions. The exception is Parkes. Parkes only relies on Lachlan River surface water for a small portion of its supply. Parkes has other sources of water including Endeavour and Beargamil Dams, as well as groundwater.

The amount of water supplied to high-security water entitlements and allocation shortfalls were calculated with restriction curves, similar to town and community water supply, to infer shortfalls in water supplied to those licences. This provides the data for the economic analysis.

General security entitlements are estimated according to the amount of water that is supplied to users based on the level of modelled water availability in the region. It is assumed that general security entitlement holders decide on an annual basis how they will use the water and what crops they will grow.[8]

For the purposes of the regional water strategies (which are broad, region-wide strategic studies), the economic base case does not capture every user of water in a region. It also does not include quantitative analysis of groundwater. Rather, it provides an indication of surface water risks. Future business cases and detailed studies will need to conduct further analysis if groundwater or other

[7] See Department of Planning, Industry and Environment. 2020. *New climate analysis informs NSW's regional water strategies*, available at: industry.nsw.gov.au/__data/assets/pdf_file/0018/321093/nsw-climate-model-report.pdf

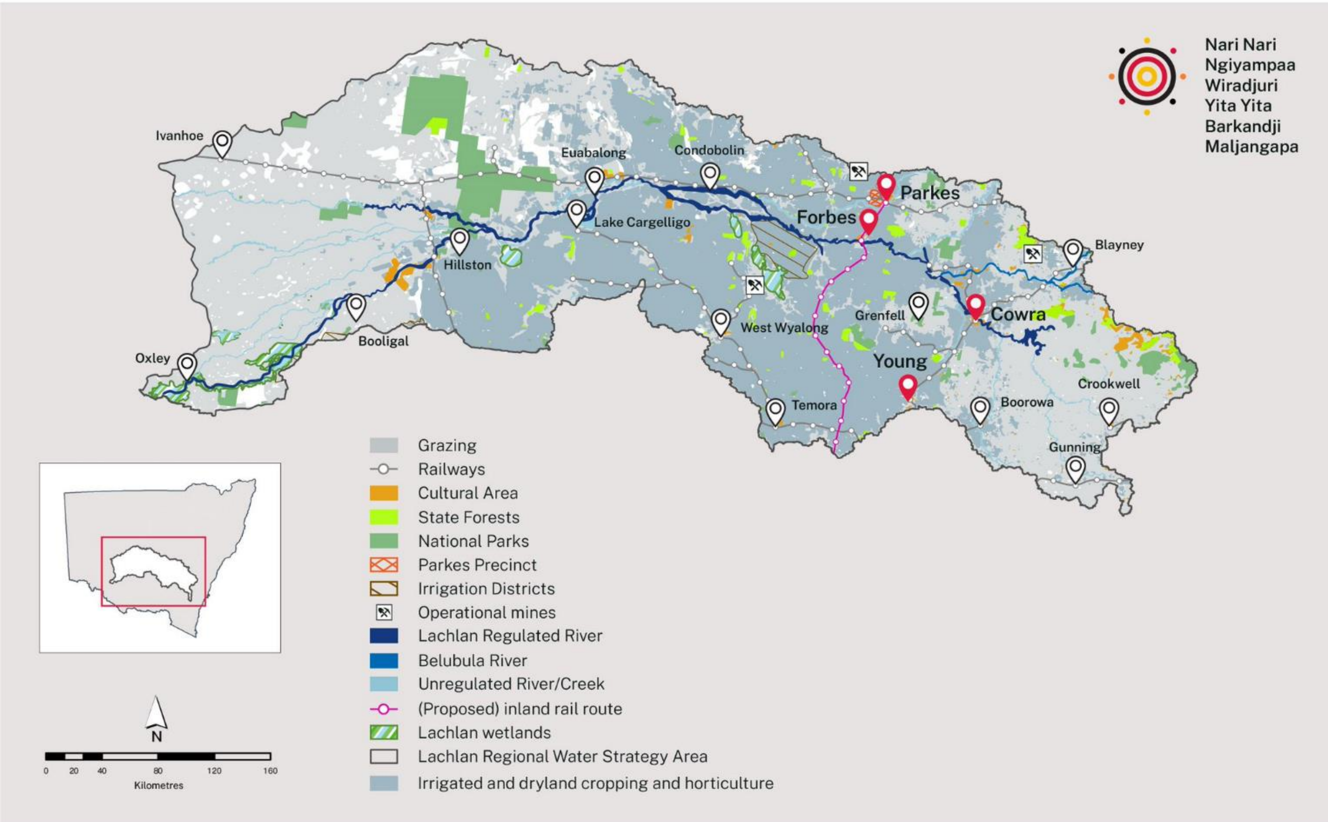
[8] Marsden Jacob Associates. 2020. *Regional Water Value Function*

alternative water sources can go to fill the gaps and shortfalls identified in this analysis. However, the economic base case represents a robust estimate of future surface water availability and the economic value of that availability. In addition, the value of water to a mine is difficult to accurately determine as it depends on the exact production methods used by the individual mine. In addition, mines often have alternative production methods or sources of water that are not available to agricultural users of water.

Lachlan region — key details

The Lachlan region

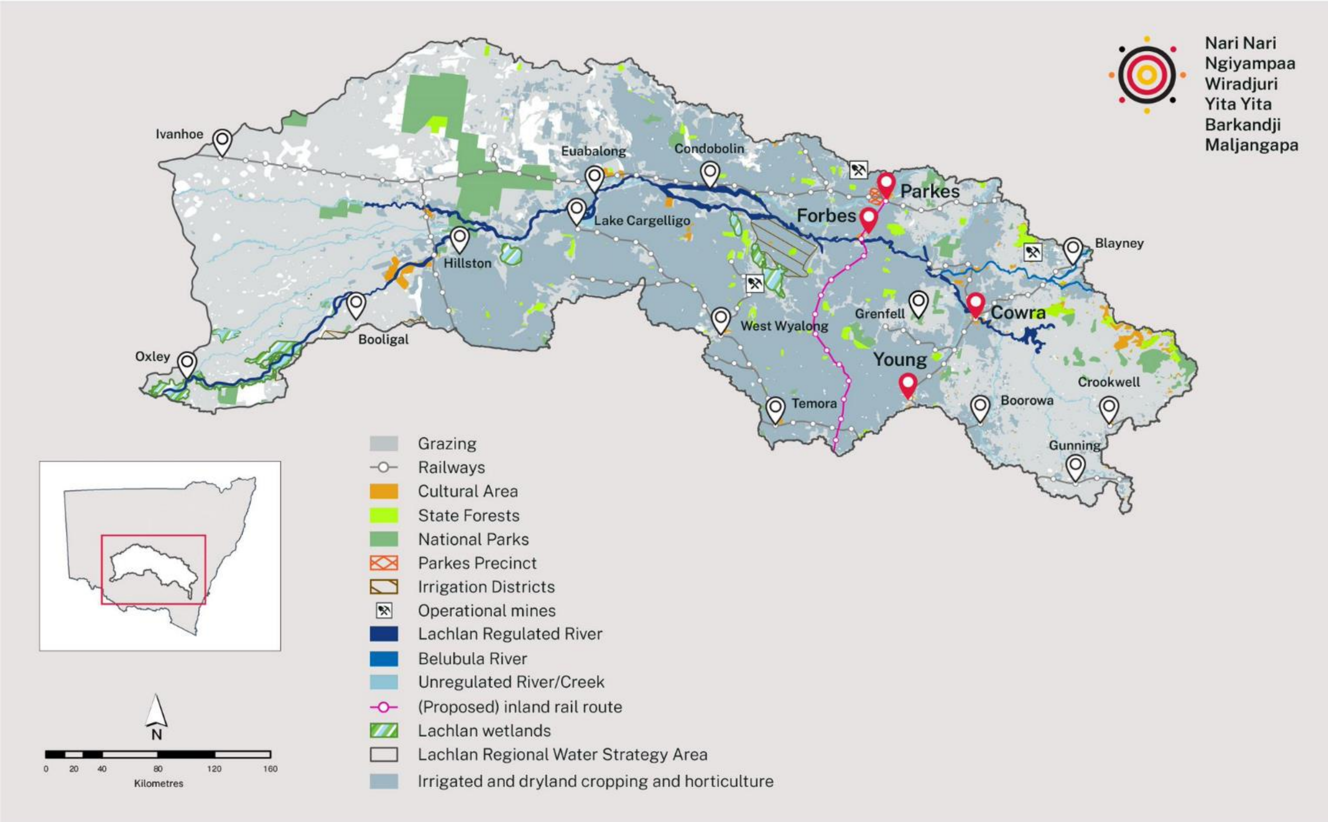
The Lachlan region (



)

lies west of the Great Dividing Range in central NSW. Extending across 90,000 km^2, the region is home to 100,000 people and the centres of Parkes, Cowra, Forbes, and Young. Agriculture drives the regional economy together with mining, tourism, transport, and logistics.

Figure 1. Map of the Lachlan region



The Lachlan region is the fourth largest river catchment in NSW by size, sourcing its water from the regulated Lachlan and Belubula rivers, unregulated rivers and creeks, and groundwater. Water supports the region's towns and communities, underpins key industries and local employment and protects culturally and nationally significant environmental assets, including the Lake Cowal–Wilbertroy Wetlands, the Booligal Wetlands, and the Great Cumbung Swamp.

The region's industry mix is also diversifying; horticulture continues to expand, tourism is increasing, and food processing is expected to grow in coming decades. The Parkes Special Activation Precinct and the Inland Rail Project will encourage further industry development and regional growth.

