Department of Planning and Environment

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Economic base case

Gwydir region

July 2022

Acknowledgement of Country

The NSW Government acknowledges Aboriginal people as Australia's first people and the traditional owners and custodians of the country's lands and water. Aboriginal 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 Gomeroi/Kamilaroi people as having an intrinsic connection with the lands and waters of the Gwydir Regional Water Strategy area. The landscape and its waters provide the Gomeroi/Kamilaroi people with essential links to their history and help them to maintain and practice their culture and lifestyle.

The NSW Government recognises that the Traditional Owners were the first managers of Country and that incorporating their culture and knowledge into management of water in the region is a significant step for closing the gap.

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Executive summary

This report details the economic base case used for the hydrologic and economic modelling undertaken to support assessment of the long list options presented in the draft Gwydir Regional Water Strategy.

The base case assumes existing infrastructure and policy settings but includes central planning assumptions on projections of future populations in the region.

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

- Towns (as water shortfall): Bingara (regulated), Gravesend (regulated) and Inverell (regulated) – where shortfall refers to a town being unable to meet its unrestricted demand from surface water supply
- Annual crop producers (as water supplied): assumed to be cotton, as this is the primary annual crop grown in the region
- Permanent crop producers (as water supplied): assumed to be pecans.

Stock and domestic users were not considered in this analysis as their overall proportion of water usage was minimal compared to total extractions in the regulated Gwydir River.

The hydrologic results indicate that the three towns that were modelled in the Gwydir region are unlikely to experience any significant shortfalls in a drier future climate. The annual agricultural producers are on average likely to experience a decrease in how often they have access to water (known as water supply reliability) under the dry climate change scenario, which will impact their profitability. Permanent agricultural farmers are not likely to experience any significant decrease in their water availability except in absolute extreme conditions. A summary of the average amount of water available for each aggregated water user group under the three plausible futures is shown in Table A below.

While the dry climate scenarios that we have analysed may not occur and are a worst case scenario, considering this scenario helps with strategic planning. It helps us to bookend the analysis to understand whether certain risks and options would benefit from additional analysis and focus.

Table A. Average yearly water provided to different water user groups

Water user group	(b) Long-term historical climate projections (stochastic)	(c) Dry climate change scenario (NARCliM)	Difference between (b) and (c)	Difference (%) between (b) and (c)
Towns (shortfall, ML/year)	0	1.0	-1.0	-0.2

Water user group	(b) Long-term historical climate projections (stochastic)	(c) Dry climate change scenario (NARCliM)	Difference between (b) and (c)	Difference (%) between (b) and (c)
Annual crops (supplied, GL/year)	391	301	-90	-23
Permanent crops (supplied, GL/year)	12	12	0	0

The second step 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 Water Value Functions* (Marsden Jacobs Associates, 2020[1]). The evaluation period for each analysis was 40 years with a discount rate of 7%. Economic valuations per megalitre (ML) of water for each water user group were:

- Towns: escalating cost is dependent on the size of the town and the length of the shortfall (noting that this value is applied on the volume of water not supplied – that is, the shortfall)
- Annual crop producers (cotton): $375/ML
- Permanent crop producers (pecans): $800/ML, $3,200/ML in shortfall

The economic impacts will be primarily felt by annual crop producers with a reduction in the availability of general security water greatly impacting their economic outcomes with a 23% reduction between the two estimates. The towns and high security farmers are not expected to be impacted.

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

Water user group	(b) Long-term historical climate projections (stochastic)	(c) Dry climate change scenario (NARCliM)	Difference between (b) and (c)	Difference (%) between (b) and (c)
Towns, cost to ($, mil)	0	-0.1	-0.1	NA*
Annual crops ($, mil)	1,995	1,532	-463	-23
Permanent crops ($, mil)	137	136	-1	-1

[1] Marsden Jacobs Associates, 2020. Available at water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/identifying-and-assessing

*Note: The initial value is small so any change results in a large percentage difference despite not being material.

The regional water strategy is not a business case and this economic base case analysis is not intended to be at the detail required for a business case. Rather, it is the first step in undertaking a strategic analysis of alternate options being considered for the Gwydir Regional Water Strategy. The analysis still needs to be robust and sufficiently specific to each region to compare the merits of different options.

The approach set out in this document aims to strike the right balance between a high level, strategic assessment and region-specific information. In doing so, 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.

Introduction

This report details the economic base case used for the hydrological and economic modelling undertaken to support assessment of the long list options presented in the draft Gwydir Regional Water Strategy.

This report has been prepared to support decision-making for the Gwydir Regional Water Strategy about options and portfolios of solutions that may impact the supply, demand or allocation of water and that can be represented adequately within catchment level hydrologic modelling. There are a range of other options in the regional water strategy that do not impact on the supply, demand or allocation of water in the region. A separate assessment process has been adopted for those options, detailed in the Options Assessment Process: Overview[2]. 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 set out in:

- TPP18-06: NSW Treasury, NSW Government Business Case Guidelines
- TPP17-03: NSW Treasury, NSW Guide to Cost-benefit Analysis.

What is the economic base case and why is it important?

The economic base case represents what the future could look like for towns and water-based industries if we do nothing over the next 4 decades. The economic base case is generated by combining the value that different extractive water users place on water against water availability forecasts for the region. It assumes current infrastructure and water policy settings but includes changes to population projections.

The water demands of user groups are generally set as fixed, with some exceptions with regards to town population growth where this is predicted to occur. This 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 is the central scenario being used to assess hydrologically modelled options developed for the regional water strategies in cost benefit analysis.

What is the Regional Water Value function?

The Regional Water Value function[3] places a value on the amount of water that is forecast to be available. The forecasts are developed through hydrologic modelling. These estimated values:

[2] Available at: water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/identifying-and-assessing

[3] *Regional Water Value Function* (Marsden Jacob Associates, 2020)

- **Focus on key water user groups** – not every water user in a region is analysed, as 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 over decades.

The values produced in the regional water value function are for key water users. In the Gwydir region, this includes:

- town water supply
- irrigators of annual crops – assumed to be cotton, as this is the primary crop grown in the region
- irrigators of permanent crops – assumed to be pecans.

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 water. As a result, irrigators with permanent plantings are more vulnerable in periods of supply shortfalls. This reflects how the economic value of water adjusts as forecast availability changes.

We recognise that this approach will not necessarily capture every detail about water use or every individual water user in the region. Such a level of detail is more appropriately considered in a comprehensive business case. However, the approach does provide a robust and high-level strategic assessment of the impacts of major infrastructure or policy changes across the region.

