Department of Planning and Environment

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Gwydir Regional Water Strategy

Detailed economic analysis

July 2022

Acknowledgement of Country

The NSW Government acknowledges Aboriginal people as Australia's first people and the Traditional Owners and Custodians of the lands and waters. 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 practise the oldest living cultures on earth.

The NSW Government acknowledge the Traditional Custodians as having an intrinsic connection with the lands and waters of the Gwydir Regional Water Strategy area. The landscape and its waters provide them with essential links to their history and help them to maintain and practise 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. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Gwydir Regional Water Strategy

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Contents

Introduction

The NSW Government is developing 12 regional water strategies that bring together the best and latest climate evidence, with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

The draft Gwydir Regional Water Strategy, including a long list of options, was released in September 2020.[1] The long list of options were analysed and shortlisted into a proposed set of actions which has been published in the *Draft Gwydir Regional Water Strategy: Shortlisted Actions – Consultation Paper*[2] released in June 2022.

Figure 1 sets out the options assessment process, with the complete options assessment process is described in the Options Assessment Process Overview[3].

This report provides the outcomes of the rapid and detailed economic assessments that were used to determine which of the long list options that influence the supply demand or allocation of water, should be included as shortlisted actions in the *Draft Gwydir Regional Water Strategy: Shortlisted Actions – Consultation Paper* released in April 2022.[4]

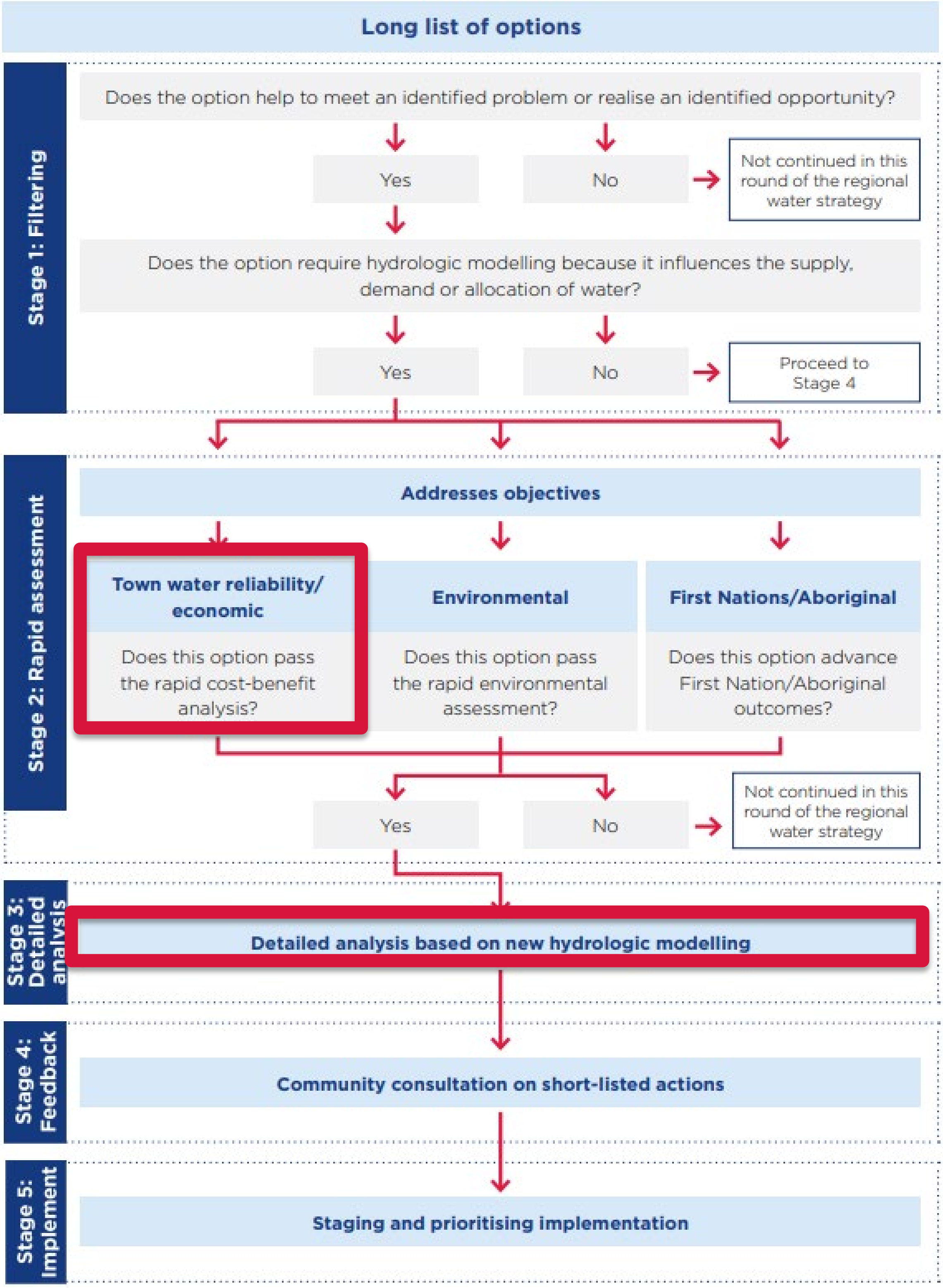
[1] The draft Gwydir Regional Water Strategy and long list of options can be viewed at www.dpie.nsw.gov.au/water/plans-and-programs/ regional-water-strategies/upcoming-public-exhibition/gwydir-regional-water-strategy

[2] See www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/public-exhibition/gwydir-regional-water-strategy

[3] See www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/identifying-and-assessing

[4] See www.water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/public-exhibition/gwydir-regional-water-strategy

Figure 1: Options assessment process



The following Gwydir long list options underwent rapid and detailed assessments:

- Enlargement of Tareelaroi Weir (Option 1 in the draft Gwydir Regional Water Strategy): rapid and detailed economic assessment
- Option 2: New Lower Gravesend Dam rapid economic assessment only

- Increase the storage reserve in Copeton Dam (previously referred to as Option 28: Review of surface water accounting and allocation processes in the draft Gwydir Regional Water Strategy): rapid and detailed economic assessment
- Bulk licence conversion (previously referred to as Option 29: Investigation of licence conversions in the draft Gwydir Regional Water Strategy): rapid and detailed economic assessment
- Partial licence conversion (previous referred to as Option 29: Investigation of licence conversions in the draft Gwydir Regional Water Strategy): rapid and detailed economic assessment

These options had the potential to influence the supply, demand or allocation of water.

This report should be read in conjunction with the Detailed Ecological Assessment for the Gwydir.

Option assessment overview

Identifying the key challenges for the region and understanding the base case

The first step in the options assessment process is to define the priority challenges in the region that we need to focus on over the next 40 years.

While all the challenges and options identified in the draft strategy are important, it is not possible or feasible to tackle every challenge at once. We need to prioritise the issues and tackle those first that are likely to cause the most significant long-term impacts to the region.

We identified the key challenges by understanding what the future could look like, and what could be the consequences, if we do nothing. This process is articulated in the Economic Base Case which interprets the outcomes of the hydrology for the major extractive users of water.[5] The key challenges were used to filter and match the options in the draft Regional Water Strategy, as well as additional options identified through stakeholder consultation, to the key challenges identified for the region. This is critical in making sure that the options selected adequately address the key challenges in the region. It is also the primary analysis used to prioritise the options that cannot be assessed quantitatively.

Rapid economic assessment

Once the filtering process has been undertaken, we determine if any option influences the supply, demand or allocation of water. Those options requiring hydrologic modelling are subject to further quantitative assessment. Options that influence the supply and demand for water, were assessed initially through a rapid cost benefit analysis or cost effectiveness analysis depending on what the options are trying to achieve.

Options aiming to improve the economic activity of the region were evaluated according to how they change the expected total economic benefits in the region. This assessment was made against the available historic record in the region, referred to as the instrumental record of approximately 130 years (1890 to 2020).[6]

Options that aimed to reduce town water security risks were first assessed against the effectiveness of the option in reducing those risks, and then which options best address the challenge at least cost.

These decision criteria should be used as a guide only for assessing the economic viability of an option. The outcomes of the rapid cost-benefit analysis are a decision-supporting tool (as opposed to a decision-making tool) and an outcome that isn't strictly positive (ie with a benefit-cost ratio less than 1) may not necessarily preclude an option from being progressed to a Detailed Assessment in Stage 3.