Extractive users of water

The hydrologic outcomes and subsequent economic impacts have been considered in the context of the region's major extractive user groups. The key water user groups considered in this economic assessment are:

- town water supplies
- agricultural users (annual crop producers, permanent crop producers, and stock and domestic producers).

In each base case scenario, the economic benefit or cost of water supplied or not supplied has been quantified in $/ML for each user.[9]

Towns and communities water supplies

The economic base case for towns and communities was developed for the following communities: Forbes, Parkes, Condobolin, Lake Cargelligo, Hillston, and Cowra.

The economic base case assigns different values for the costs of replacing surface water for towns and communities when surface water supply shortfalls are modelled. The cost of a shortfall is dependent on the size of the town or community and the restriction level or length of shortfall being experienced, depending on the availability of information within the hydrologic modelling. For example, for small towns it is assumed that local water utilities can manage brief periods of shortfalls through water carting. The management response to longer shortfall periods is assumed to require a more permanent, costlier solution. For larger towns, carting may not be a feasible option under any circumstances. Details of towns considered within this document, their associated shortfall costs are shown in **Error! Reference source not found.** for towns where restriction level d ata was used to apply a cost per ML, and in Table 2 for towns where the length of a shortfall event was used to apply a cost per ML.

[9] Detailed information on the development of the value of water for different extractive users can be found in *Regional Water Value Functions* (Marsden Jacob Associates, 2020).

Table 1. Economic cost of town water supply shortages in the Lachlan region – Towns calculated using restriction data

	Cowra	Forbes	Condobolin	Lake Cargelligo	Hillston	Central Tablelands Water
Population*	12,838	10,023	4,406	1,950	2,145	24,750
System type	Regulated	Regulated	Regulated	Regulated	Regulated	Unregulated
Restriction Level						
1	$1,680/ML	$1,680/ML	$1,680/ML	$1,680/ML	$1,680/ML	$1,680/ML
2	$2,400/ML	$2,400/ML	$2,400/ML	$2,400/ML	$2,400/ML	$2,400/ML
3 (alternative water source)	$16,000/ML	$16,000/ML	$16,000/ML	$16,000/ML	$16,000/ML	$16,000/ML
Greater than 3 (alternative water source)	$16,000/ML	$16,000/ML	$16,000/ML	$16,000/ML	$16,000/ML	$16,000/ML

*Approximate 2022 populations, sourced from NSW Government's Common Planning Assumptions.

Note: Population projections are based on the high growth projections included in the NSW Government's Common Planning Assumptions.

Table 2. Economic cost of town water supply shortages in the Lachlan region – Towns calculated using event length data

Time in water shortage	Parkes
Population*	14,683
System type	Regulated
Restriction Level	
0– 6 months (restrictions)	$1,500/ML
6–12 months (restrictions)	$3,500/ML
Greater than 12 months	$16,000/ML (alternative water source)
Continued shortages (greater than 24 months)	$16,000/ML (alternative water source)

*2022 populations, sourced from NSW Government's Common Planning Assumptions.

Note: Population projections are based on the high growth projections included in the NSW Government's Common Planning Assumptions.

Water supply is assumed to be restricted within the regulated system when the level of water in key storages (the Wyangala Dam for towns and communities on the Lachlan River) falls below certain storage levels. These assumptions are based on how the dams have been operated in previous droughts, with restrictions imposed on different users. Where there are no past precedents,[10] professional assessments were about the storage levels that would trigger restrictions. The assumed restrictions regime in the Lachlan catchment are shown in Table 5, for the Belubula catchment they are given in Table 4.

Lachlan Catchment

For the towns located in the Lachlan catchment of Cowra, Forbes, Condobolin, Lake Cargelligo and Hillston, the Wyangala Dam storage level has been used for simulating in the model when town water supply restrictions would likely be applied and the % restriction. These restriction levels are given below.

Table 3. Local Water Utility Restriction simulated restriction regime – Lachlan Catchment

Restriction Level	Wyangala Dam level (GL)	Local Water Utility (% of demand))
No restrictions	300	100

[10] For instance, at extremely low levels of storage that have not occurred in the historic record, but that do occur in either the stochastic or NARCliM scenarios.

Restriction Level	Wyangala Dam level (GL)	Local Water Utility (% of demand))
1	250	80
2	125	70
3	120	50
4	80	40
5	65	0

Belubula Catchment

The Central Tablelands Water utility located within the Belubula catchment sources it's water from Lake Rowlands. The relative storage level in Lake Rowlands has been used for simulating in the model when the water utility applies supply restrictions and the magnitude of restriction. These storage and restriction levels are given below.

Table 4. Local Water Utility Restriction simulated restriction regime – Belubula Catchment

Restriction Level	Lake Rowlands Level (GL)	Local Water Utility (% of demand)
No restrictions	>70%	100
1	250	80
2	125	70
3	120	50
4	80	40
5	65	0

Agricultural users

The economic benefit of water for agriculture varies depending on the assumed crop. The marginal economic benefit per megalitre of water supplied for an annual crop will not change with a shortfall in supply, as the area cropped is adjusted to match the expected water availability at the time of planting. For permanent crops, a shortfall in supply will increase the marginal economic benefit per megalitre of water, which recognises the replacement cost of establishing the crop. Table 5 highlights the majority of the agricultural crops grown in the Lachlan region, water licences and the economic value of water. Values given in brackets refer to the negative economic impact under shortfall conditions.

Table 5. Lachlan agricultural water supply economic benefit[11]

Crop/Stock	Cropping	Water licence	Marginal economic benefit of water ($/ML)
Cotton	Annual	General security Supplementary (Belubula only)	250
Wheat	Annual	General security Supplementary (Belubula only)	175
Oranges	Permanent	High security	450 (2,300)
Almonds	Permanent	High security	1,100 (1,300)
Olives	Permanent	High security	1,200 (2,800)
Stock and domestic	N/A	Stock and domestic	(5,000)

Note: Values given in brackets refer to the negative economic impact under shortfall conditions.

The assumed economic values for the major crops grown annually and permanently in the Lachlan region are:

- annual crops: cotton ($250/ML)
- permanent crops: oranges ($450/ML, negative $2,300/ML in shortfall).

[11] These were derived from the *Regional Water Value Functions* (MJA, 2020).

Both crops have sensitivities associated with their producer surplus, estimated at the long-run profitability derived from a megalitre of water, as detailed in the Regional Water Value Function report.[12]

[12] Marsden Jacobs Associates (2020). *Regional Water Value Function*

Hydrologic and economic base case outcomes

This section outlines the estimated hydrologic and economic outcomes from the economic base case hydrologic modelling for the key extractive users in the Lachlan region the historical (observed), stochastic (long-term paleoclimate) and NARCliM (climate change) scenarios.

There are 10,000 years of data in the stochastic and climate change datasets. This data has been split into 1,000 40-year realisations or 'windows' for each major water user.[13]

All economic calculations use a discount rate of 7%, as recommended by the NSW Treasury.[14]

Town and community hydrologic base case outcomes

The hydrologic modelling indicates that towns within the region are likely to experience low levels of surface water supply shortfalls, with a moderate increase in magnitude predicted due to climate change. The average length and magnitude of each town's expected annual shortfall for the 1,000 40-year windows under the stochastic and NARCliM models are shown in Table 6 and Table 7. Table 8 summarises the difference between the stochastic and NARCliM modelling results.

All towns exhibit some level of average annual unrestricted shortfalls across both datasets. The level of these shortfalls is typically low under the stochastic results, with an average shortfall as a percentage of demand for all towns, except Central Tablelands Water, less than 4%. This increases significantly under the NARCliM dataset, illustrating that towns water supplies may be at risk under a drier climate.

[13] Each realisation or 'window' covers a single 40-year hydrologic simulation. There are 1,000 of these realisations for each of the stochastic and NARCliM datasets. The windows are drawn from 40-year rolling periods extracted from the 10,000-year generated climatic datasets, with an approximate 9-year overlap between periods.

[14] NSW Treasury (2017) *TPP17-03: NSW Government Guide to Cost–Benefit Analysis.*

Table 6. Town water supply hydrologic base case outcomes — stochastic model

Town	Average annual unrestricted shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall
Cowra	31	2894	1.1	2.6
Forbes	77	2257	3.4	10.8
Parkes	40	4166	1.0	4.8
Condobolin	31	954	3.3	9.1
Lake Cargelligo	3	401	0.8	0.5
Hillston	6	267	2.1	6.5
Central Tablelands Water	105	1899	5.5	3.7

Table 7. Town water supply hydrologic base case outcomes — NARCliM scenario

Town	Average annual unrestricted shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall
Cowra	423	2955	14.3	4.9
Forbes	398	2376	16.7	11.2
Parkes	72	4289	1.7	4.9
Condobolin	160	990	16.1	9.7
Lake Cargelligo	53	401	13.2	3.1
Hillston	38	267	14.3	8.2
Central Tablelands Water	229	1899.4	12	5.8

Table 8. Town water supply hydrologic base case outcomes — difference between NARCliM and stochastic scenarios

Town	Average annual unrestricted shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall
Cowra	392	62	13.2	2.2
Forbes	321	119	13.3	0.4

Town	Average annual unrestricted shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall
Parkes	32	122	0.7	0.1
Condobolin	129	36	12.8	0.6
Lake Cargelligo	50	0	12.4	2.7
Hillston	33	0	12.2	1.7
Central Tablelands Water	124	0	6.5	2.1