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

Using the Integrated Quality and Quantity Model streamflow modelling platform, 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.[4]

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 Gwydir' major dam (Copeton Dam). The various assumptions of these restrictions are detailed in the next section of this report.

The amounts 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. The relevant assumptions are detailed in the next section of this report.

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.[5]

There are no significant mining or other industrial activities that are reliant on substantial water supplies in the Gwydir region.

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 on how far groundwater or other 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.

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[4] See DPIE 2020, New climate analysis informs NSW's regional water strategies, www.industry.nsw.gov.au/__data/assets/pdf_file/0018/321093/nsw-climate-model-report.pdf

[5] *Regional Water Value Function* (Marsden Jacob Associates, 2020)

Gwydir key details

The Gwydir region (Figure 1) is located within the traditional lands of Gomeroi Nation. Aboriginal people have been caretakers of the Gwydir region for over 60,000 years.

The Gwydir prides itself as a productive agricultural region and home to internationally and culturally significant wetland complexes including the Gwydir Wetlands. These wetlands are among the most extensive semipermanent wetlands in NSW and include four sites listed under the International Ramsar Convention.

The region has one main river, the Gwydir River, which begins northwest of Uralla and flows west for 480 km, joined by over 30 tributaries. The river spreads out into various smaller rivers and creeks as it reaches the Gwydir floodplain, which stretches west from Moree. Near Moree, the river branches out into three separate systems: the Mehi River, Lower Gwydir River and Carole Creek.

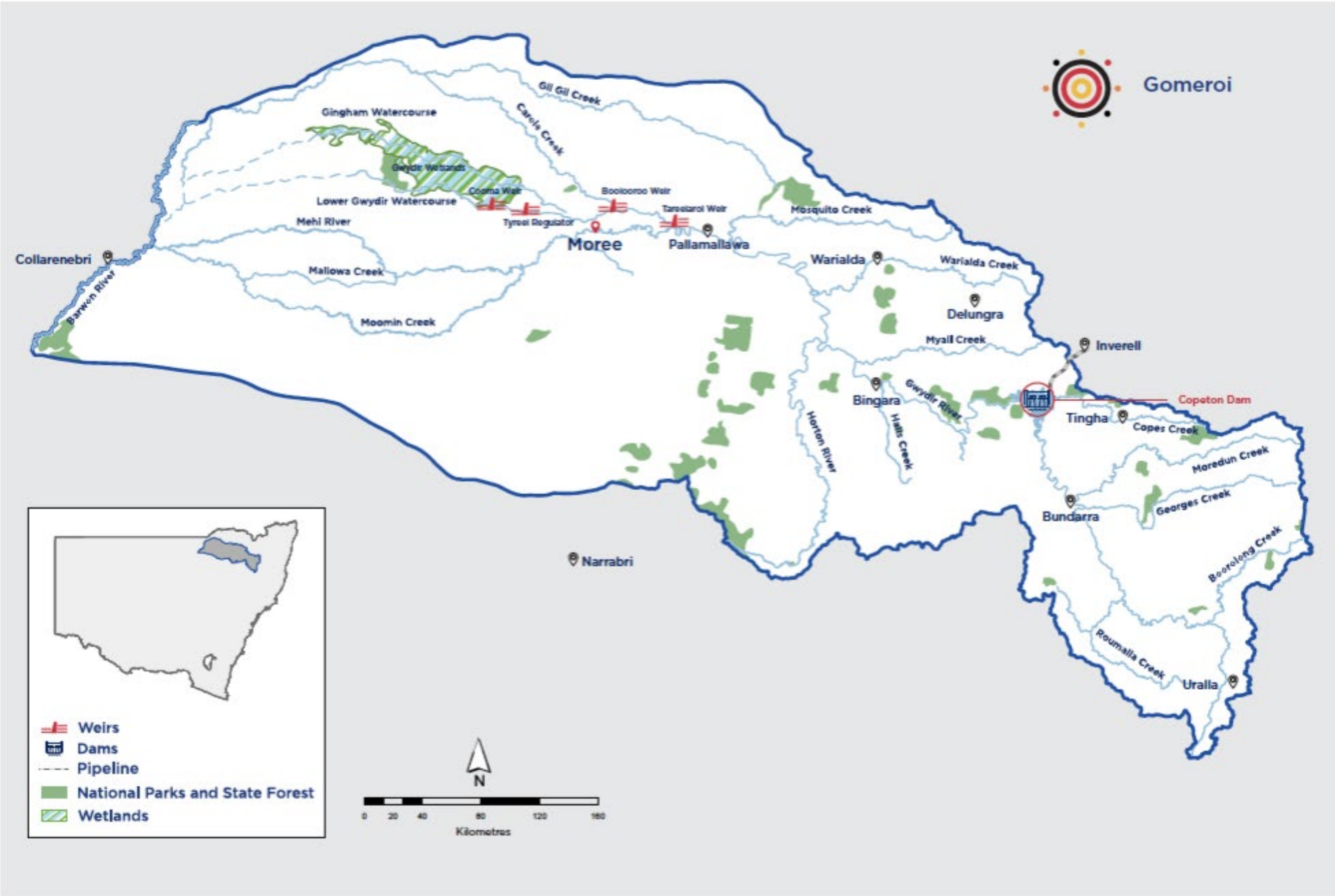


Figure 1. Map of the Gwydir region

Agriculture is the main industry and largest employer in the Gwydir region – directly and indirectly employing nearly 50% of all workers. Agriculture also accounts for approximately 78% of all licensed water use in the region; most of which is used to grow cotton on the alluvial plains downstream of Moree. Other agricultural land uses include grains production that provide export industries for the region, and oil seeds, olives, pecans, walnuts, oranges, and intensive livestock that contribute significantly to the local and national economy.

The region's population is around 25,000. Moree is the largest town and an important employment and services hub for outlying areas. There are also smaller towns in the region with populations ranging from around 300 to 2,500 people, including Uralla, Bingara, Warialda, Tingha and Delungra.

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 supply
- Agricultural users, considered as producers of:
  - Annual crops
  - Permanent crops

The approach taken in each base case scenario is to quantify the economic benefit or cost of water supplied or not supplied in $/ML for each user.[6]

Towns and communities

The economic base case for towns and communities is developed according to the systems from where they draw their surface water supplies. A number of towns have not been included in the analysis. Inverell, while located in the Border Rivers region, draws its water supply from Copeton Dam in the Gwydir region and is considered in this document. Moree was not considered in the hydrological modelling as most of its water comes from groundwater sources.