Options may still pass through to be detailed assessment if they are of significant community interest.

Detailed economic assessment

[5] The ecological challenges for the region were already identified in the draft Regional Water Strategy.

[6] The exact time period of the instrumental record is detailed in the Hydrologic Report, accessible from the Department's website here.

Options that passed through the filtering and rapid assessment processes were then assessed against the new stochastic and climate change data:

- Long-term historic climate projections (stochastic data): these assume that our future climate is similar to what the science is indicating our long-term paleoclimate was like and are based on a 10,000 year dataset
- A dry climate change scenario (NARCliM[7] modelling): this assumes that there is a dry, worst-case climate change scenario in the future and is also based on a 10,000 year dataset.

This helped to understand the resilience of the options in more extreme scenarios. This stage of the assessment measured economic and environmental outcomes.[8]

The full options assessment process has been published in the Options Assessment Process: Overview report.[9]

Economic analysis overview

The key information that informed the cost-benefit analysis of each option included:

- **Understanding what happens if we do nothing,** which included hydrological modelling under the two different hydrologic models. These models are sampled to each provide 1,000 40-year forecasts of the future of the region and how much water is available to different licences under the base case and each option. More detail on the base case is available in the Gwydir Economic Base Case[10].
- **High-level cost estimates** prepared for each option, including capital and operational expenditure for infrastructure options[11], and operational costs for non-infrastructure options. These costs were broad and high-level. Further investigation of any option will require more detailed cost estimates.
- **Benefit estimates:** the economic value of water for towns and industries has been developed and used as the primary benefit to assess the costs against. This is referred to as the regional water value function[12]. A summary of the value of water for each major water user is below. The detail behind how these values were calculated are in the Gwydir Economic Base Case.

Key outcomes of the detailed analysis are defined using two metrics or decision criteria: the net present value and the benefit-cost ratio.

The net present value is the summation of the present value economic outcomes of the option case minus the summation of the present value economic outcomes of the base case. It is the

[7] 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 www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARCliM.

[8] See *Scenario Analysis: the relevant region* attachment and *Relevant Region Water Strategy: Ecological assessment of options*

[9] The Options Assessment Process: Overview is accessible from here: www.water.dpie.nsw.gov.au/__data/assets/pdf_file/0006/506463/options-assessment-process.pdf

[10] See the *Regional Water Value Functions* (MJA, 2022) for all regions, available for download at www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/identifying-and-assessing .

[11] The department engaged ARUP to develop high level cost estimates of the options in the draft Gwydir Regional Water Strategy long list.

marginal difference between the two outcomes, with the option cost (and the timing of costs and benefits) taken into account. A positive net present value indicates that there is potential economic benefit from pursuing an option while a negative net present value indicates that the option creates more costs than the generated benefits, when the time value of money is incorporated. Net present value can be expressed as Equation 1.

Equation 1 Net Present Value (NPV)

$$NPV_{option} = (PV_{option\ scenario} - PV_{base\ case}) - PV_{option\ cost}$$

Benefit-cost ratio divides the incremental benefits of an option to the region by the discounted whole-of-life cost (capital and operational expenditure) of the option. A benefit-cost ratio of 1 or greater indicates that the project is economically feasible as the benefits outweigh the costs. Benefit-cost ratio is illustrated in Equation 2.

Equation 2 Benefit-Cost Ratio (BCR)

$$BCR = \frac{PV_{benefits}}{PV_{costs}}$$

These decision criteria should be used as a guide only for assessing the economic viability of an option. The outcomes of the rapid cost-benefit analysis are a decision-supporting tool (as opposed to a decision-making tool) and an outcome that is not strictly positive (such as an outcome with a benefit-cost ratio less than 1) should not preclude an option from being progressed to the detailed analysis stage.

In addition to these decision-support tools, the detailed analysis also conducts:

- **sensitivity analysis:** was used to identify the extent to which changes to the key assumptions influence the outcomes of the detailed analysis. The sensitivity analysis was carried out across:
    - discount rate (3% and 10%)
    - capital and operational expenditure (+30% / -30%)
    - the value of water assigned to each economic activity
    - reactive infrastructure solutions
- **distributional impacts**: which looked at how the option impacts different water users and classes of licences
- **breakeven analysis:** was used to determine what price for a megalitre of water would result in the costs being equivalent to the benefits. This analysis assumes the proposed option is viable on the balance of outcomes within the economic analysis framework presented and determines what price for a megalitre of water would make the benefits equal the cost of the option.

It is not always possible to determine a breakeven point, so some options may not have a breakeven analysis described.

The detailed assessment was completed by applying the regional water value function to the outputs of the hydrologic modelling to determine the incremental change between the base case and the option, while taking into account the cost of the option.

An Economic Impact Assessment, or Input-Output Analysis, was not undertaken as per the NSW Cost-Benefit Analysis guidelines.[13] Economic Impact Assessments are concerned with measuring economic activity. They are not a tool to measure economic wellbeing created from projects, nor does it take account of the alternative uses (opportunity costs) of resources. Finally, they do not necessarily measure net benefits. For example, poor investments in heavily subsidised fields of endeavour could be associated with greater levels of activity than good investments.

Economic assumptions

Economic value of water to key user groups

The economic valuation of water to key user groups given in Table 1 has been drawn from the regional water value function[14] and is applied as a $/ML supplied (or not supplied in the case of town water supply and also permanent crops). These values are given in Table 2 for town water supply shortfalls and in Table 3 for agricultural users and are used as the basis for analysing the benefits of the options.

Due to the high level of uncertainty regarding environmental valuations within a cost-benefit analysis context, no attempt has been made include an economic ecological assessment within this cost-benefit analysis. Separate quantitative and qualitative ecological assessments have been undertaken for options that progressed past the rapid cost-benefit analysis stage.

Table 1. Key water users

Key water user	Water licence	Economic benefit of water use
Towns (Bingara, Gravesend, Inverell)	Local water utility	Reduction in economic cost of water supply shortfalls
Annual crop producers (i.e. cotton)	• General security • Supplementary • Floodplain harvesting • Rainfall harvesting	Marginal increased yield of crop due to irrigation, compared to dryland production.
Permanent crop producers (i.e. pecans)	High security	Marginal increased yield of crop due to irrigation, compared to dryland production – and – Reduction in cost associated with growing replacement crops to maturation due to crop-perishing in dry periods

[13] TPP March 2017, NSW Government Guide to Cost-Benefit Analysis, page 65.

[14] See the *Regional Water Value Functions* (MJA, 2022) for all regions, available for download at https://www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/identifying-and-assessing .

Table 2. Economic cost of town water supply shortages in the Gwydir

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/ML (alternative supply)	$16,000/ML (alternative supply)	$16,000/ML (alternative supply)
Continued shortages (greater than 24 months)	$16,000/ML (alternative supply	$10,000/ML (carting)	$16,000/ML (alternative supply)

*2016 populations, sourced from New South Wales Government, 2019. *Australian Statistical Geography Standard 2019 Local Government Area projections* and Australian Bureau of Statistics census data

Table 3. Gwydir agricultural water supply economic benefit[15]

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

Population increases have been included in accordance with the NSW Government's Common Planning Assumptions' medium population growth forecasts. These planning assumptions predict that towns within the Gwydir region will have reductions in population. Analysis undertaken for the regional water strategies assumes that population levels will be flat, rather than decreasing, to ensure conservative estimates across all outputs.

[15] Note: Only values used in the analysis that represent the highest value crop were used. Other values on crop type groups in the region are in Marsden Jacobs Associates (2020) *Regional Water Value Functions*.

Infrastructure option costings

The capital and operational expenditure for infrastructure options are derived from cost models built to allow a consistent comparative assessment across regions. They are not site-specific cost estimates and are not intended to be used beyond the scope of this study. The cost models rely on the relationship between the physical characteristics of infrastructure, such as dam size or pipeline length, and the expected cost to construct, with each category of infrastructure — dams, pipelines, desalination plants, etc. — having its own unique valuation method. These relationships are arrived at through analysis of similar projects and professional assessment.