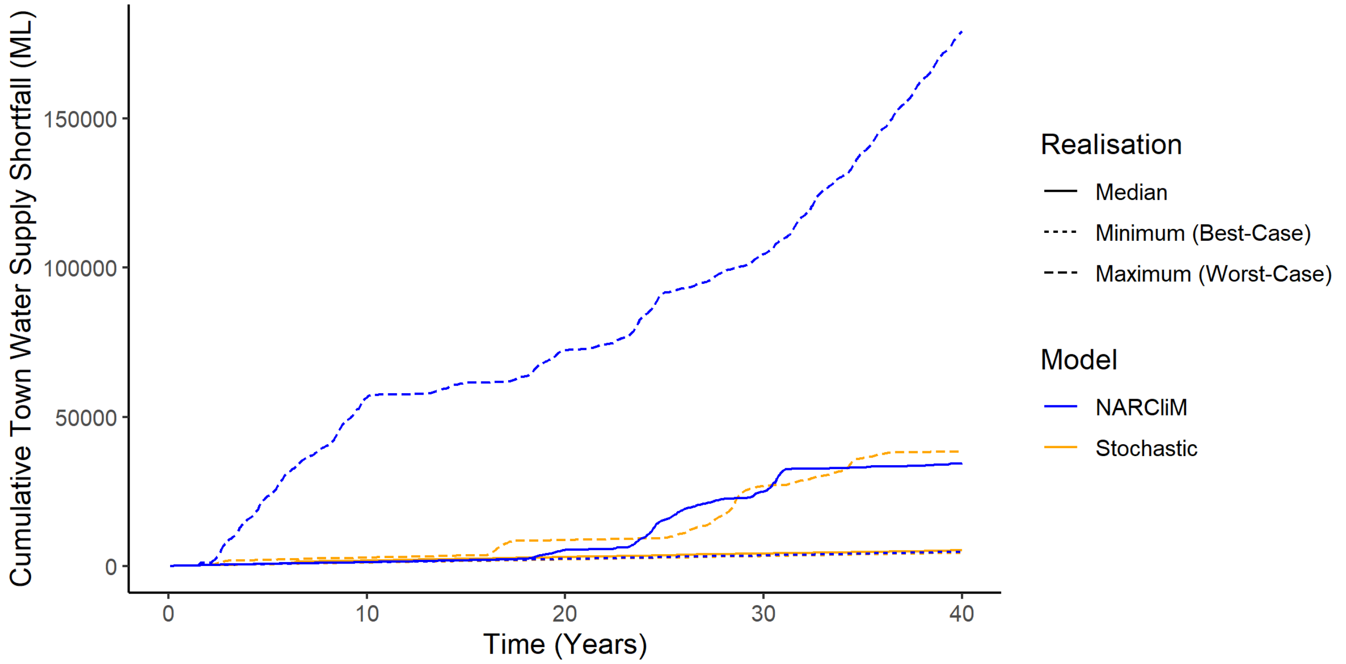
Figure 2 illustrates the key town water supply shortfall scenarios of the 1,000 40-year windows for individual towns, and the combined towns, in the stochastic and NARCliM models. Figure 2 shows these scenarios as cumulative totals over the 40-year simulation period. The key scenarios are:

- minimum — the best-case scenario
- median — the exact middle scenario
- maximum — the worst-case scenario.

These scenarios allow an understanding of the spread of outcomes (what could happen) over all the 40-year windows simulated for the region and how towns might experience the predicted economic outcomes of the climate models over time. In short, it shows that over the next 40 years, the number of times a town might run out of surface water could be anywhere between the dotted lines. In instances where there are no (or very low) shortfalls, lines may overlap.

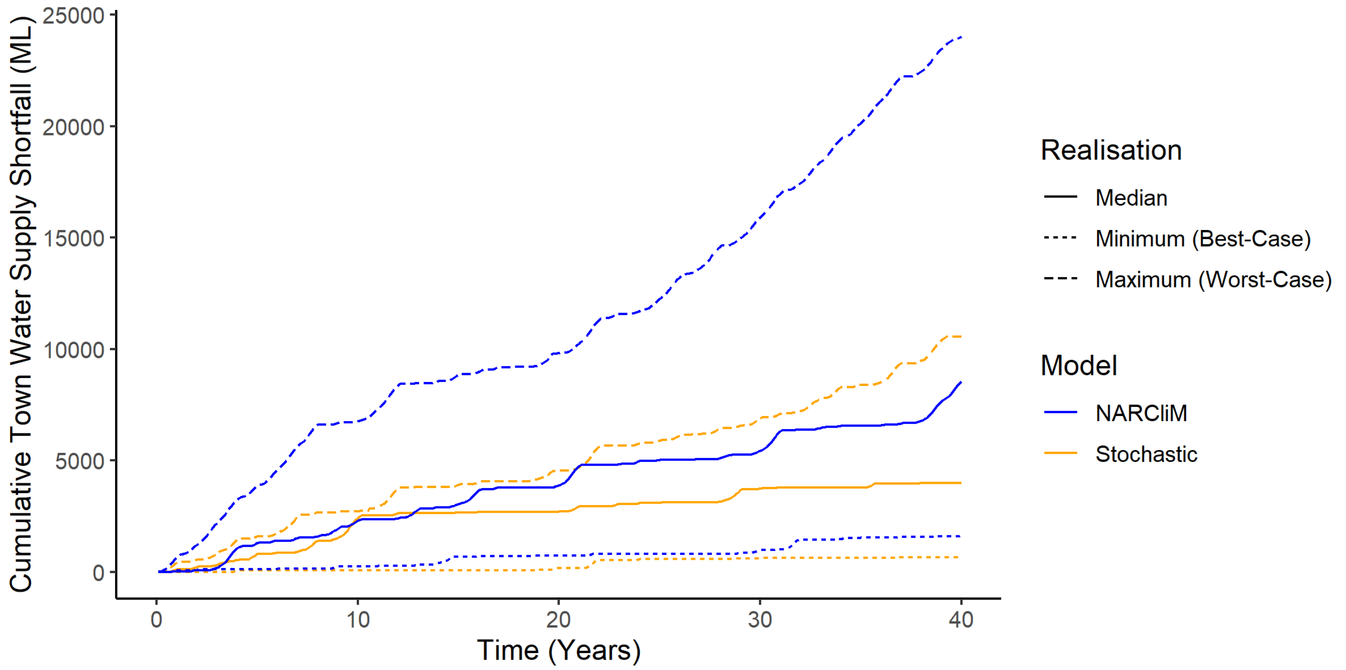
Similar to the data in Table 7, the graphs in Figure 2 show that expected cumulative shortfalls for town water supplies are much lower in the stochastic dataset than in the NARCliM dataset. Under the stochastic dataset, the worst-case cumulative shortfalls are zero for almost the first 10 years. At that point they increase, but always remain lower than in the NARCliM dataset. Under the best-case simulation results, very low to no shortfalls are experienced under all climate datasets.

Figure 2. Lachlan towns supply cumulative 40-year shortfall series



In the Belubula catchment there is a wide variety of outcomes in the databases. The instrumental outcomes are worse than the stochastic or NARCliM both in the extreme and on average. The expected cumulative shortfalls for town water supplies are much lower in the stochastic dataset than in the NARCliM dataset. Under the best-case simulation results, very low to no shortfalls are experienced under both climate datasets.

Figure 3. Belubula catchment town supply cumulative 40-year shortfall series



Town and community economic base case outcomes

The estimated average economic impact of water supply shortfalls for towns within the Lachlan region over a 40-year period are shown in Table 9 All towns are predicted to experience declines in economic outcomes due to water restrictions. Although these costs of water supply shortfalls increase for all towns under a drier climate, they have the potential to significantly increase for Forbes, Parkes, and Condobolin. It should also be noted that Lake Cargelligo is a major tourist destination (due to the Lake Cargelligo system). This is likely to result in economic consequences for the town that are outside the ability of this options assessment process to quantify.

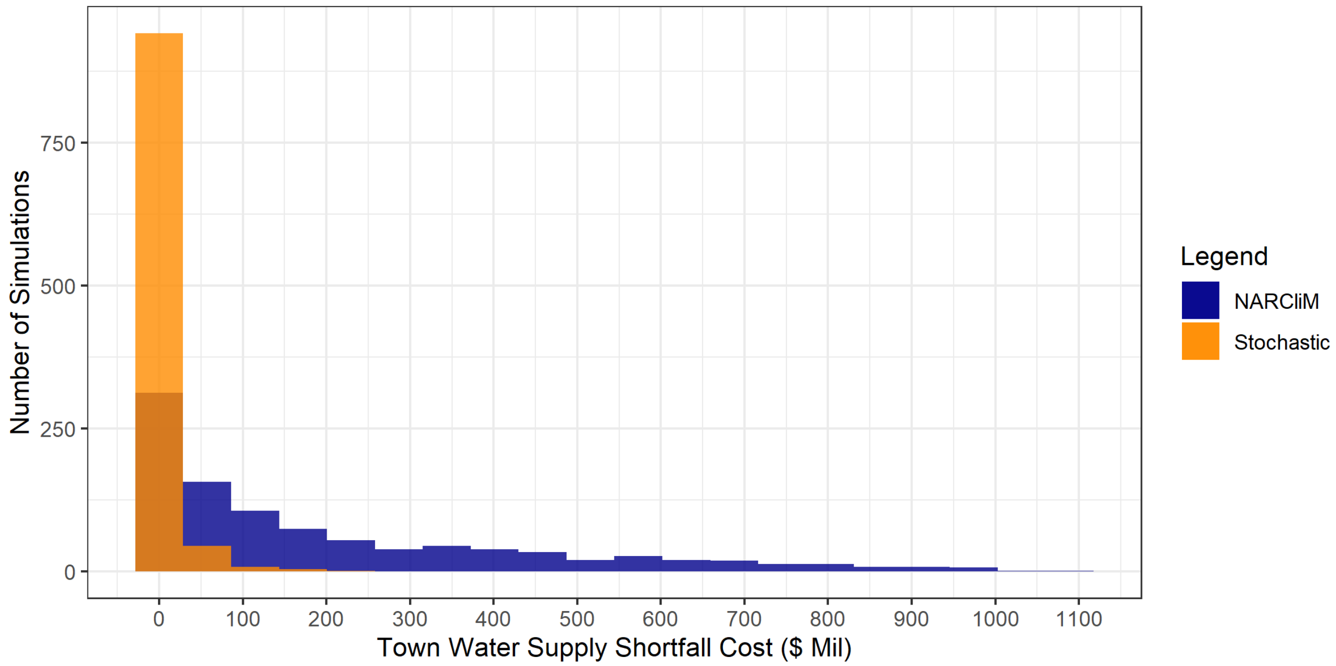
Table 9 Economic base case outcome — town water supply average 40-year shortfall, net present costs