There are also townships and discrete communities in the region with populations that are too small to be considered in current modelling, including Uralla, Bundarra, Delungra and Warialda. These communities have been omitted to enable the strategy to focus on region-wide impacts. We assume that the region-wide impacts will also be reflected to some extent in these smaller communities; however, this assumption will need to be tested in any detailed business cases that is recommended to progress relevant options from the regional water strategy.

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 length of shortfall being experienced. 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

[6] 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).

to require a more permanent, more expensive solution. For larger towns, carting may not be a feasible option under any circumstances. Details of towns considered within this document and their associated shortfall costs are shown in Table 1 below.

Table 1. Economic cost of town water supply shortages in the Gwydir region

Time in water shortage	Bingara	Gravesend	Inverell
Population*	1,094	321	9,740
System type	Regulated	Regulated	Regulated
0 - 6 months (restrictions)	$1,500/ML	$1,500/ML	$1,500/ML
6 to 12 months (restrictions)	$3,500/ML	$3,500/ML	$3,500/ML
Greater than 12 months	$16,000 (alternative supply)	$16,000 (alternative supply)	$16,000 (alternative supply)
Continued shortages (greater than 24 months)	$16,000 (alternative supply)	$10,000/ML (Carting)	$16,000 (alternative supply)

**2016 populations, sourced from ASGS 2019 LGA projections (NSW, 2019) and ABS census data*

Population projections are based on the medium 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 falls below certain storage levels. These assumptions are based on how the dams have been operated in previous droughts, with restrictions imposed on different user groups. Where there are no past precedents,[7] professional assessments are made as to what storage levels would trigger restrictions. The assumed restrictions regime in the Gwydir is shown in Table 2. Note that both conditions for a town have to be met for it to be considered as experiencing shortfalls.

[7] 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 models.

Table 2. Assumed restrictions regime

Dam	Storage level	Associated restrictions
Copeton Dam	9.7%	Essential Supply - restricts access to general security and environmental contingent allowances
	6.4%	Critical essential supply - triggered at 6.4% - which restricts access to general security, environmental contingent allowances and non-permanent planting high security

Agricultural users

The economic benefit of water for agriculture varies depending on the crop produced. The marginal economic benefit per ML of water supplied for an annual crop will not change with a shortfall in supply, as the area cropped is adjusted to match the amount of water available. For permanent crops, a shortfall in supply will increase the marginal economic benefit per ML of water – recognising the replacement cost of establishing the crop. Table 3 below highlights the majority of the agricultural crops grown in the Gwydir region, water licenses and the economic value of water.

Table 3. Gwydir agricultural water supply economic benefit[8]

Crop/Stock	Cropping	Water license	Marginal economic benefit (of water) ($/ML)
Cotton	Annual	• General security • Supplementary • Floodplain harvesting • Rainfall harvesting	375
Pecan	Permanent	High security	800 (3,200)

The highest economic values for annual and permanent crops in the Gwydir region are:

- Annual crops: cotton ($375/ML)
- Permanent crops: pecans ($800/ML, $3,200/ML in shortfall).

Both of these 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 Functions* report.[9] Annual crops grown in the region are predominantly cotton with a producer surplus ranging from $300 to $425/ML. There are several permanent crops grown in the region. For this economic

[8] These were derived from the *Regional Water Value Functions* (Marsden Jacob Associates, 2020).

[9] *Regional Water Value Function* (Marsden Jacob Associates, 2020)

base case analysis, it is assumed pecans are grown.[10] Pecans generate a producer surplus of 800/ML through to $3,200 /ML when shortfalls occur.

Stock and domestic users were not considered in this analysis as their overall proportion of water usage was insignificant compared to total extractions.

[10] Pecans were considered suitable for areas of the Gwydir region based on feedback received by Department of Planning and Environment during Mole River Dam market sounding and on suitability mapping present within *Pecan industry expansion* (DPI, 2016: www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/586518/Pecan-industry-expansion.pdf)

Hydrologic and economic base case outcomes

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

There are 10,000 years of data in the stochastic and climate change datasets. This data has been split into 1000 40-year realisations or 'windows' for each major water user.[11]

All economic calculations use a discount rate of 7%, as recommended by the NSW Treasury.[12]

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 1000 40-year windows under the stochastic and NARCliM models are given in Table 4 and Table 5. Table 6 summarises the difference between the stochastic and NARCliM modelling results.

The modelled results indicate that on average, surface water can provide typically all of the towns' unrestricted demand for water under both the stochastic and NARCliM climatic conditions with no significant shortfalls being experienced. In this modelling approach, towns and communities forecast to experience declining population growth by the Common Planning Assumptions are included with static demand. This provides a conservative estimate of their future demand, and their actual demand is likely to be less.

Previously, the *draft* Regional Water Strategy for Gwydir[13] highlighted very high levels of water security risk in the towns of Uralla and Bingara and high levels of water security risk in Warialda and Moree, as estimated under the *Safe and Secure Water Program*.[14] As previously mentioned above these towns were not hydrologically modelled in this analysis. The *Safe and Secure Water Program* modelled risks for surface water entitlement reliability, water security access risk analysis (undertaken by local water utilities) which took into account the local water utility's

- headworks arrangement and capacities
- physical water delivery system and operational rules under water sharing plans

[11] 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 nine-year overlap between periods.

[12] TPP17-03: NSW Treasury, NSW Guide to Cost-benefit Analysis

[13] www.industry.nsw.gov.au/__data/assets/pdf_file/0016/324511/draft-rws-gwydir.pdf p71. (last accessed 19 August 2021).

[14] www.industry.nsw.gov.au/water/plans-programs/infrastructure-programs/safe-and-secure-water-program (last accessed 19 August 2021).

- operating protocol and past experiences in delivering water in drought conditions.

In response to the most recent drought (2017 - 2020), the following was undertaken:

- $1.3 million to assist with emergency infrastructure for water treatment and to provide the community with bottled water in Uralla
- $1.5 million was provided to investigate groundwater supplies to improve water security in Uralla
- $480 000 was provided to Moree Shire Council to undertake an Integrated Water Cycle Management Strategy for Moree.