Capital and operational expenditure costs of options were discounted to present day values with the following assumptions:

- the option is constructed and fully operational from the start of Year 1 (that is, at Year 0), indicating no discounting is applied to the construction costs.
- operational costs occur annually for the full period of the cost-benefit analysis from Year 1.

A residual value for infrastructure was considered through the addition of an end of life value for it, discounted at a linear rate at the end of the analysis period.

Policy option costings

Policy options were calculated as the cost of the number of full-time equivalent staff required to implement an option. The costs are incurred at the beginning of Year 1 (that is, at Year 0) and there is no annual cost associated with the option. It is assumed there is no measurable change between the effort required to administer the region each year with and without the policy change implemented.

Rapid economic assessment only

There was only one option that was subject to a rapid economic assessment that was not also considered in the detailed economic assessment as well.

Economic assessment results

Option 1: Enlargement of Tareelaroi Weir

Tareelaroi Weir and the Mehi Regulator are located along the Gwydir River. The structures act as regulating water storages that assist with water diversions to the Mehi River system.

This option includes enlargement of Tareelaroi Weir and modifications to the adjoining Mehi Regulator to form an increased mid-system water storage. By raising the full supply level from 219.3m AHD to 222 m AHD (a 2.7m rise), an estimated 4 GL increase in storage volume can be achieved. The current weir pool at full supply level has a volume of approximately 2.5 GL, thus resulting in a total storage post raising of 6.5 GL. This new full supply level governs the height of the proposed weir and regulator, which will both need to be reconstructed with increased height to accommodate the higher full supply level.[16]

The option has an assumed capital cost of approximately $137 million for the enlarged weir, with operational costs of approximately $0.5 million per year.

A rapid and detailed cost-benefit analysis was undertaken on this option.

Results

Table 4 provides a summary of the rapid economic modelling for the option and Table 5 provides a summary of the detailed economic assessment. The results in Table 5 represent the averages across all 1,000 realisations undertaken in the analysis. Because each 40-year analysis period has an equal likelihood of occurrence, the averages also represent the expected values (or outcomes) for the option.

Table 4. Rapid cost benefit analysis results for Option 1 - Enlargement of Tareelaroi Weir

CAPEX ($m)	OPEX ($m)	Net present value ($m)	Benefit-cost ratio
137	0.5	-136.3	-0.03

Table 5: Average results for Option 1 - Enlargement of Tareelaroi Weir under the detailed economic assessment

Net Present Cost ($m)	Stochastic net present value ($m)	NARCliM net present ($m)	Stochastic benefit-cost ratio	NARCliM benefit-cost ratio
132.5	-136.4	-132.2	-0.03	0.00*

*Value of 0.002

[16] Note the Draft Regional Water Strategy states an increase in volume of 3.65GL with a Full Supply Volume of 6GL can be achieved. Modelling has assumed a slightly higher volume based upon the storage geometry information provided by WaterNSW.

The option has a negative net present value of $136.4 million under the stochastic dataset and negative $132.2 million under the NARCliM dataset. The benefit-cost ratio is near zero under both datasets, indicating that the costs of the extending the weir's capacity under this option outweigh the economic benefits. The average negative benefit-cost ratio achieved under the stochastic dataset reflects a marginal average net-negative economic outcome for the region upon adoption of the option. This outcome is not unexpected given the earlier modelling of the economic base case for the Gwydir region which identified minimal shortfalls throughout the region.

The hydrologic record includes a great deal of variation, not fully represented in average values. With 1,000 realisations of each hydrologic dataset, examining the range of potential outcomes of the option is important. Table 6 presents the range of possible outcomes for the option's performance over any 40-year period. The 1st percentile is effectively the worst outcome while the 99th is the best.

Sixty percent of outcomes in the stochastic dataset and 40% of outcomes in the NARCliM dataset produce negative benefit-cost ratios, indicating a net negative outcome for the users of the region before including the cost of the option. In the higher percentiles for both climate datasets and at the most extreme end, the 99th percentile, positive outcomes for the region are achieved; however, the magnitude of benefit realised is only about 10% of the whole of life cost of the option.

The information presented in Table 6 is given graphically in the histogram of net present values under both climate datasets in Figure 2. This histogram shows that the impact of climate on the outcome of the option is limited, in-line with the average results. However, the option typically performs marginally better under the NARCliM dataset.

Table 6. Decile and extreme percentile results for Option 1

Percentile	Stochastic net present value ($m)	Stochastic benefit-cost ratio	NARCliM net present value ($m)	NARCliM benefit-cost ratio
1%	-153.8	-0.16	-144.4	-0.09
10%	-146.3	-0.1	-137.9	-0.04
20%	-142.6	-0.08	-135.8	-0.03
30%	-140.1	-0.06	-134.4	-0.02
40%	-137.8	-0.04	-133.4	-0.01
50%	-135.9	-0.03	-132.3	0
60%	-134.4	-0.01	-131.4	0.01
70%	-132.6	0	-130.3	0.02
80%	-130.6	0.01	-128.6	0.03

90%	-127.4	0.04	-126.3	0.05
99%	-117.4	0.11	-119.5	0.1

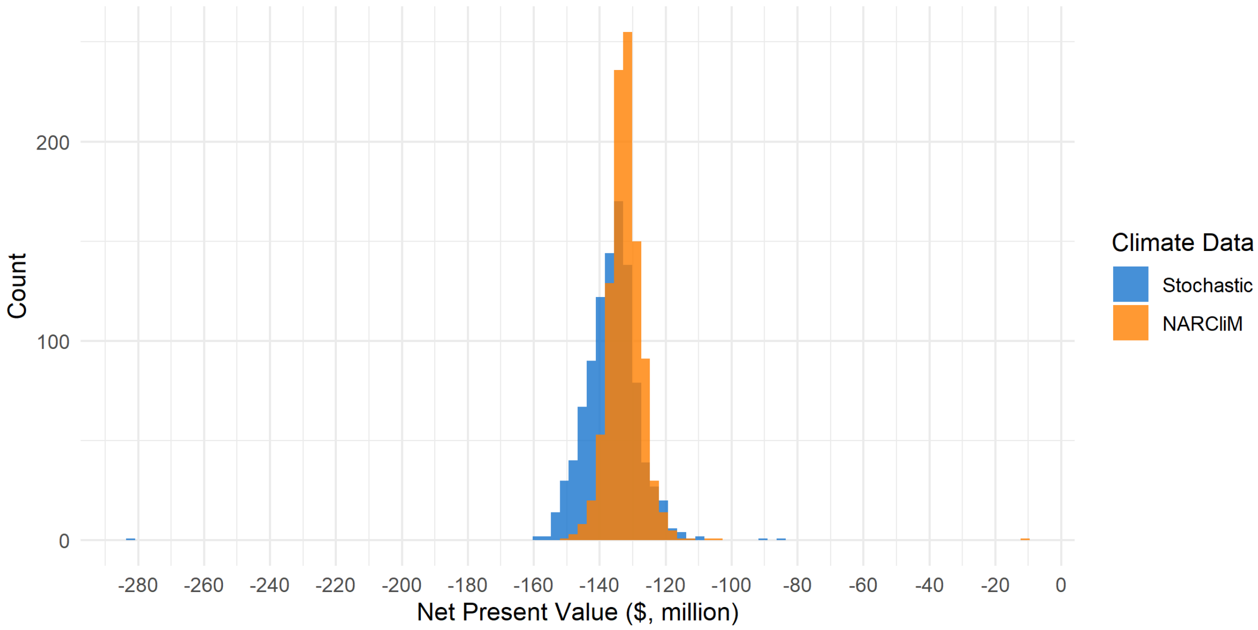


Figure 2. Option 1: Enlargement of Tareelaroi Weir net present value histogram

Sensitivity analysis

The intention of the option was to increase delivery efficiencies in existing water availability for farmers of annual crops, in this case cotton. Sensitivity analysis was undertaken for the option which included the following cases:

- higher (10%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) option costs
- higher and lower economic costs, the magnitude of which varies depending on the marginal economic value.

Table 7 provides the summary results data for this option for the central case and sensitivity analysis across the key underlying assumptions used in this modelling approach for the stochastic and NARCliM climate datasets. Sensitivity analysis identifies the extent to which changes in the key assumptions influence the outcomes of the cost-benefit analysis.