Town	Stochastic ($m)	NARCliM ($m)	Difference ($m)
Cowra	-2.5	-83.4	-80.8
Forbes	-2.0	-69.7	-67.7
Parkes	-0.9	-1.7	-0.9
Condobolin	-0.9	-28.3	-27.4
Lake Cargelligo	-0.3	-10.6	-10.3
Hillston	-0.2	-7.1	-6.9
Central Tablelands Water	-15.4	-42.4	-27.0
Total	-22.2	-243.2	-221.0

The distributions of the expected economic outcomes for each model are shown in Figure 4. Figure 4 condenses the economic costs of town water supply shortfalls for all 1,000 40-year windows by grouping results into ranges of values — in this case, 20 ranges per data series. Figure 4 also illustrates that both the magnitude and uncertainty (that is, the spread) of the average cost of town water supply shortfalls increases under the NARCliM forecasts. The increase in the spread of town water supply costs under a NARCliM scenario reflects the estimated increase in the number and severity of shortfalls where water supply is required to be supported by a more expensive alternative source.

Figure 4 indicates that the absolute worst economic outcomes for the combined town water supply shortfalls of towns captured within this study of the Lachlan catchment would be approximately $200 million for the stochastic dataset and upwards of $900 million for the NARCliM dataset, although it should be acknowledged that these values are highly unlikely. Similar to the hydrologic results, the worst-case NARCliM outcomes are significantly higher than the worst-case stochastic outcomes. Likewise, the skew in results for the NARCliM outcomes suggest a higher percentage of the scenarios result in town water shortfalls for towns and communities.

Figure 4. Total average towns water supply, net present costs



Agricultural hydrologic base case outcomes

The following section describes the hydrologic impacts on the agricultural industry within the Lachlan region. Agriculture has been separated into two groups for this region:

- annual crops (cotton)
- permanent crops (oranges).

The estimated annual average volume of water these producers use under both the stochastic and NARCliM scenarios are given in Table 11 for the Lachlan catchment and in Table 12 for the Belubula catchment.

Within the Lachlan catchment annual crop water use is expected to decline, on average, by around 51 GL or 30% between the stochastic and NARCliM datasets. Water for permanent crops is assumed sourced from high-security water access licence shares, which account for less than 10% of the Lachlan region's licences shares. Permanent crops are expected so see a 1.5 GL reduction, or a 14% reduction in water usage. The relatively lower percentage reduction of usage compared to that experienced by annual crops reflects the higher level of reliability.

Similar patterns in usage drops for all water users in the NARCliM climate dataset when compared to the stochastic dataset are experienced in the Belubula. The volumes of water used within the Belubula are far less than those extracted from the Lachlan River.

Table 10. Average annual agricultural water use volumes–stochastic and NARCliM scenarios – Lachlan catchment

Crop classification	Water use metric	Stochastic	NARCliM	Difference	Difference (%)
Annual crops (GL/year)	Average	168.8	117.3	-51.4	-30.5
	Maximum	214.7	212.2	-2.5	-1.1
	Median	175.0	116.0	-59.0	-33.7
	Minimum	85.1	23.8	-61.2	-72.0
	Standard deviation	26.5	42.4	15.9	60.1
Permanent crops (GL/year)	Average	10.8	9.3	-1.5	-14.0
	Maximum	10.9	10.9	0.0	0.0
	Median	10.9	9.6	-1.2	-11.4
	Minimum	9.3	4.5	-4.8	-51.3
	Standard deviation	0.2	1.4	1.2	553.2

Table 11. Average annual agricultural water use volumes–stochastic and NARCliM scenarios – Belubula catchment

Crop classification	Water use metric	Stochastic	NARCliM	Difference	Difference (%)
Annual crops (GL/year)	Average	1.1	0.6	-0.5	-42.0
	Maximum	1.4	1.4	0.0	-3.2
	Median	1.1	0.6	-0.5	-48.3
	Minimum	0.2	0.1	-0.1	-61.9
	Standard deviation	0.2	0.3	0.1	23.8
Permanent crops (GL/year)	Average	1.3	1.1	-0.3	-19.6
	Maximum	1.4	1.4	0.0	-0.4
	Median	1.4	1.1	-0.3	-19.8
	Minimum	1.0	0.5	-0.5	-52.0
	Standard deviation	0.1	0.2	0.1	106.0

Graphs of the modelled annual agricultural water use within the Lachlan region are shown in Figure 5 and Figure 6 for annual and permanent crops respectively. The figures group the results of the 40-year realisations into 20 ‘bins’ to provide an overview of the outcomes for the 1,000 realisations of each model. They indicate that the amounts of water used on average for both annual and permanent crops are predicted to reduce under the climatic conditions present in the NARCliM model. The amount of variation is expected to remain roughly the same between the two datasets.

The histogram of annual agriculture production in the Lachlan region shows considerable variability. While the stochastic scenarios are clustered around 180 GL/year, the NARCliM results peak at around 120 GL/year. This suggests a significant decline in the amount of water available in the NARCliM dataset compared to the stochastic one.

The histogram for permanent agriculture is highly clustered around the maximum amount of water supplied to high security entitlements in the stochastic dataset. However, in the NARCliM dataset there are few scenarios where the full entitlement is met over the 40 years of the scenarios and a significant number where there are significantly smaller amounts provided.

Figure 5. Lachlan River–Annual crop water use under stochastic and NARCliM scenarios

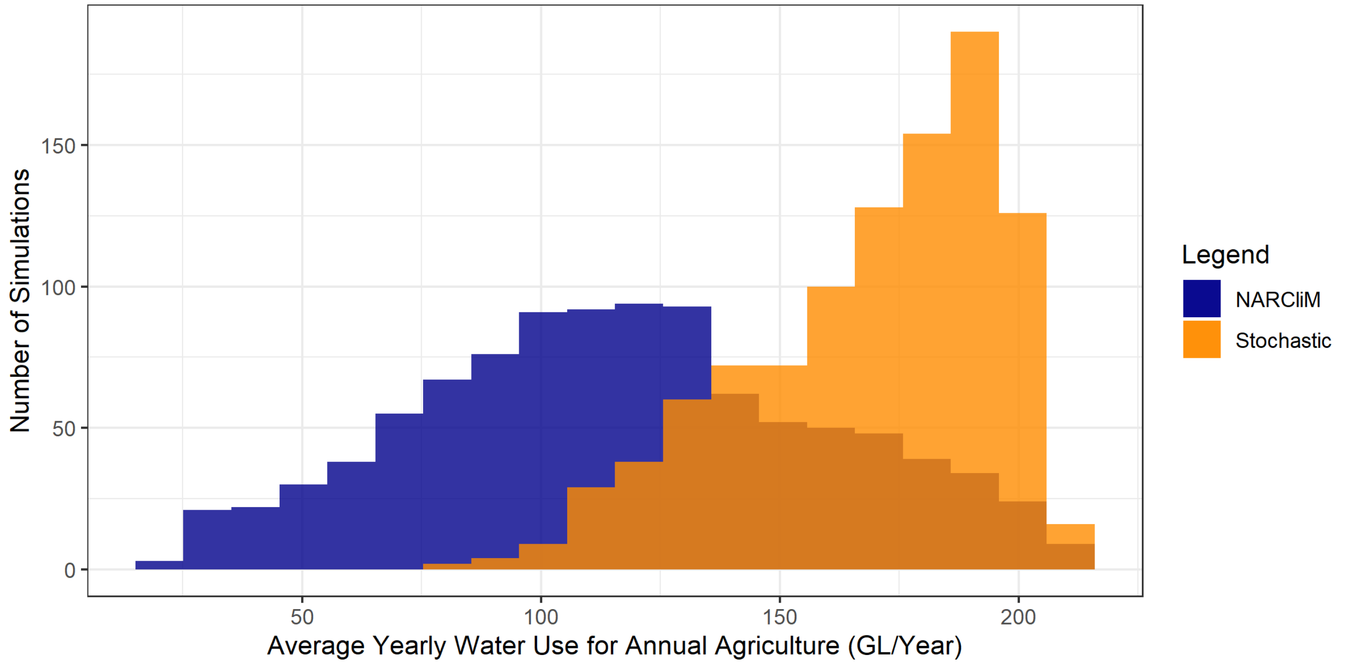
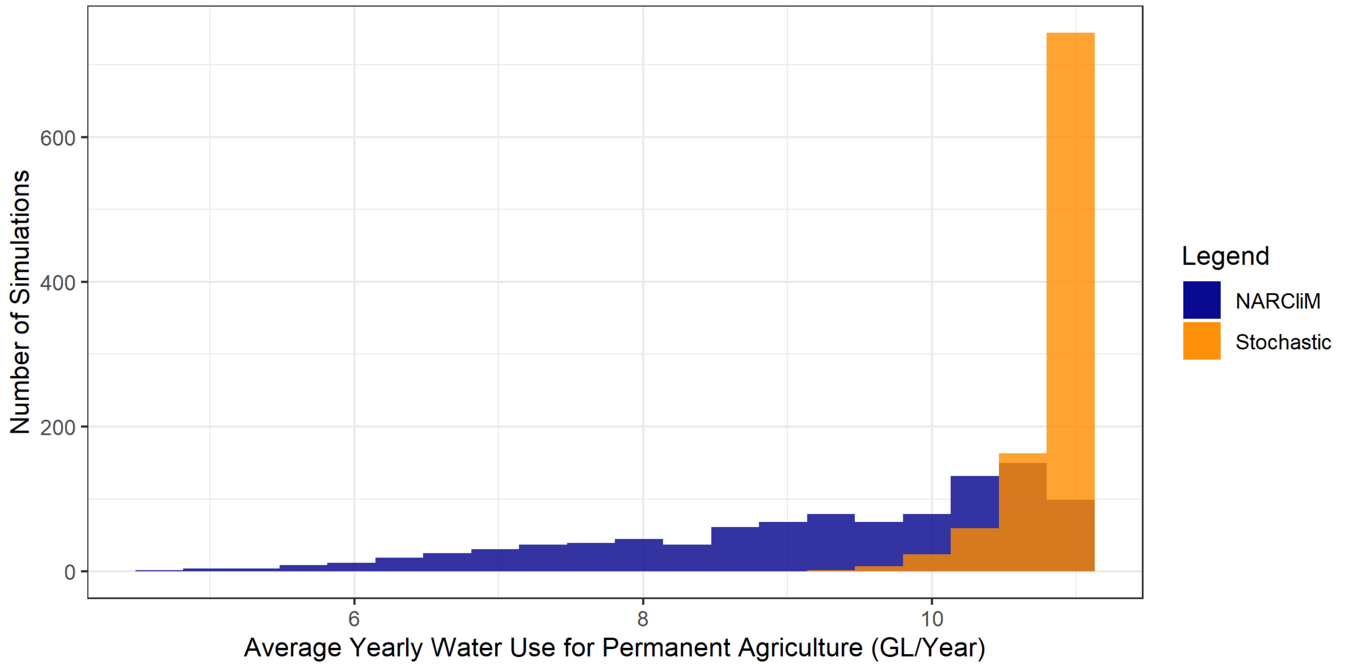