Table 4. Town water supply Hydrologic Base Case outcomes – stochastic model

Town	Average annual shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall	Average % of the year with shortfall
Bingara	0.0	654	0.0	0.0	0.0
Gravesend	0.0	118	0.0	0.0	0.0
Inverell	0.0	3,046	0.0	0.0	0.0

Table 5. Town water supply Hydrologic Base Case outcomes – NARCliM model

Town	Average annual shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall	Average % of the year with shortfall
Bingara	0.8	654	0.1	0.0	0.2
Gravesend	0.2	118	0.1	0.0	0.1
Inverell	0.0	3,046	0.0	0.0	0.0

Table 6. Town water supply Hydrologic Base Case outcomes – difference (NARCliM – stochastic)

Town	Average annual shortfall (ML)	Average annual demand (ML)	Shortfall as % of demand	Average months per year with shortfall	Average % of the year with shortfall
Bingara	-0.8	-0.7	0.1	0.0	0.2
Gravesend	-0.2	-0.1	0.1	0.0	0.2
Inverell	0.0	0.0	0.0	0.0	0.0

Figure 2 illustrates the key town water supply shortfall scenarios of the 1000 40-year windows for all towns in the region, in the stochastic (in yellow) and NARCliM (in blue) models. It gives 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 of 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 that a town could run out of surface water could be anywhere between the dotted lines. Note that in instances where there are no (or very low) shortfalls, lines may overlap.

Similar to Table 4 and Table 5 above, the graphs in Figure 2 show that there is no expected shortfalls for towns under both the stochastic and NARCliM dataset. This is shown by the solid blue line that is flat for the 40-year window in the series, meaning that the towns modelled in the Gwydir region will not be experiencing any water supply shortages over that period. The solid and dotted yellow lines for the stochastic dataset are not visible as they are being obscured by the NARCliM dataset (also indicating no town shortfalls for this period).

The worst-case (maximum) scenarios for the NARCliM dataset shows a significant increase in expected town supply shortfalls (approximately 1500 ML) when compared with the worst-case stochastic scenarios (approximately 500 ML) for the Gwydir region. This is only in the absolute worst-case scenario across the 1000 40-year windows.

This graph presented in Figure 2 indicates that the Gwydir's individual town water supplies appear to be very secure under both the stochastic dataset and NARCliM datasets.

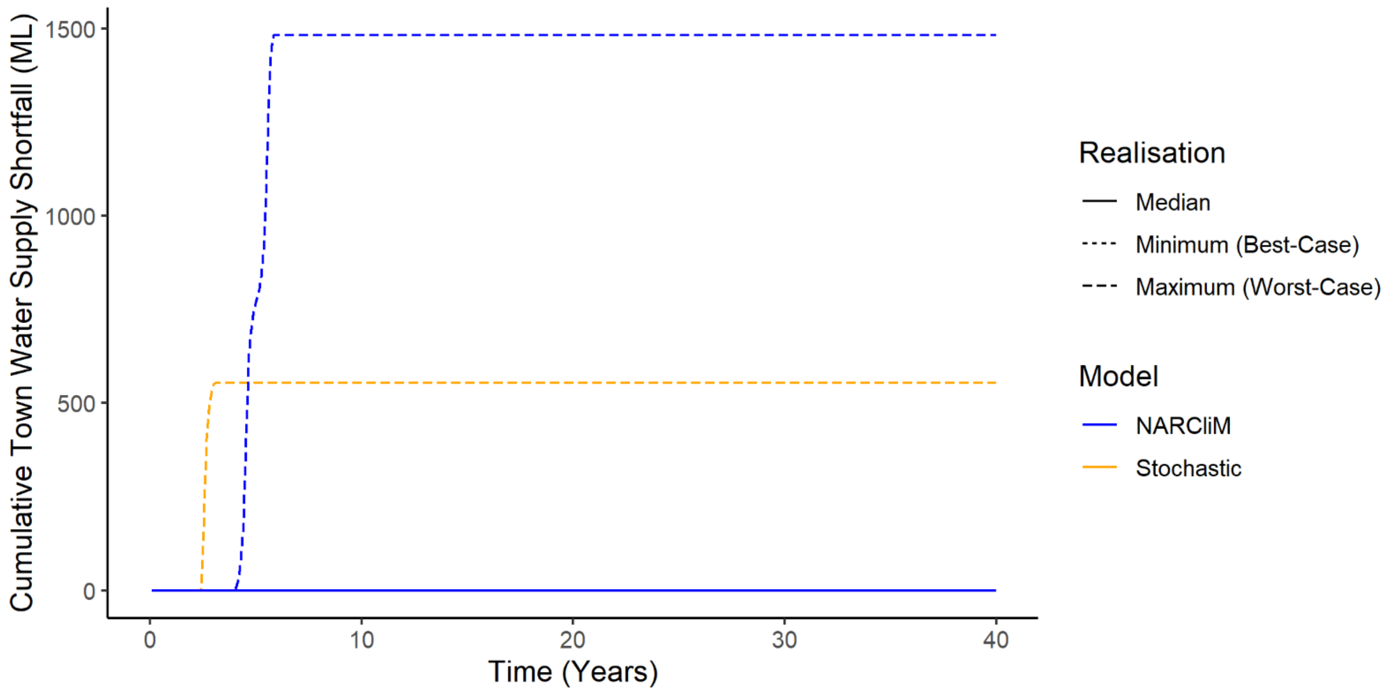


Figure 2. Town supply cumulative 40-year shortfall series (ML)

Town and community economic base case outcomes

All economic impacts to towns have been assessed within the framework presented in Table 1.

The estimated average economic impact of water supply shortfalls for towns within the Gwydir over a 40-year period are provided in Table 7 below. With all three modelled towns in the Gwydir not predicted to experience any significant shortfalls, no negative economic outcomes have been identified due to water restrictions and any requirements to source alternative water supplies under both the stochastic and NARCliM scenarios.

Table 7. Economic Base Case outcomes, key water user group: town water supply average 40-year shortfall

Town	Stochastic	NARCliM	Difference
Bingara	0.0	-0.1	-0.1
Gravesend	0.0	0.0	0.0
Inverell	0.0	0.0	0.0
Total	0.0	-0.1	-0.1

The distributions of the expected economic outcomes for each model (stochastic in orange and NARCliM in blue) can be seen in a histogram, shown in Figure 3. The histogram condenses town shortfall economic costs for all 1000 40-year windows by grouping results into ranges of values (in this case, 20 ranges per data series). The figure illustrates that both the magnitude and uncertainty (that is, the spread) of the average cost of town shortfalls increases under the NARCliM forecasts. The increase in spread of the town water supply costs under a NARCliM scenario reflects the predicted increase in the number and severity of shortfalls where water supply is required to be supported via a more expensive alternative source.

For almost all of the 1000 40-year windows the Figure 3 below indicates that the worst economic outcomes with regards to town water supply shortfalls for both the stochastic and NARCliM datasets would be less than $0.5 million. The blue shaded area representing the NARCliM results is predominantly obscured by the stochastic results. Similar to the hydrologic results, the actual worst-case NARCliM outcomes are significantly higher than the worst-case stochastic outcomes. This highlighted by the long tail in the figure below, with the worst-case outcome being approximately $10 million. It should be noted that the number of simulations where the outcomes are significantly worse under NARCliM is very low.