The net impact of this option is that it performs poorly from an economic perspective under the paleoclimate dataset, but better under the climate change scenario. Under the central case, the option performs very poorly under both the stochastic and NARCliM datasets with 100% of all realisations having a benefit-cost ratio of less than one.

By varying the discount rate from the central case assumption of 7% to a lower value of 3%, the net present value increases to negative $108 million under stochastic and negative $102 million under NARCliM, with the benefit-cost ratios average remaining close to zero under both scenarios. A higher discount rate of 10% lowers the value of future benefits and any residual value of the option, resulting in lower net present values.

Varying the costs (both capital expenditure and operating costs) of the option by 30% down results in net present values improving by approximately $40 million when compared to the central case in when considering the lower bound cost. When varying the costs up it results in a reduction of a similar amount in the case of the upper bound cost.

Sensitivity testing of key user marginal economic values of water generally shows a low level of sensitivity to these assumptions. Using high economic valuations increases the variability of outcomes seen. This is most visible in the results of the outlying realisations where adopting high economic values has the impact of decreasing the net present value in the worst case by approximately $20 million and increasing the net present value in the best case by a similar margin. In the later it is worth noting that one realisation under the NARCliM dataset can achieve a positive net present value of approximately $8 million.

Table 7. Sensitivity analysis on Option 1 across the stochastic and NARCliM datasets

Stochastic dataset

Sensitivity case	Present value capital cost ($m)	Average net present value ($m)	Benefit-cost ratio Average	Benefit-cost ratio Minimum	Benefit-cost ratio Maximum	% of benefit-cost ratio with benefit-cost ratio > 1
Central	132.5	-136.4	-0.03	-1.12	0.35	0%
Low discount rate (3%)	103.1	-108.3	-0.05	-2.18	0.85	0
High discount date (10%)	137.3	-140.7	-0.03	-0.81	0.25	0
Option cost (+30%)	172.2	-176.1	-0.02	-0.87	0.27	0
Option cost (-30%)	92.7	-96.7	-0.04	-1.61	0.51	0
Economic values (high)	132.5	-136.9	-0.03	-1.27	0.4	0
Economic values (low)	132.5	-135.6	-0.02	-0.9	0.28	0

NARCliM dataset

Sensitivity case	Present value capital cost ($m)	Average net present value ($m)	Benefit-cost ratio Average	Benefit-cost ratio Minimum	Benefit-cost ratio Maximum	% of benefit-cost ratio with benefit-cost ratio > 1
Central	132.5	-132.2	0.002	-0.13	0.92	0
Low discount rate (3%)	103.1	-101.7	0.013	-0.24	1.99	0.1

High discount rate (10%)	137.3	-137.4	-0.0003	-0.11	0.62	0
Option cost (+30%)	172.2	-171.9	0.002	-0.1	0.71	0
Option cost (-30%)	92.7	-92.4	0.003	-0.19	1.32	0.1
Economic values (high)	132.5	-132	0	-0.15	1.05	0
Economic values (low)	132.5	-132.3	0	-0.11	0.74	0.1

Histograms of the results of the sensitivity analysis can be seen in Figure 3. They support the results of Table 7, indicating that there is no set of conditions under which the option regularly produces economic benefits higher than its costs.

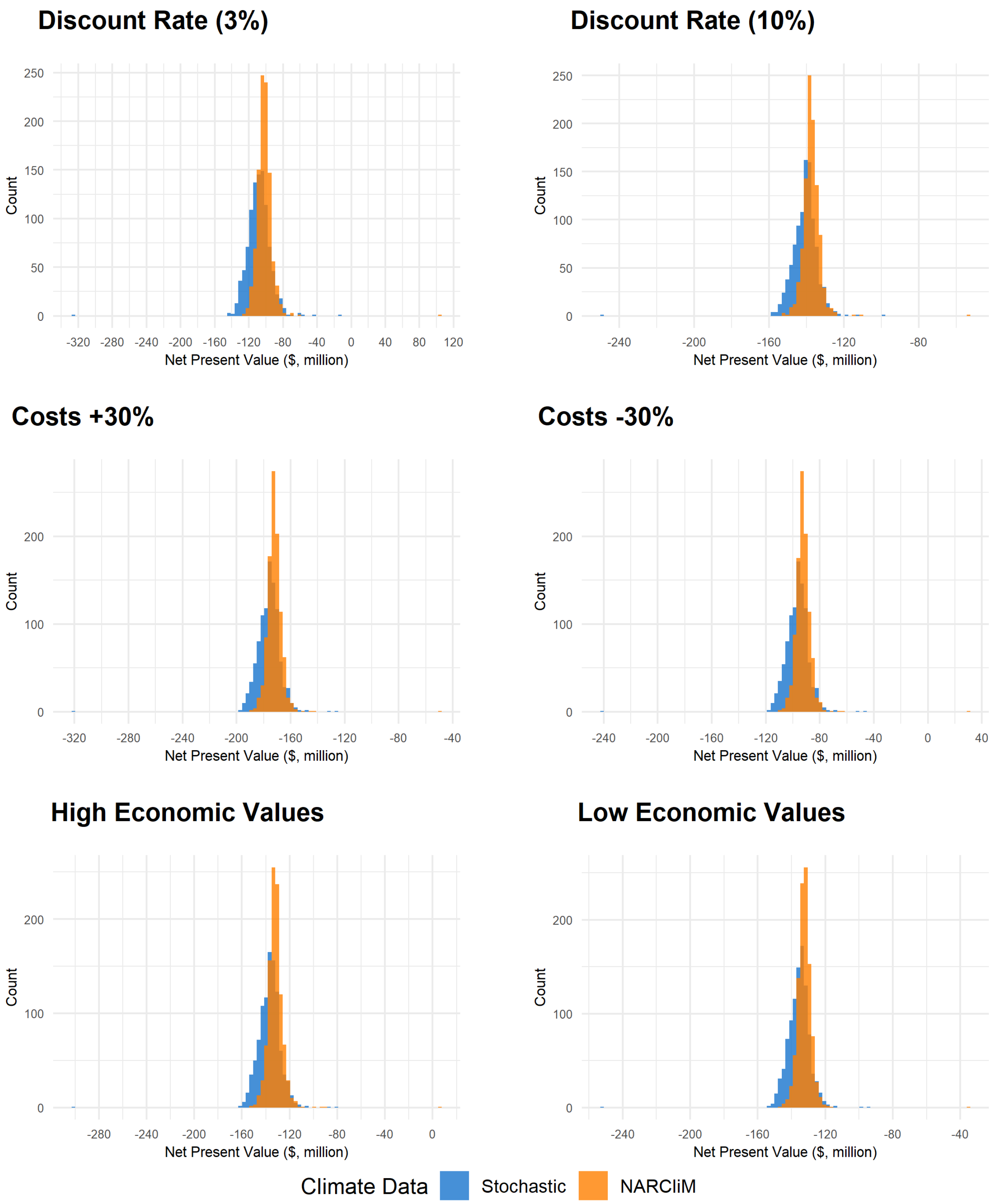


Figure 3. Option 1 sensitivity case net present value histograms

Distributional analysis

Table 8 shows the average distributional impacts that could be expected from the introduction of the option when compared to the economic base case across both datasets. The table highlights that if the option was adopted there would be no significant changes (on average) in the either the economic benefits or the underlying distribution of these benefits across the Gwydir region under either the stochastic or NARCliM datasets. Under both stochastic and

NARCliM climate datasets annual agriculture producers would experience marginally lower economic outcomes on average. Under the NARCliM dataset, benefits to towns and permanent agriculture due to a higher reliability of water supply are realised. The magnitudes of these improvements are not high enough to outweigh the cost of the option.

Table 8. Average distributional impacts from Option 1 compared to the economic base case across both datasets

Stochastic dataset

	Towns ($m)	Annual crop producers ($m)	Permanent crop producers ($m)	Totals ($m)
Economic base case	0	1,995	137	2,132
Option 1	0	1,991	137	2,128
Change ($m)	0.0	-4.0	0.0	-4
% change	0.0%	-0.2%	0.0%	-0.2%

NARCliM dataset

	Towns ($m)	Annual crop producers ($m)	Permanent crop producers ($m)	Totals ($m)
Economic base case	-0.1	1,532	136	1,668
Option 1	0.0	1,532	137	1,668
Change ($m)	0.0	-0.1	0.3	0.3
% change	40.9%	0.0%	0.2%	0.0%

Option 2: New Lower Gravesend Dam on the Gwydir River downstream of Warialda Creek

This option would involve construction of a new 175 GL dam on the Gwydir River, approximately 200 metres downstream of the confluence of Warialda Creek and seven kilometres south east of the town of Gravesend.