Figure 6. Lachlan River–Permanent crop water use under stochastic and NARCliM scenarios



While the total amount of water provided to agriculture is low, on the Belubula River, there are stark differences between the stochastic and NARCliM datasets as shown in Figure 7 and

Figure 8. The stochastic scenarios are clustered around 1.3 to 1.5 GL/year, while the NARCliM scenarios are clustered between 0.5 to 0.8 GL/year. Almost all the stochastic scenarios result in around 1 GL/year of water being provided to permanent agriculture. However, the NARCliM dataset results in permanent agriculture receiving less than the full allocation in almost all scenarios.

Figure 7. Belubula River–Annual crop water use under stochastic and NARCliM scenarios

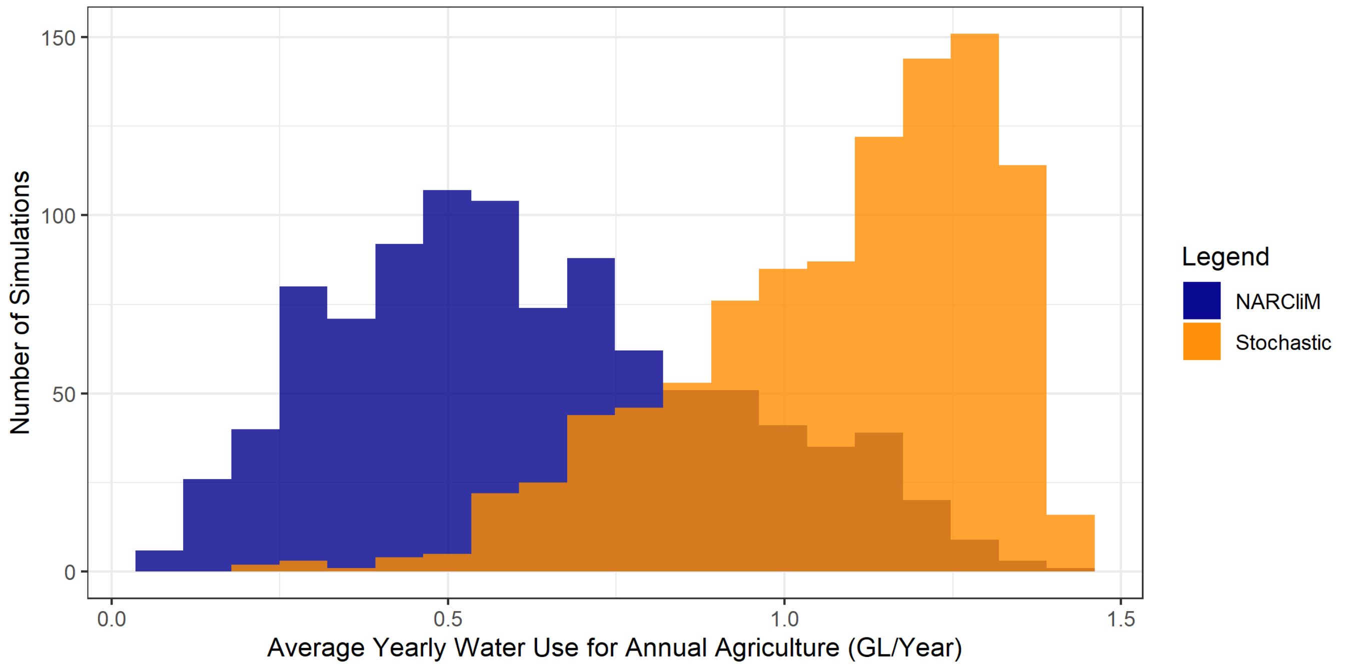
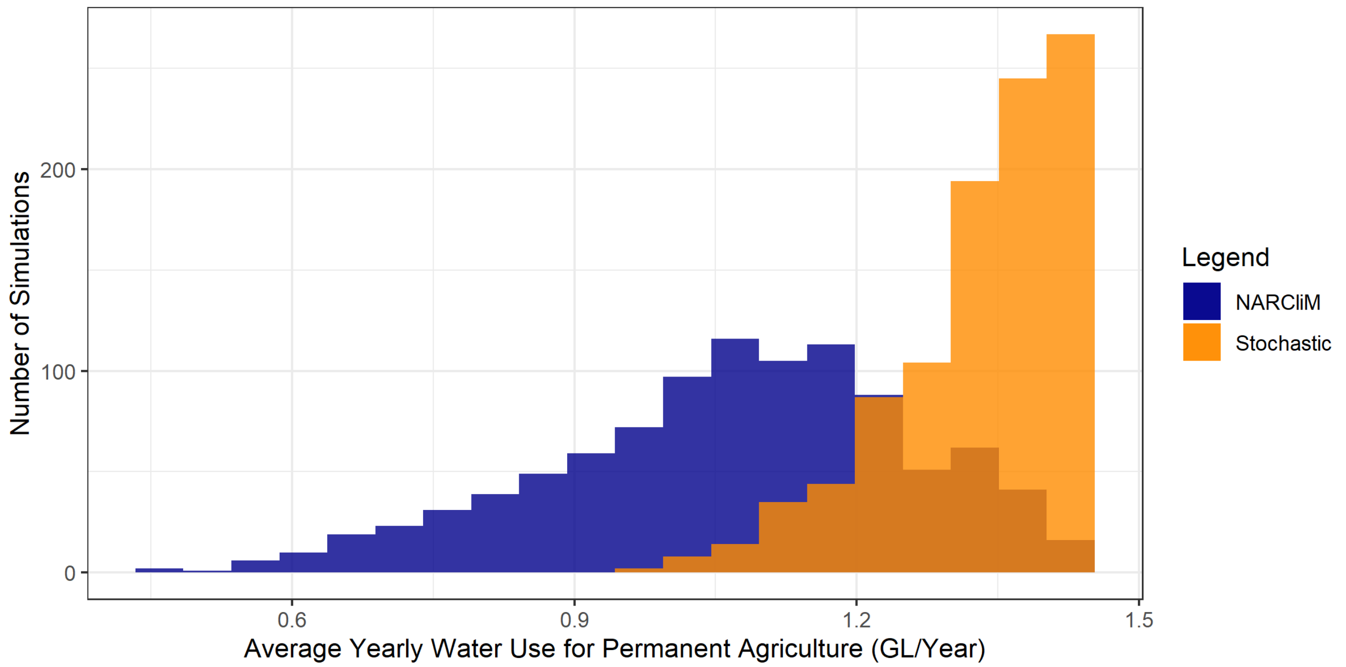


Figure 8. Belubula River–permanent crop water use under stochastic and NARCliM scenarios



Three outcomes of expected cumulative water use for producers of annual and permanent crops are shown in **Error! Reference source not found.** and Figure 10 for both the stochastic and NARCliM hydrologic models of the Lachlan River. Figure 11 and Figure 12 give the same information for the Belubula River. The outcomes presented are:

- minimum: the best-case scenario

- median: the exact middle scenario
- maximum: the worst-case scenario.

These results show that the climate predictions under the NARCliM scenario result in less water availability for the production of annual crops. The median cumulative expected water use for annual crops under the NARCliM scenario is nearly below the minimum result for the stochastic scenario, suggesting a significant decrease in water availability for annual crops under the climate change scenario when compared to stochastic climate projections. Under the stochastic scenario, the amount of water supplied for annual crops under the worst-case nearly exceeds the median amount of water provided under the NARCliM dataset for a large part of the 40-year timeframe.