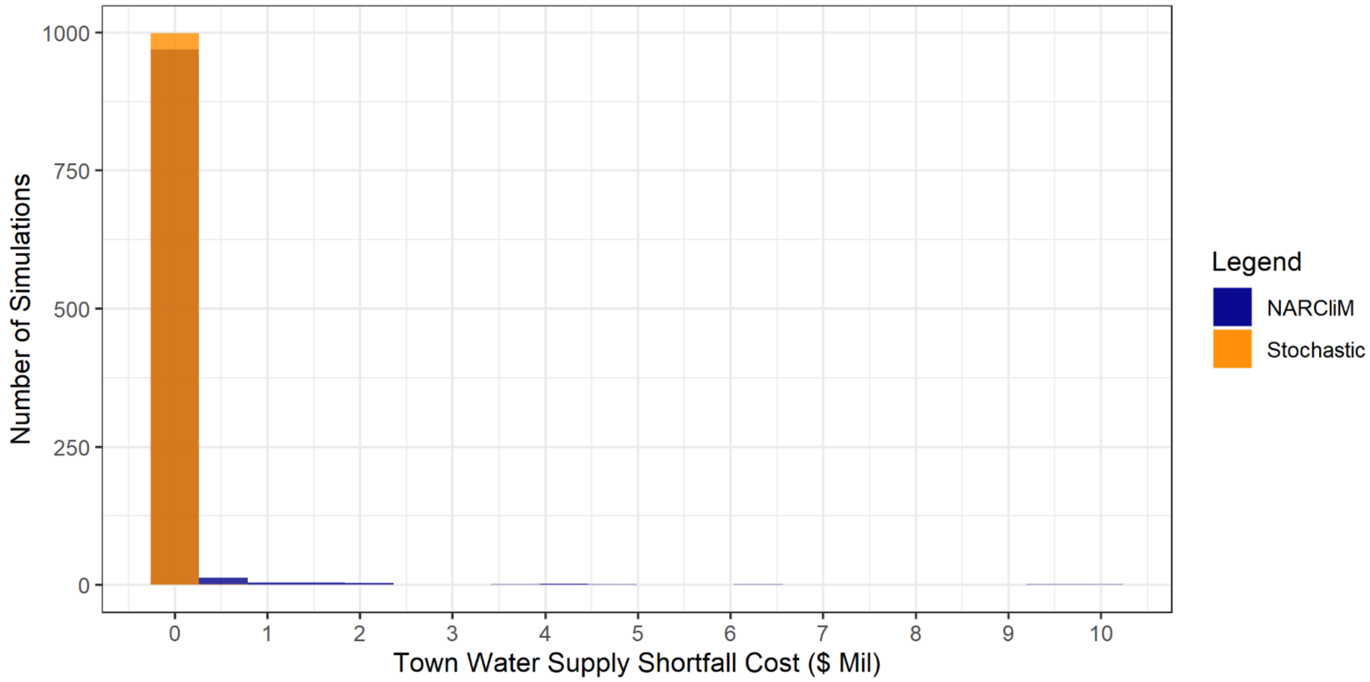


Figure 3. Total average towns water supply, net present costs

Agricultural hydrologic base case outcomes

The following section describes the hydrologic impacts on the agricultural industry within the Gwydir. As discussed previously, agriculture has been separated into two groups for this region:

- Annual crops (cotton)
- Permanent crops (pecans).

The estimated annual average volume of water that these producers use under both the stochastic and NARCliM (climate change) scenarios are given in Table 8 below.

Agricultural water users are expected to receive considerably less water under the dry climate change scenario than the stochastic scenario, with an average use difference of about 90 GL per year (a 23% reduction). Annual crop water use is sourced from general security, supplementary, floodplain harvesting and rainfall harvesting water access licences shares. Permanent crops water use is sourced from high security access licence shares, which account for less than 3% of the Gwydir licences shares. It is not expected that these high security licence holders will see any significant reduction in their water allocations under the drier climate scenario.

Table 8. Average annual agricultural water use volumes – stochastic and NARCliM

Crop classification	Water use metric	Stochastic	NARCliM	Difference	Difference (%)
Annual crops (GL/year)	Average	391	301	-90	-23
	Maximum	523	471	-51	-10
	Median	395	300	-95	-24
	Minimum	210	159	-51	-24
	Standard Deviation	54	54	-1	-1
Permanent crops (GL/year)	Average	12	12	0	0
	Maximum	12	12	0	0
	Median	12	12	0	0
	Minimum	12	12	0	0
	Standard Deviation	0	0	0	0

Histograms of the modelled annual agricultural water use within Gwydir (orange for stochastic and blue for NARCliM) can be seen in Figure 4 and Figure 5 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 1000 realisations of each model.

Figure 4 indicates that the amounts of water used on average for annual cropping is 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.