The 175 GL dam at Lower Gravesend would increase overall diversions above the sustainable diversion limit, and as a result, to bring diversions back within diversion limits there would need to be a reduction of 60% to supplementary shares as a growth-in-use response.

This option was analysed using a rapid cost-benefit analysis only. The costs of building and operating the dam used in the rapid cost-benefit analysis is given in Table 9.

Table 10 shows the result of the rapid economic assessment of the Lower Gravesend Dam is that the net present value is almost negative $1.5 billion, and the costs outweigh the benefits with a negative benefit-cost ratio. The negative benefit-cost ratio is an indication that the option does not produce an aggregate benefit for the region, before the consideration of cost. Given these results, this option was not progressed through to detailed assessment.

Table 9. Lower Gravesend Dam costs

Dam size (GL)	CAPEX ($b)	OPEX ($m)
175	~1.3	~13.6

Table 10. Lower Gravesend Dam net present value and benefit-cost ratio

Description	Net present value ($m)	Benefit-cost ratio
Lower Gravesend Dam	-1,458	-0.03

The rapid assessment involved 14 realisations of 40 years, drawn from the instrumental record. The results of these 14 40 year periods are detailed in Table 11.

Table 11. Lower Gravesend Dam net present value over the 14 realisations

Description	Realisation	Net present value ($m)
Lower Gravesend Dam	1	-1,461.9
	2	-1,433.6
	3	-1,421.1
	4	-1,457.7

Description	Realisation	Net present value ($m)
	5	-1,462.2
	6	-1,478.9
	7	-1,502.1
	8	-1,496.7
	9	-1,494.9
	10	-1,462.1
	11	-1,477.4
	12	-1,441.2
	13	-1,380.2
	14	-1,436.9

The 14 realisations do not show very much variability, with the best net present value being negative 1,380 million and the worst being approximately negative 1,500 million. Given the results were so far away from breaking even, it was decided not to subject this option to a detailed analysis.

Option 28: Increase the storage reserve in Copeton Dam

Option 28 involves increasing the Gwydir storage reserve by one year, bringing the entire reserve to three years' worth of water. It was previously listed as Option 28 in the draft Gwydir Regional Water Strategy, and is a policy-related change with minimal implementation costs. The 111 GL reserve set aside in the Gwydir model covers two years of water for essential supplies. The assessed option would see an extra year of reserve (55.5 GL) added and then the changes to water security would be evaluated. The result is a trade-off between higher security for towns and communities and less water available for agriculture

In contrast to many infrastructure options considered within the cost-benefit analysis process, the cost associated with this option is solely the effort required to implement the policy change. This is estimated to cost about $4.2 million, which is considered as an upfront cost similar to capital costs for the infrastructure options. No recurring costs are considered for this option, as any changes relating to the execution of the water sharing plan (which will take place regardless of the policy implementation) are considered insignificant.

Results

Table 12 and Table 13 provide the summary data for the rapid and detailed economic analyses for the option. The results represent the averages across all 1,000 realisations undertaken in the analysis. Because each 40-year analysis period has an equal likelihood of occurrence, the averages also represent the expected values (or outcomes) for the option.

Table 12. Rapid economic assessment results for Option 28 – Increase the storage reserve in Copeton Dam

Option cost ($m)	Net present value ($m)	Benefit-cost ratio
4.2	-24.6	-4.8

While this option produced a negative net present value, and a negative benefit cost ratio, given the influence of climate change it was considered worth being subject to a detailed assessment.

Table 13: Average results for Option 28 – Increase the storage reserve in Copeton Dam

Net Present Cost ($m)	Stochastic Net present value ($m)	NARCliM Net present value ($m)	Stochastic Benefit-cost ratio	NARCliM Benefit-cost ratio
4.2	-22.0	-16.9	-4.2	-3.0

This option has a negative average net present value of $22 million under the stochastic dataset, rising to negative $16.9 million using the NARCliM dataset. The average benefit-cost ratio rises from negative 4.2 to negative 3 under the drier climate scenario, also indicating that reserving the water for emergency conditions will, on average, have a net negative impact on the region across a 40-year period.

The hydrologic modelling for the Gwydir region's towns that relied on water from Copeton Dam did not highlight any severe issues with reliability, and only picked up small shortfalls on occasion. For this reason, the cost-benefit analysis results are not unexpected, because the opportunity costs from an economic perspective are highlighted when water is taken from agricultural purposes and stored for town or high security licence reliability, although the modelling suggests that this is not required on a regular basis.

The hydrologic record includes a great deal of variation, not fully represented in average values. With 1,000 realisations of each hydrologic dataset, examining the range of potential outcomes of the option is important. Table 14 presents the range of possible outcomes for the options performance over any 40-year period. The 1st percentile is effectively the worst outcome while the 99th is the best.

The stochastic results indicate that increasing the storage reserves results in a net negative economic outcome under the full range of realisations examined. The same is true under the NARCliM climate dataset with the exception of the 99th percentile, which shows potential for significant improvement in a limited number of realisations.

Table 14. Decile and extreme percentile results for Option 28

Percentile	Stochastic Net present value ($m)	Stochastic Benefit-cost ratio	NARCliM Net present value ($m)	NARCliM Benefit-cost ratio
1%	-39.4	-8.33	-33	-6.82
10%	-30.4	-6.21	-25.8	-5.1
20%	-27.5	-5.52	-22.6	-4.34
30%	-25	-4.93	-20.3	-3.81
40%	-23.3	-4.53	-18.7	-3.42
50%	-21.5	-4.08	-17.2	-3.08
60%	-19.6	-3.65	-15.5	-2.66
70%	-18.1	-3.29	-14.2	-2.36
80%	-16.2	-2.83	-12.6	-1.99
90%	-13.9	-2.28	-10.5	-1.48
99%	-9	-1.12	19.7	5.66

The information presented in Table 14 is given graphically in the histogram of net present values under both climate datasets in Figure 4. This histogram reinforces the results discussed regarding Table 14, showing the majority of realisations under both datasets delivering a negative net present value, with the costs of the option outweighing the benefits.

There are a number of realisations under both datasets that return a positive net present value; however, the tabulated results combined with the histogram show that the number under the stochastic data is limited at less than 10 out of the 1000 examined. The number of realisations yielding a positive net present value is higher under the NARCliM dataset however is still less than 100 out of the 1,000 40-year periods.

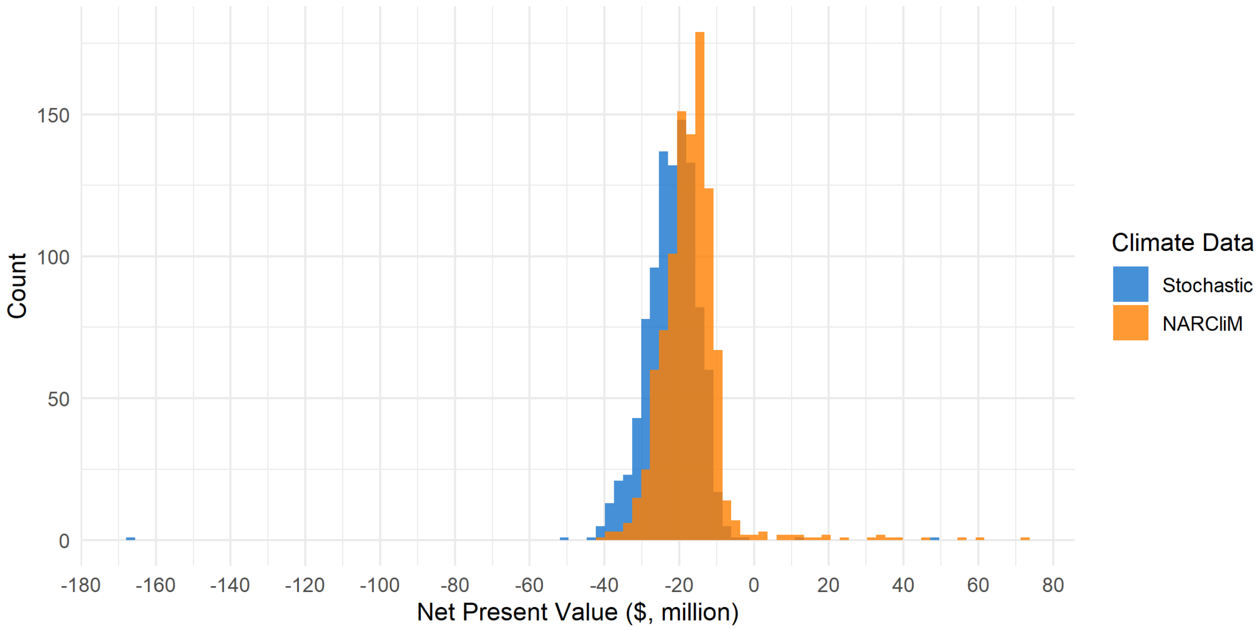


Figure 4. Option 28 net present value histogram

Sensitivity analysis

Sensitivity analysis was undertaken for the option which included the following cases:

- higher (10%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) combined option costs
- higher and lower economic costs, the magnitude of which vary depending on the marginal value altered.