In Figure 10, the impact of climate change on permanent crops is less visible as the best-case scenario under the NARCliM dataset is equivalent to the median outcome under the stochastic dataset. This is reflective of the relatively higher reliability of the high security licenses. The reliability shows significant weakness under the worst NARCliM scenario in the dataset.

Figure 9. Lachlan River–Annual crop water use under cumulative stochastic and NARCliM scenarios

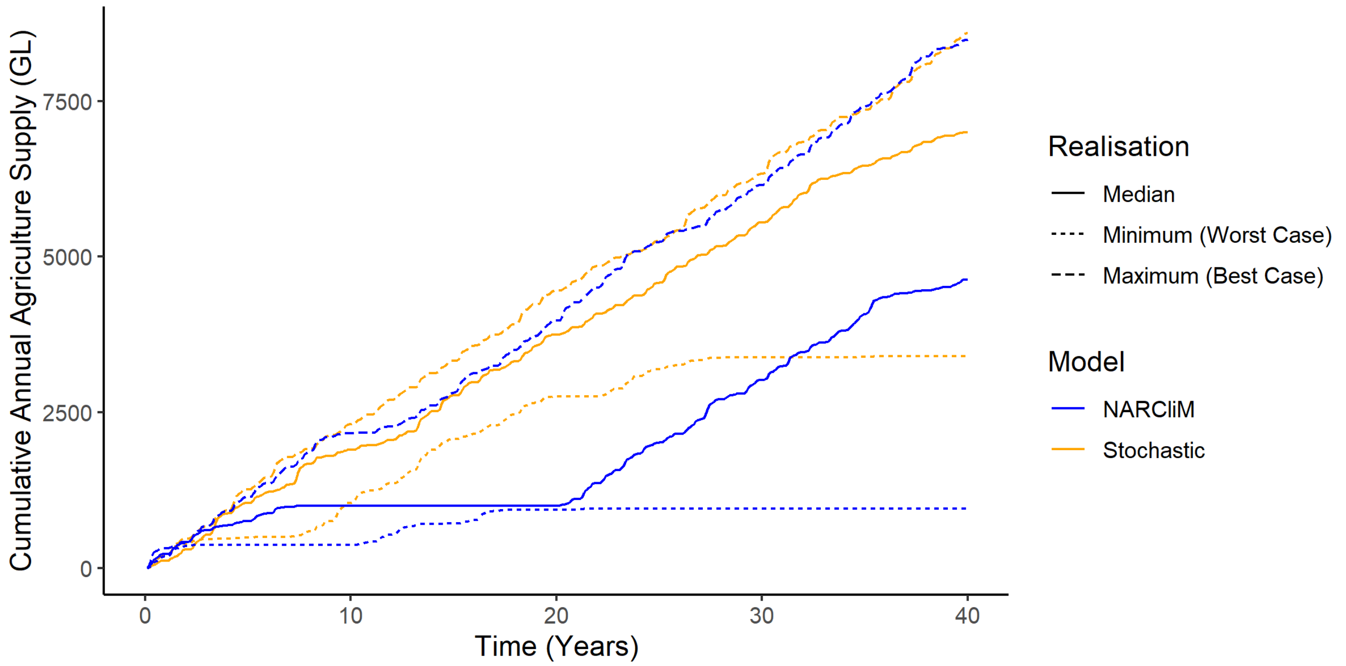
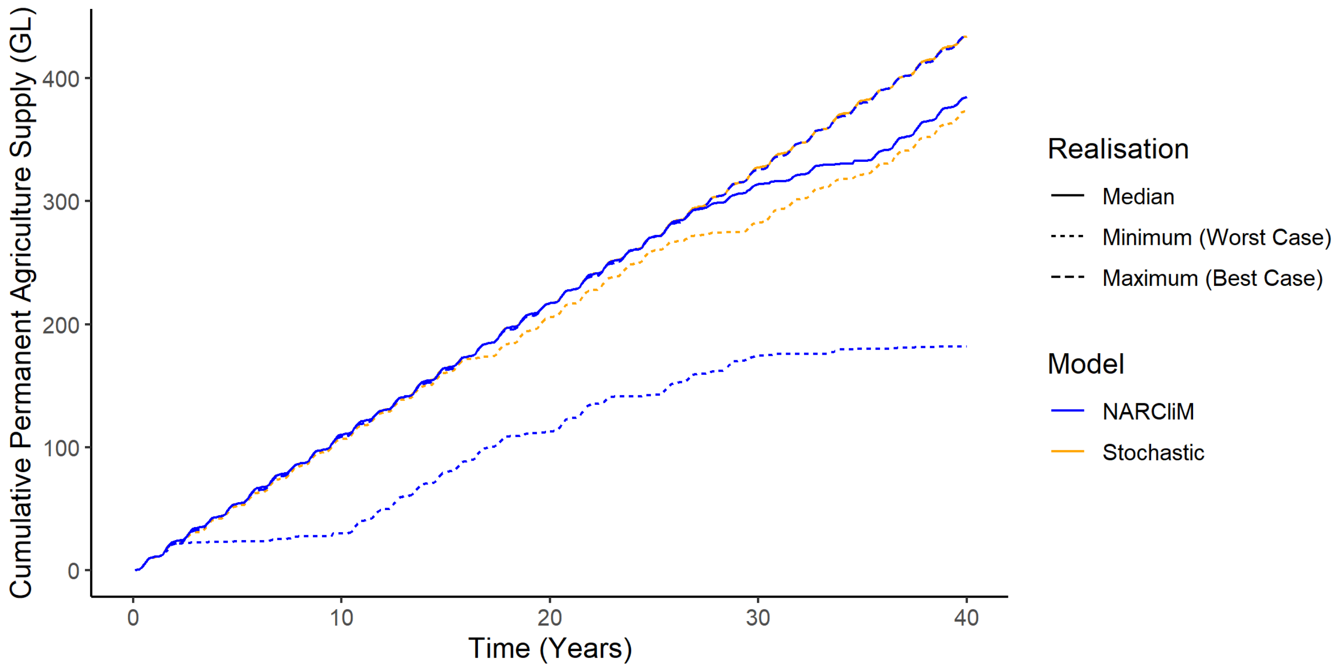


Figure 10. Lachlan River–Permanent crop water use under cumulative stochastic and NARCliM scenarios



Similar to the Lachlan River values, the Belubula River shows a significant decrease in the reliability of water under the NARCliM climate scenario. Water extractive for annual crops has the potential for long periods of very low usage under both climates, with the issue exacerbated under the NARCliM climate. Reliability of the high security water used for permanent crops shows considerable impact under a climate change scenario, in this case the median NARCliM outcome is comparable to the worst-case stochastic outcome.

Figure 11. Belubula River–Annual crop water use under cumulative stochastic and NARCliM scenarios

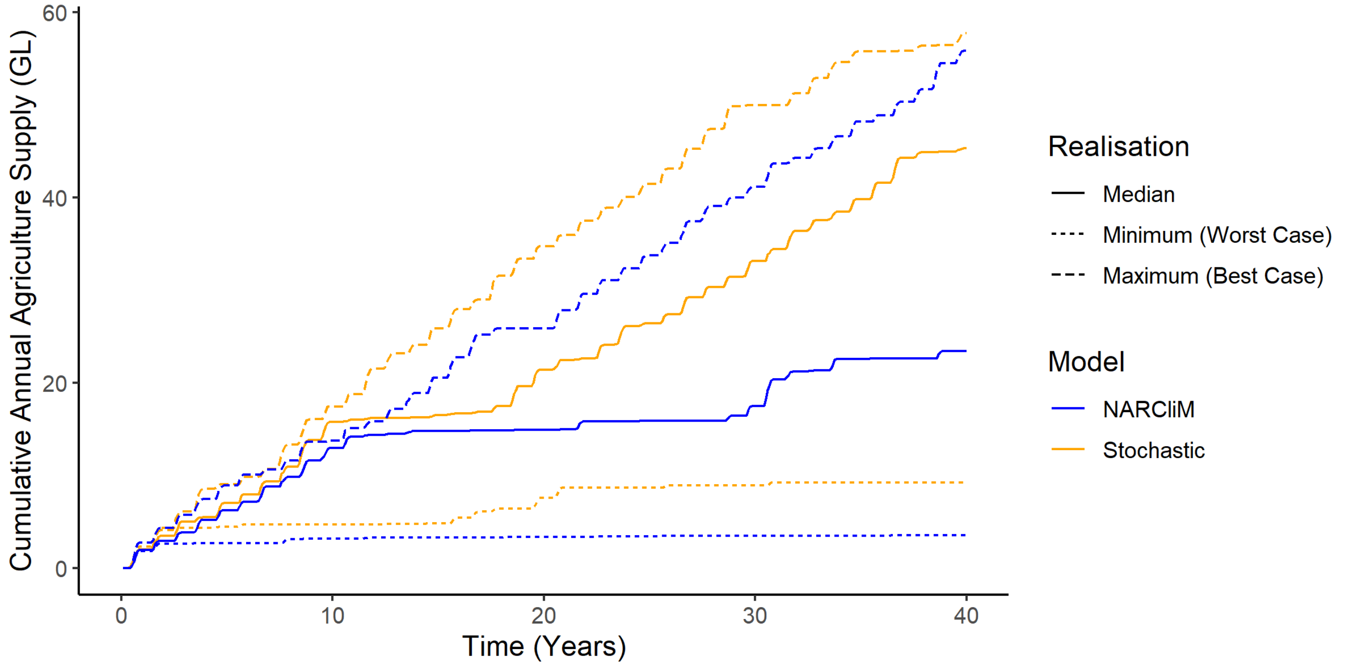
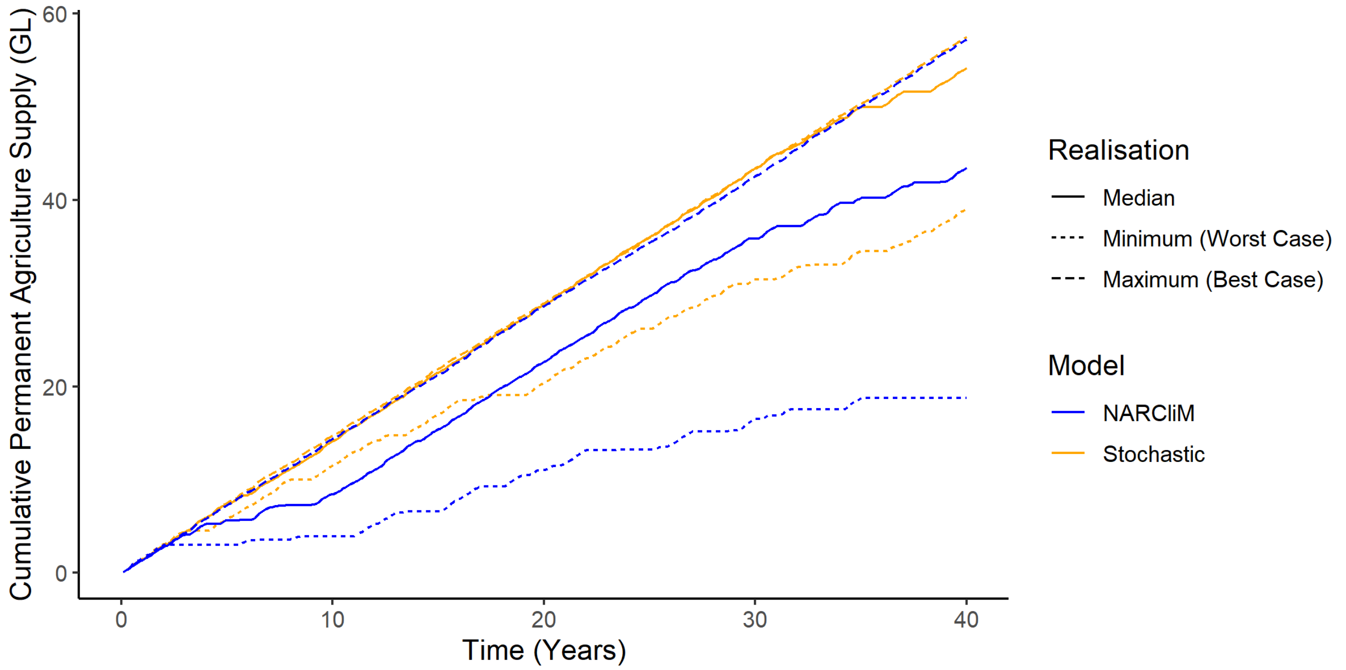