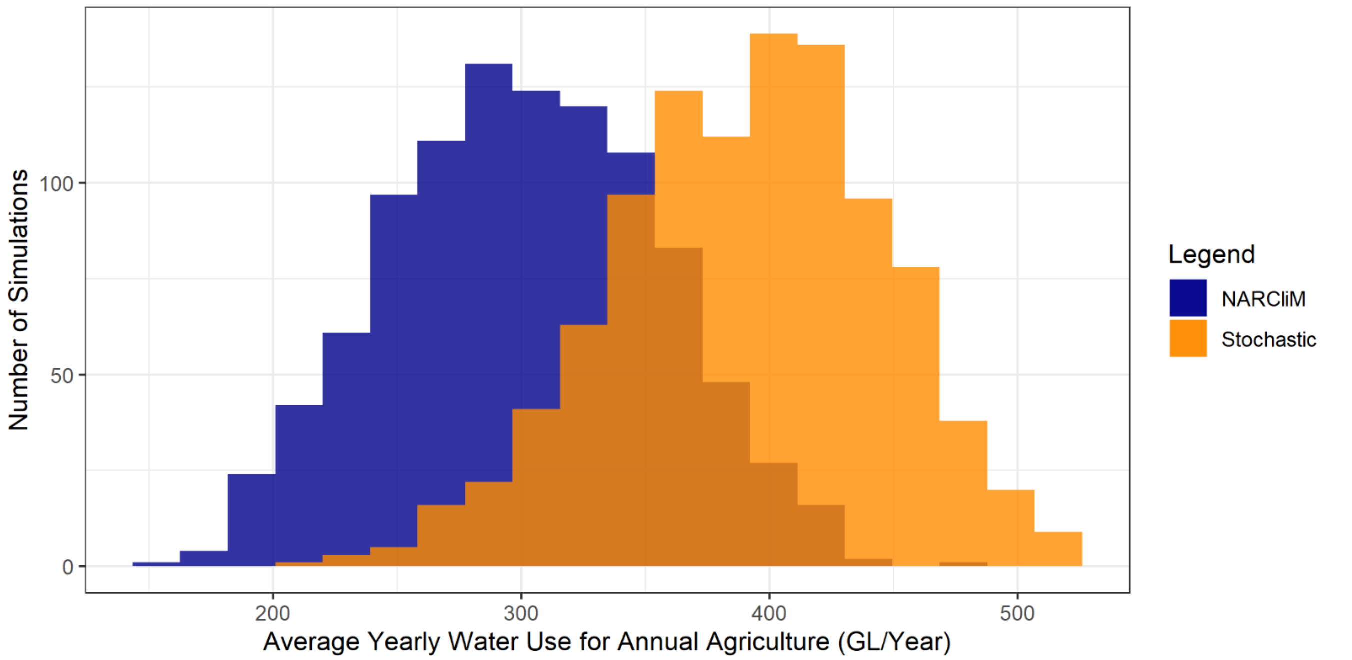


Figure 4. Stochastic and NARCliM annual crop water use

Figure 5 indicates that the amounts of water used on average for permanent cropping is predicted to be very similar for the vast majority of simulations under both the stochastic and NARCliM datasets. The amount of variation is expected to remain roughly the same between the two datasets, with just a few of the NARCliM datasets showing a very small reduction in water usage.

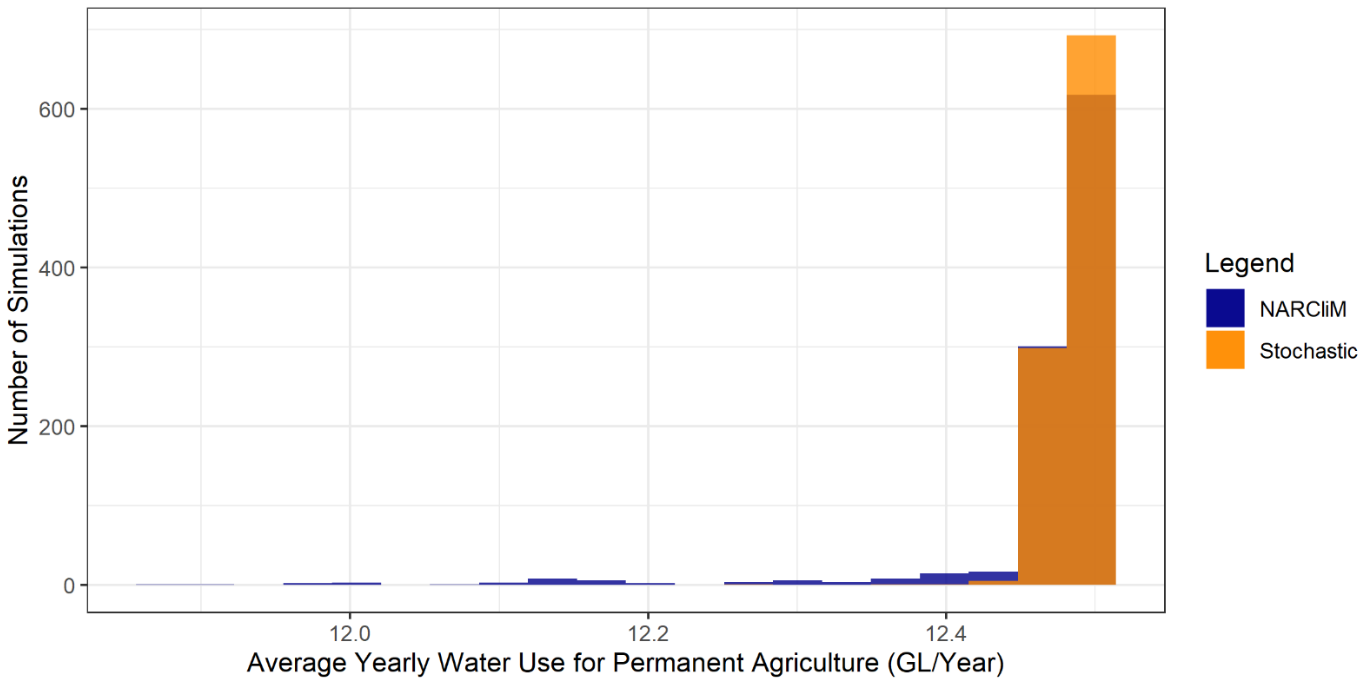


Figure 5. Stochastic and NARCliM permanent crop water use

Three scenarios of expected cumulative water use for producers of annual and permanent crops are presented in Figure 6 and Figure 7 for both the stochastic (orange) and NARCliM (blue) hydrologic models. The scenarios are:

- Minimum: the best-case scenario
- Median: the exact middle scenario
- Maximum: the worst-case scenario.

These results illustrate 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 agriculture in the climate change scenario is below the median result for the stochastic climate conditions for just over half the simulated timeframe, suggesting a decrease in the amount of water available for annual agriculture under the climate change scenario when compared to our historical climate projections.

In Figure 7, the impact of climate change on permanent plantings is less notable, with the modelling indicating very similar outcomes under both scenarios and hence a very stable water source for high security water holders.