Table 15 provides the summary results data for the option for the central case and sensitivity analysis for the stochastic and NARCliM datasets.

Table 15. Sensitivity analysis across the stochastic and NARCliM datasets

Stochastic dataset

Sensitivity case	Present value capital cost ($m)	Average net present value ($m)	Benefit-cost ratio Average	Benefit-cost ratio Minimum	Benefit-cost ratio Maximum	% of benefit cost ratio with benefit-cost ratio > 1
Central	4.2	-22	-4.2	-38.5	12.65	0.2
Low discount rate (3%)	4.2	-34	-7.1	-58.4	30.6	0.2
High discount rate (10%)	4.2	-17.6	-3.2	-28.7	6.3	0.3
Option cost (+30%)	5.5	-23.3	-3.24	-29.6	9.7	0.2
Option cost (-30%)	3.0	-20.7	-6.01	-55.0	18.08	0.2
Economic values (high)	4.2	-24.3	-4.76	-43.6	14.3	0.2
Economic values (low)	4.2	-18.5	-3.37	-30.8	10.1	0.1

NARCliM dataset

Sensitivity case	Present value capital cost ($m)	Average net present value ($m)	Benefit-cost ratio Average	Benefit-cost ratio Minimum	Benefit-cost ratio Maximum	% of benefit cost ratio with benefit-cost ratio > 1
Central	4.2	-16.9	-3.01	-8.6	18.2	3
Low discount rate (3%)	4.2	-24.8	-4.88	-12.7	19.3	3
High discount rate (10%)	4.2	-14.0	-2.33	-6.9	16.4	2.2
Option cost (+30%)	5.5	-18.2	-2.31	-6.6	14.0	2.3
Option cost (-30%)	3.0	-15.7	-4.29	-12.3	25.9	2.5

Economic values (high)	4.2	-18.1	-3.29	-9.7	29.2	2.8
Economic values (low)	4.2	-14.8	-2.5	-6.87	7.41	1.5

The option was created to increase the reserve that is currently set aside for essential supplies in the Copeton Dam from two years to three years. This option performs poorly across both the stochastic and NARCliM datasets but does show small improvements under the drier climate. Despite the relatively small capital expenditure requirements ($4.2 million), the central base case has a negative net present value of $22 million under stochastic and negative $17 million under NARCliM. For all of the sensitivities modelled, the amount of time that benefit-cost ratios were recorded above one never exceeded 3%. This included the very favourable changes of either increasing the marginal economic returns of water to higher values or using a 3% discount rate. This indicates that there are very few situations where this option would provide a net economic benefit to society.

Histograms of the results of the sensitivity can be seen in Figure 5, supporting the results of Table 15, which suggests that there is not a set of conditions under which the option regularly produces economic benefits higher than its costs.

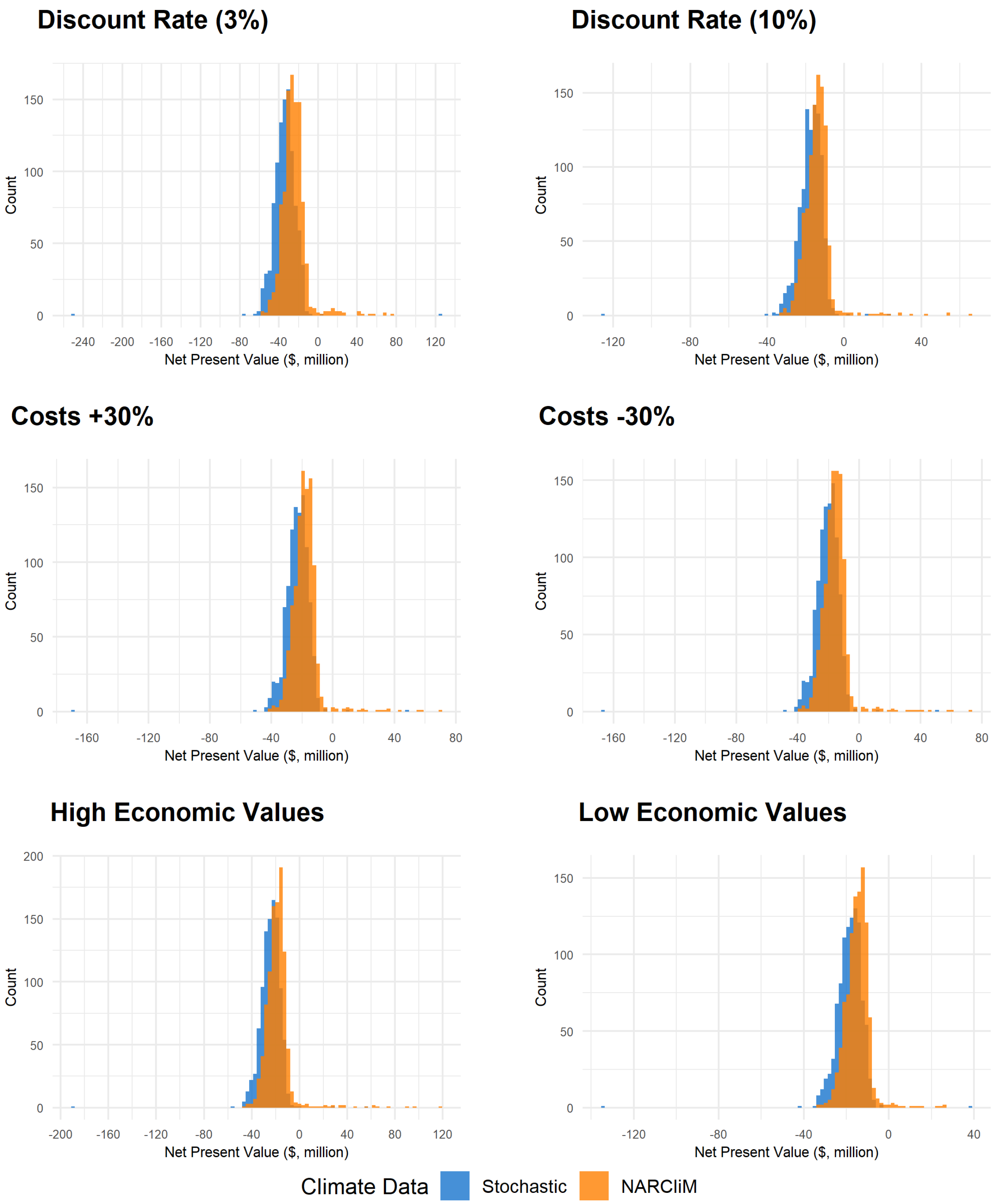


Figure 5. Option 28 sensitivity case net present value histograms

Distributional analysis

Table 16 highlights the average distributional changes that would impact the Gwydir region if the option was introduced.