Figure 12. Belubula River–Permanent crop water use under cumulative stochastic and NARCliM scenarios



Agricultural economic base case outcomes

Average economic values of water for agricultural producers within the Lachlan region, inclusive of Lachlan River and the Belubula River, over the 40-year analysis period are shown in Table 12. The small amount of high-security water allocations within the catchment translates to a small producer surplus for permanent crops (oranges) despite its high economic value on a per unit basis, roughly 7.5% of all economic value generated. Conversely, annual crops like cotton represent a large economic addition for the region due to the larger allocation of less secure water assumed to be used for growing the crop.

Under the NARCliM scenario, a decrease in the average economic value for annual (26%) and permanent crop (132%) producers reflect the reduction of agricultural production due to decreased water reliability under a climate change scenario. In total, the NARCliM dataset suggests a decline of almost $220 million on average over a 40-year period in producer surplus for waters' share of agricultural activity in the region.

Table 12. Economic base case outcomes: agriculture net present producer surplus averages over 40 years

Crop classification	Stochastic ($m)	NARCliM ($m)	Difference ($m)	Difference (%)
Annual crops	598	440	-158	-26.4
Permanent crops	46	-15	-60	-132.2
Total	**644**	**426**	**-218**	**-33.9**

Summaries of the distributions of possible outcomes for crop producers within the Lachlan River are shown in Figure 13 for annual crops, and Figure 14 for permanent crops. These figures show the wide range of possible economic outcomes under the stochastic and NARCliM scenarios.

The predicted economic surplus due to irrigation for producers of annual crops under stochastic conditions ranges from approximately $250 million to $780 million, with an average value of around $600 million over the forecast 40 years. For the NARCliM results, the value of output for producers of annual crops shifts lower, with values ranging from $75 million to $780 million and an average value of $400 million.

For permanent agriculture in the Lachlan region, the majority of stochastic outcomes result in high-security entitlement holders receiving their full annual allocations which is evident by the right skew of the results at approximately $45 million. Under the NARCliM forecasts, the spread of outcomes widens and includes negative producer surpluses, with a range of -$175 million to $45 million. The negative economic surplus represents the loss of long-term plantations in the region due to surface water supply shortfalls. It is noted that producers of permanent crops generally will have access to alternative water sources in times of surface water shortfalls, this dynamic is not captured within this modelling.

Figure 13. Lachlan River: Annual agriculture net present producer surplus over 40 years

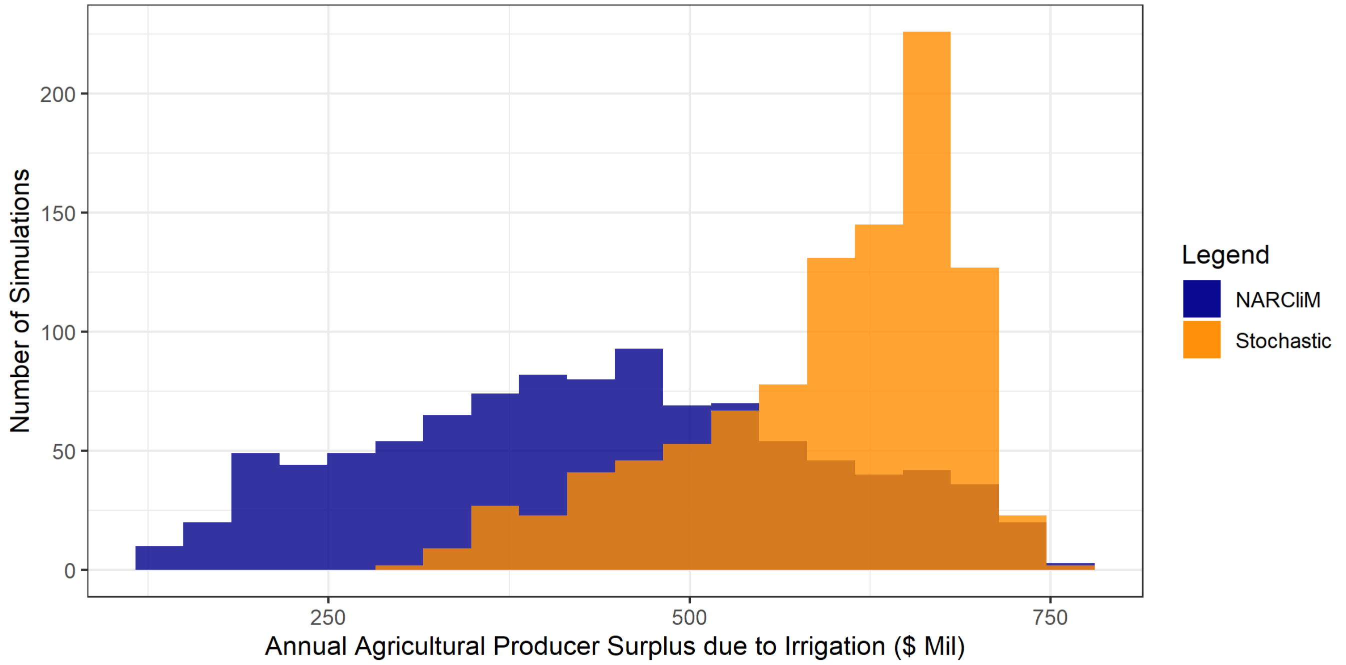


Figure 14. Lachlan River: Permanent agriculture net present producer surplus over 40 years