Figure 6. Stochastic and NARCliM cumulative annual crop agriculture water use

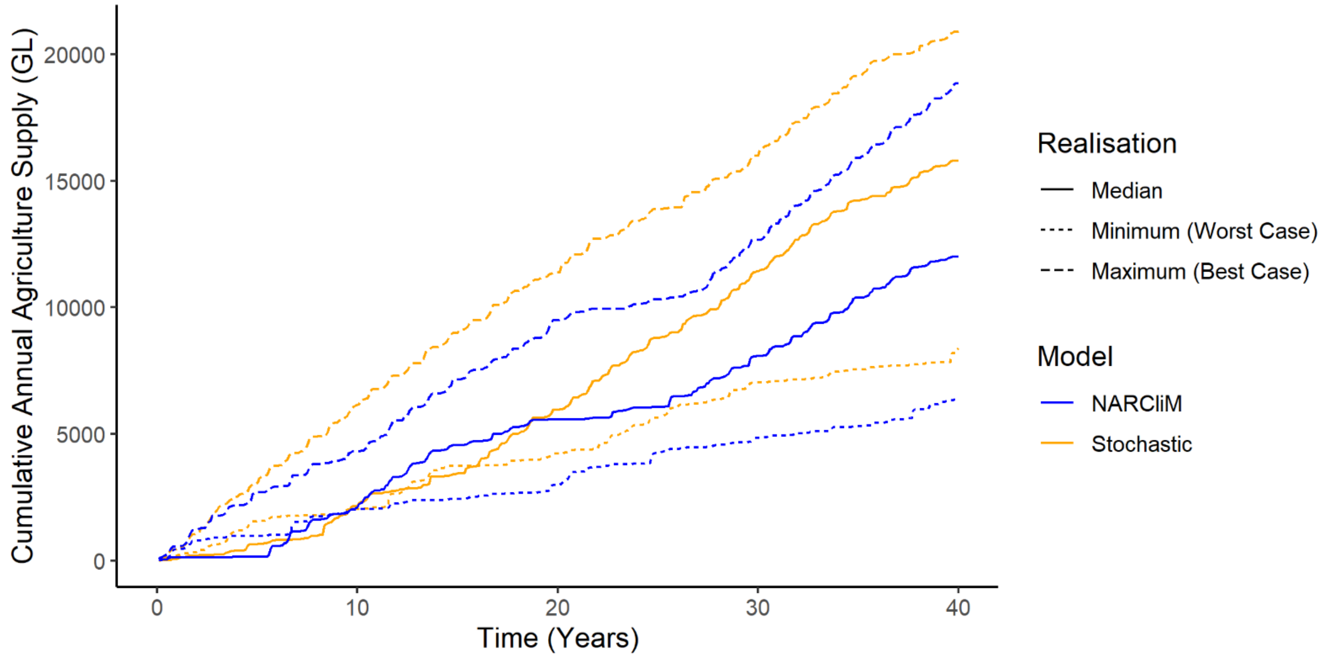
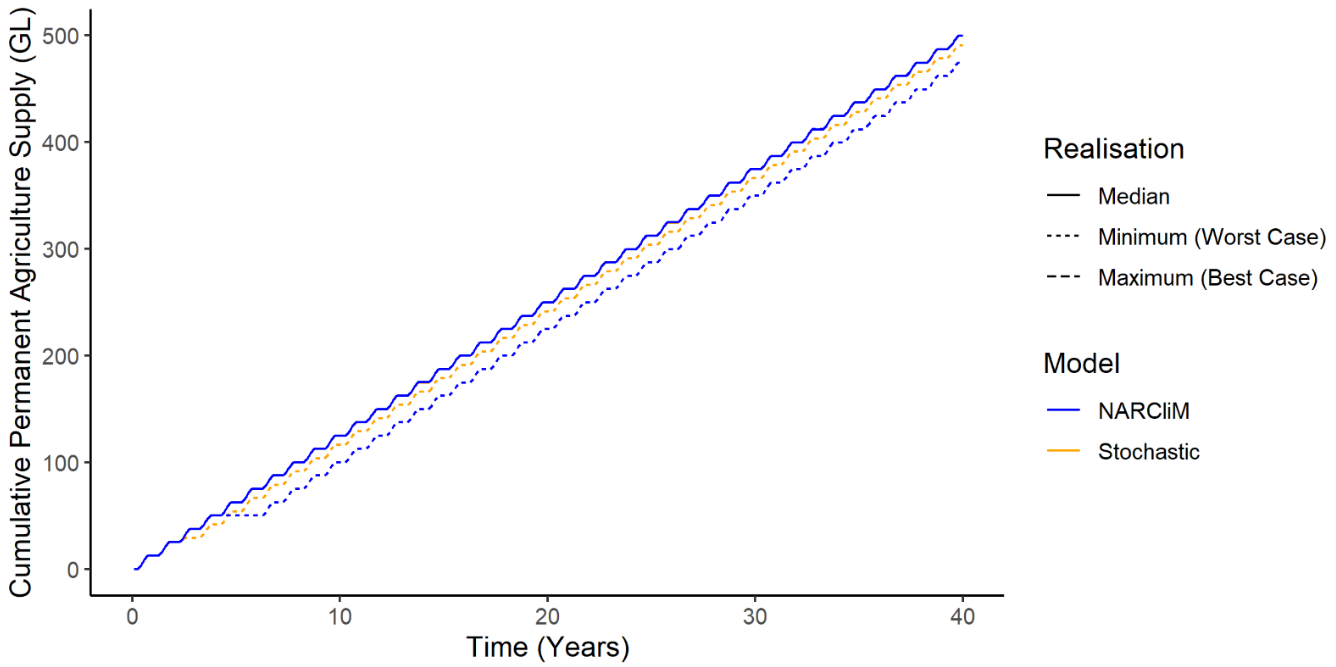


Figure 7. Stochastic and NARCliM cumulative permanent crop agriculture water use



Agricultural economic base case outcomes

Average economic values of water for agricultural producers within the Gwydir region over the 40 year analysis period are given in Table 9. The small amount of high security water allocations within the catchment translates to a small relative producer surplus for permanent crops (pecans) despite its high economic value on a per unit basis. Conversely, annual crops (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 crop producers (23%) reflects the reduction of agricultural production due to decreased water supply under a climate change scenario. There is no significant change to the value of permanent crops in-line with the analysis above which indicated that high security users would not suffer any real loss of water usage under the drier climate scenario.

Table 9. Economic base case outcomes, key water user group: agriculture net present producer surplus averages over 40 Years ($, Mil)

Crop classification	Stochastic	NARCliM	Difference	Difference (%)
Annual crops	1,995	1,532	-463	-23
Permanent crops	137	136	-1	-1
Total	0	0	0	0

Summaries of the distributions of possible outcomes for agricultural producers are provided in Figure 8 for annual crops and Figure 9 for permanent crops. The figures illustrate the wide range of possible economic outcomes under the NARCliM and stochastic scenarios. The predicted decrease in economic activity due to a reduction in water availability for producers of annual crops ranges from approximately $1 billion to $3 billion, with an average of approximately $2 billion under stochastic conditions over the forecast 40 years. For the NARCliM results, the value of water for producers of annual crops shifts lower, with values ranging from $900 million to $2.6 billion with an average of approximately $1.5 billion.