Table 16. Average distributional impacts from the option compared to the economic base case across both datasets

Stochastic dataset

	Towns ($m)	Annual crop producers ($m)	Permanent crop producers ($m)	Totals ($m)
Economic base case	0	1,995	137	2,132
Option 28	0	1,977	137	2,114
Change ($m)	0.0	-17.9	0.1	-18
% change	100.0%	-0.9%	0.1%	-0.8%

NARCliM dataset

	Towns ($m)	Annual crop producers ($m)	Permanent crop producers ($m)	Totals ($m)
Economic base case	-0.1	1,532	136	1,668
Option 28	0	1,518	137	1,655
Change ($m)	0.1	-13.9	1.0	-13
% change	99.5%	-0.9%	0.7%	-0.8%

Once again, it shows that this option would make no significant changes to either the amount of economic benefit or the distribution of economic output throughout the Gwydir region if it was introduced. Positive impacts are experienced by permanent agriculture producers and towns; however, the magnitude of the increase is small in comparison to the output of the region.

Breakeven analysis

In this case the targeted primary beneficiary of increasing the Copeton Dam's storage reserve by one year is presumed to be regional town water security, for which the relevant price level is the economic cost of water supply shortfalls. This cost was increased separately for the stochastic and NARCliM economic analysis until the average, or expected value, of benefit-cost ratio outcomes for the 1,000 40 year runs of each dataset was equal to, or near to one.

The breakeven price level, and the calculated average benefit-cost analysis using this price level, for the economic costs of town water supply shortfall within this option for both climate datasets are given in the regional water value function report by MJA. The results are shown in Table 17.

Table 17. Breakeven price level

Climate dataset	Benefit-cost ratio average	Economic cost of town water supply shortfalls ($/ML)
Stochastic	1.07	$18,000,000
NARCliM	1.04	$1,150,000

For both climate datasets, the marginal economic cost of a town water supply shortfall is required to be several orders of magnitude higher than the cost assumed within this study of carting water to a town (about $10,000/ML). These results agree with the economic value sensitivity runs that vary all price levels in tandem, which suggest that the average outcome of this option is not particularly sensitive to these price level changes.

It is also noted that the required marginal economic cost of a town water supply shortfall under the NARCliM climate dataset is an order of magnitude lower than that of the stochastic dataset. This is due to the relatively more frequent and longer duration of town water supply shortfalls present within the climate-change scenario.

Option 29a: Investigation of licence conversions (bulk licence conversion)

This option is listed as Option 29 in the draft Gwydir Regional Water Strategy and is a policy-related change with minimal implementation costs required.

This is implemented by retaining water in dams for future years (called the reserve) for the high security licences, rather than allocating that water for immediate use. General security licences do not have a reserve set aside, meaning that in droughts they typically receive no or a very low part of their entitlement. High security licences have enough water reserved so they would receive their full allocation even through a repeat of the worst droughts present in the historic climate data records.

The impact of converting general security licences to high security licences is that there is more water in the dams for longer, and less need for drought operation measures. This can have social benefits as dams and rivers are often used for recreation and social purposes.

This option could also allow environmental water holders to convert some of their general security holdings to high security to change their portfolio mix and improve the protection of water for the environment that is retained for critical environmental needs during times of shortage. While the NSW and Commonwealth environmental water holder's use carryover to help meet a range of environmental demands across multiple years in the Gwydir region, there have been times when they could not order water because there was not enough system water to deliver it to critical assets or ecosystems.

To determine the capacity of Copeton Dam to support high security licences, preliminary analysis of a bulk and partial conversion of licences was undertaken.

Under bulk conversion, all current general security licences (408GL) would be converted to high security licences (179GL) within the region. These new high security licences are estimated to be 98% reliable. With all general security licences converted, Copeton Dam would be maintained at or above 25% full at all times under the historic climate, 95% of the time under the longer term climate and 78% of the time under a dry climate.

The licence conversion is designed to facilitate the growth of high value crops that require a higher level of water reliability for establishment and ongoing production. Pecans are a high-value crop that has been identified as being suitable for growing in the Gwydir region using a high security licence.

The cost associated with this option is solely the effort required to implement the policy change. This is estimated to cost about $8.4 million and is considered as an up-front cost similar to capital expenditure for the infrastructure options. No recurring costs are considered for this option, because any changes in options relating to the execution of the water sharing plan (which will take place regardless of the policy implementation) are considered insignificant.

Results

Table 18 and Table 19 provide the summary data for the modelled option. The results represent the averages across all 1,000 realisations undertaken in the analysis. Because each 40-year analysis period has an equal likelihood of occurrence, the averages also represent the expected values (or outcomes) for the option.

Table 18. Rapid economic assessment results for 29a: investigation of licence conversions (bulk licence conversion)

Option cost ($m)	Net present value ($m)	Benefit-cost ratio
8.4	842	100

The rapid assessment provides a very high net present value and benefit cost ratio. On this basis the option was subject to more detailed assessment in the fuller stochastic and NARCliM datasets.

Table 19: Average results of the detailed economic analysis results for option 29a: investigation of licence conversions (bulk licence conversion)

Net present cost ($m)	Stochastic Net present value ($m)	NARCliM Net present value ($m)	Stochastic Benefit-cost ratio	NARCliM Benefit-cost ratio
8.4	648.6	-17.0	77.8	-1.0

This option produces a very high and positive result under stochastic modelling with an average net present value of $649 million and a very high average benefit-cost ratio of 77.8. Under the NARCliM modelling the average net present value drops significantly to negative $17 million (and the average benefit-cost ratio to negative 1), indicating that the new high security licences will not be as secure under a drying climate.

The hydrologic record includes a great deal of variation, not fully represented in average values. With 1,000 realisations of each hydrologic dataset, examining the range of potential outcomes of the option is important. Table 20 presents the range of possible outcomes for the options performance over any 40-year period. The 1st percentile is effectively the worst outcome while the 99th is the best.

The table shows the wide range of possible outcomes under either climate scenario and, by extension, the high degree of uncertainty regarding the performance of the option over a 40-year period. Under both climate scenarios, over 50% of the realisations produce a net positive outcome for the region (80% of realisations under the stochastic dataset and 60% under the NARCliM dataset).

While these numbers are encouraging, there remains a potential of highly negative outcomes in both datasets. The 1st percentile net present value of the stochastic dataset is about negative $1,900 million, and the NARCliM equivalent deteriorates to about negative $3,900 million. This potential for highly negative outcomes for the region ultimately results in the average negative net present value and benefit-cost analysis results seen under the NARCliM dataset.

Table 20. Decile and extreme percentile results

Percentile	Stochastic net present value ($m)	Stochastic benefit-cost ratio	NARCliM net present value ($m)	NARCliM benefit-cost ratio
1%	-1,891.9	-222.98	-3,885.7	-459.03

10%	-132.6	-14.70	-2,105.7	-248.29
20%	477.4	57.51	-1,046.9	-122.94
30%	704.5	84.40	-451.7	-52.47
40%	774.1	92.64	120	15.21
50%	845.0	101.04	491.7	59.21
60%	915.8	109.42	785.1	93.95
70%	967.7	115.56	943.6	112.71
80%	1,036.1	123.66	1,050.6	125.38
90%	1,114.4	132.93	1,143.9	136.43
99%	1,251.8	149.20	1,289.2	153.62

The information presented in the above table is given graphically in the histogram of net present values under both climate datasets in Figure 6. The histogram shows the high number of realisations that produce a positive net present values for the region, with an emphasis on the number of runs that achieve this under the stochastic climate dataset. The histogram is heavily left-skewed, with a high number of realisations resulting in a negative net present value. While both climate datasets produce highly negative net present values, the number and magnitude of these negative net present values are greater under the NARCliM climate scenario.