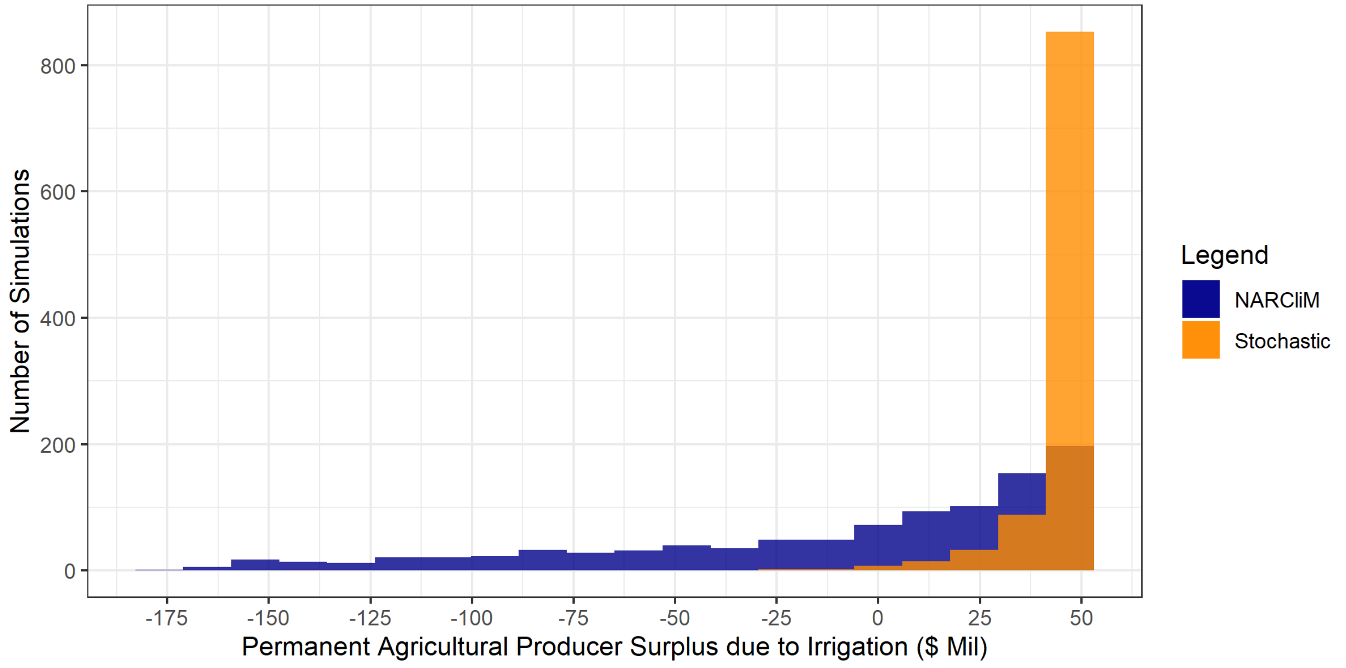


Figure 15 and Figure 16 give the distributions of modelled economic outcomes for annual crop producers and permanent crops within the Belubula system. Due to the relatively smaller industry of annual crop producers located on the Belubula, the variability economic outcomes are small in comparison to those of the Lachlan River, however there remains a significant shift to less production under a climate change scenario.

The plot showing the modelled economic outcomes for permanent crop producers indicates a higher level of vulnerability to these industries in the Belubula system when compared to the Lachlan River, due to a lower reliability of high security licenses. Under a climate change scenario, the majority of the NARCliM outcomes are negative, indicating a high level of potential stress on these industries under dry climate conditions. It can also be observed that under the stochastic climate a larger percentage of permanent economic outcomes are negative in the Belubula than in the Lachlan River, a further reflection on the higher variability of water reliability within the Belubula.

Figure 15. Belubula River: Annual agriculture net present producer surplus over 40 years

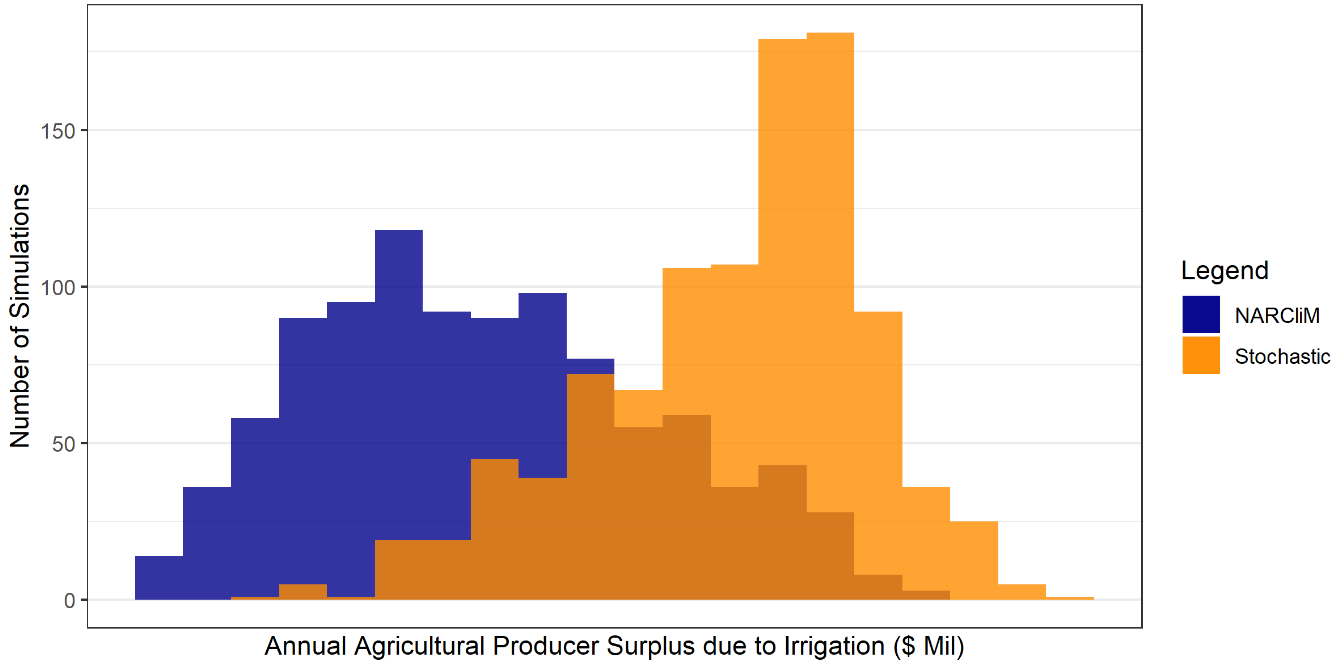
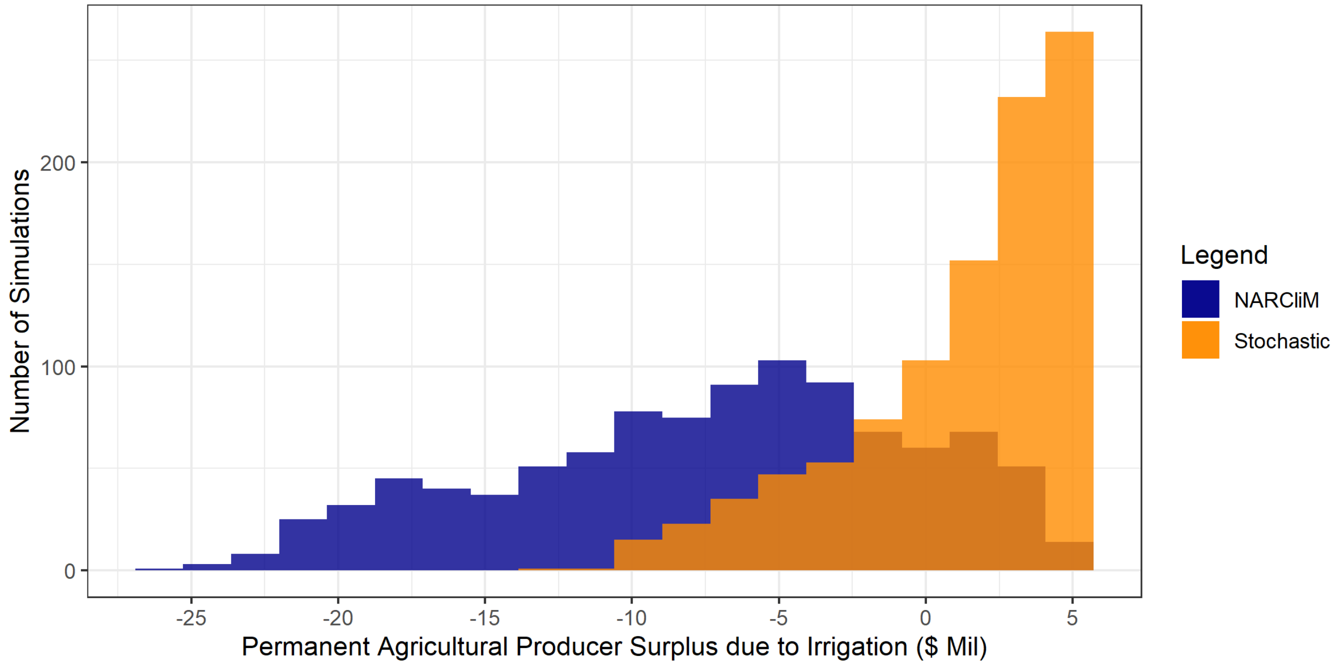


Figure 16. Belubula River: Permanent agriculture net present producer surplus over 40 years



Assumptions and uncertainties

The analyses in the regional water strategies are based on the best available information at the time. As with all types of analyses, a range of assumptions, uncertainties and qualifications are made.

Assumptions adopted within this economic base case analysis include:

- Town water supply shortfalls consider only modelled surface water availability and do not include any consideration of existing alternative supply sources such as groundwater or desalination plants. The purpose of the analysis was to identify how secure the surface water supply is for each town. Further analysis needs to be undertaken to understand how these risks can be met by existing alternative water sources that the towns already access.
- Population increases have been included in accordance with the NSW Government's Common Planning Assumptions' high population growth forecasts. Some towns within the Lachlan region are predicted to have reductions in population; for these towns, it is assumed that population growth will be flat rather than decreasing.
- Current uses of water, in both general security and high security entitlements, are assumed to be constant over the 40 years examined. In practice, it is likely that technology and global demand for food and fibre will change the nature of the crops produced in the Lachlan region, therefore changing the amount of water used. Estimating these changes is beyond the regional water strategies project.
- It is noted that producers of permanent crops generally will have access to alternative water sources in times of surface water shortfalls, this dynamic is not captured within this analysis.

Uncertainties and qualifications relevant to this study include:

- Town water supply shortfall analysis presented is not a replacement for secure yield analysis undertaken by local water utilities as part of integrated water cycle management strategies; however, it can be used as an input into determining the secure yield.
- Economic outcomes are likely to be highly sensitive to the discount rate considered. The producer surpluses are based on long-run estimates. In practice, the profitability of each crop will vary year-by-year. Estimating these changes is beyond the scope of the regional water strategies project.