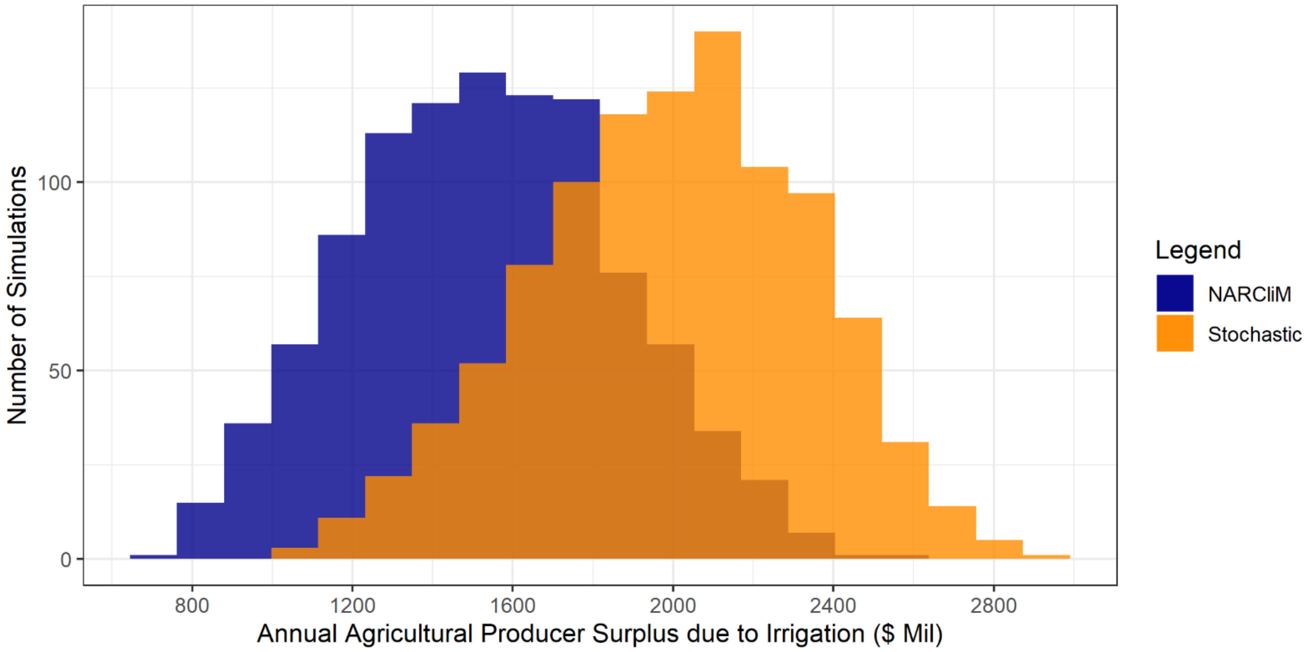


Figure 8. Annual agriculture net present producer surplus over 40 years

For permanent based agriculture activities (as seen in Figure 9 below) the economic outcomes for the farmers are going to be very similar under both the modelled stochastic and NARCliM scenarios on average. But under extreme circumstances when high security allocations are reduced the farmers could see a significant drop in their economic output by as much as 50%.

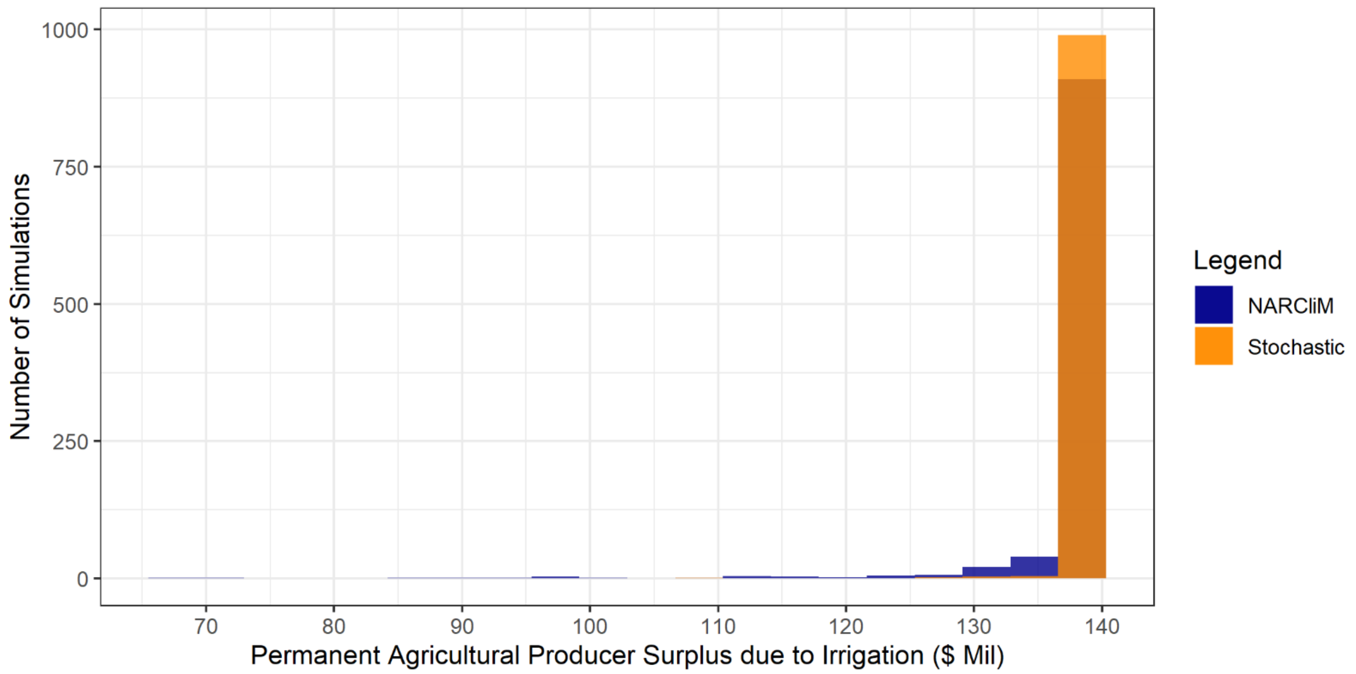


Figure 9. Permanent agriculture net present producer surplus over 40 years

Assumptions and uncertainties

The analysis in the regional water strategies is based on the best available information at the time. As with all types of analyses, a range of assumptions, uncertainties and qualifications need to be made to be able to conduct the analysis.

Assumptions adopted within this economic base case analysis include:

- Town 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 is 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' medium population growth forecasts. Towns within the Gwydir region are predicted to have reductions in population; for these towns, it is assumed that population growth will be flat rather than decreasing.
- It is assumed that the current uses of water, in both general security and high security entitlements, are 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 Gwydir and the amount of water used. Estimating these changes is beyond the regional water strategies project.
- Uncertainties and qualifications relevant to this study include:
  - Town 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.