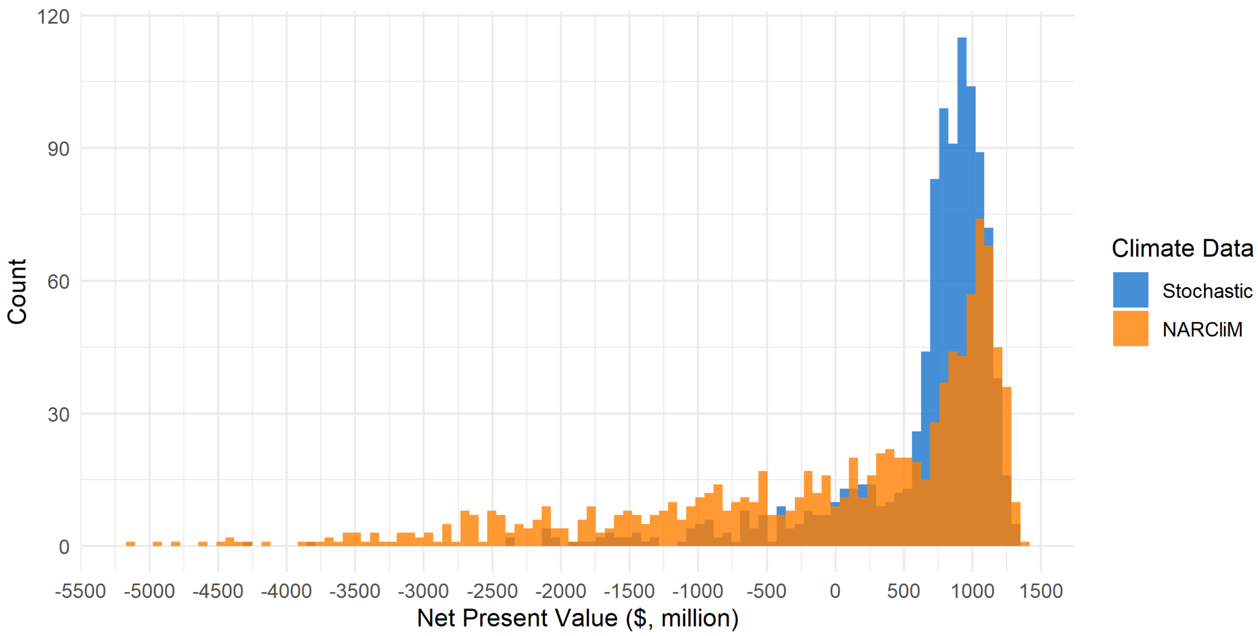


Figure 6. Option 29a net present value histogram

These extremely positive numbers (under most outcomes but particularly under the stochastic conditions) for such a low capital outlay (estimated at approximately $8.4 million) are the result of the modelling approach that has been undertaken and should not be taken as a given if this type of policy approach is adopted. By removing all general security water licences (408 GL in total with an average take of 192 GL per year) and replacing this with 179 GL of high security water, the modelling approach has assumed that almost all water users would shift from producing annual crops of cotton to high-value permanent plantations of pecans.

Under the modelling assumptions, which have been informed by the MJA Regional Water Values Function report,[17] a shift to pecans would see agricultural users achieve a marginal economic benefit of $800/ML compared to cotton of $375/ML.

For any economic activity to succeed, four key factors of production are required: land, labour, capital and entrepreneurship. The broad-based modelling approach adopted for the regional water strategy takes a positive approach to these factors, assuming that businesses have the ability to shift gears to new areas of activity without any corresponding loss of economic value. This approach tends to over-estimate the speed at which benefits can be obtained and ignores the opportunity cost lost when switching activities. For this option, it has been assumed that it is possible to convert land that is currently used for cotton production to pecans from day one. This is not realistic. It would take a large amount of capital to achieve this, a cost that would be borne by the farmers.

This modelling approach has also only considered the cost to government of this option, not the broader economic cost to landowners. Some of these costs would include capital items such as a change in machinery use (tractors and implements), irrigation infrastructure, new sheds and machinery for harvesting. The modelling approach assumes that there are no constraints on capital, enabling all producers to switch to pecans immediately. This is also unrealistic, because not all farmers will have access to the capital/money required to make this change.

From a labour perspective, the modelling approach also assumes that the skills required to grow and harvest pecans could be acquired from the cotton industry from day one, a very unrealistic assumption. Such a dramatic change in industry composition would require the labour force to be retrained, which would take a significant amount of time.

In addition, this modelling approach assumes that all the economic benefits from producing pecans would be achieved by the farmers from day one. Pecans are a slow growing tree, only lightly cropping after five years and not cropping commercially until around eight to 10 years of age.[18] In addition, the opportunity cost of losing all income from cotton and other opportunistic crops over this time period, until the pecans can produce a viable commercial return, has not been considered in this analysis.

This approach also does not incorporate the entrepreneurship value of farmers who currently maximise output (farming as much cotton as possible) over long extended periods of irregular water supply.

All of these items would significantly reduce the economic benefit of Option 29a. While this discussion has focussed on the option not having sufficient benefits to justify its costs, the analysis highlights the range of possible economic benefits that can be achieved when

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17 See *Regional Water Value Functions* (MJA, 2020).

[18] Queensland Government Department of Agricultural and Fisheries 2016, *Case study 2: Bioeconomic analysis of Southern Qld. Pecan production*, p4.

agricultural producers are given the opportunity to farm under more favourable water conditions. Having a more consistent water source gives the agricultural industry the opportunity to move production from lower value opportunistic cropping to more certain high value outputs. More work would need to be done before this type of licence adjustment could be made, including a full investigation into the broader economic costs and benefits.

Whilst under stochastic conditions the option 29a performs very well across all aspects; under NARCliM the results are not as strong with the net present value dropping to negative $17 million from $649 million under the central base case. This indicates that the actual level of water security provided for farmers under this option will be much less as the region moves towards a drier climate.

Sensitivity analysis

Sensitivity analysis was undertaken for the option, which included the following cases:

- higher (10%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) option costs
- higher and lower economic costs, the magnitude of which vary depending on the marginal value altered

Table 21 provides summary results of central case and sensitivity analysis for the stochastic and NARCliM datasets. The full histograms of the sensitivity results can be seen in Figure 7. The results reveal a high level of sensitivity to both the discount rates and marginal economic values of water use in both climate datasets, which are not sensitive to the adopted cost of the option.

A lower discount rate of 3% has the impact of valuing future benefits more highly and has a very large positive impact on the outcomes achieved. Note that it has the impact of improving the positive net present values of a realisation and also of intensifying the negative impacts when negative net present values are seen in the central case, this is most clearly visible in the histograms. The higher discount rate of 10% typically reduces the net present values, which is seen by lower average net present values in the result table.

The option cost has the impact of shifting all results by positive or negative $2-3 million depending on whether a higher or lower option cost is being considered. Given the wide range and high magnitude of positive and negative outcomes in either direction the option cost has little impact on the outcomes of the analysis.

Testing the economic values by raising or lowering marginal benefits of water use concurrently within each analysis has mixed impacts on the results and is identified as a key area for consideration in further work. Increasing economic values dramatically improves the average net present values achieved under both climate datasets however also significantly increases the magnitude of negative outcomes. Using lower economic valuations gives different movement to the average net present value in comparison to the central case depending on the climate dataset being considered. Under the stochastic dataset the average net present value is reduced by approximately $200 million. In contrast, the average net present value is increased under the NARCliM dataset by nearly $300 million, moving the average outcome from a negative in the central case (-$17 million) to a positive under the low economic value sensitivity case (+$285 million). The histograms show that this is likely due the reduced variability experienced when economic values are lowered, which lessens the worst impacts under the climate-change scenarios.

Table 21. Sensitivity analysis on Option 29a across the stochastic and NARCliM datasets

Stochastic dataset

Sensitivity case	Present value capital cost ($m)	Average net present value ($m)	Benefit-cost ratio Average	Benefit-cost ratio Minimum	Benefit-cost ratio Maximum	% of benefit cost ratio with benefit-cost ratio > 1
Central	8.4	648.6	77.78	-506.9	157.5	88.3
Low discount rate (3%)	8.4	1,240.8	147.9	-605.6	267.2	92.4
High discount rate (10%)	8.4	441.5	53.27	-436.6	118.7	85.9
Option cost (+30%)	11	646.0	59.83	-389.9	121.1	88.3
Option cost (-30%)	5.9	651.1	111.12	-724.1	224.97	88.3
Economic values (high)	8.4	3,855.4	457.4	-499.2	567.1	98.6
Economic values (low)	8.4	460.2	55.48	-159.8	102.7	94.4

NARCliM dataset

Sensitivity case	Present value capital cost ($m)	Average net present value ($m)	Benefit-cost ratio Average	Benefit-cost ratio Minimum	Benefit-cost ratio Maximum	% of benefit cost ratio with benefit-cost ratio > 1
Central	8.4	-17.0	-1.01	-606.4	165.67	62.3
Low discount rate (3%)	8.4	185.6	22.97	-936.9	282.7	64.3
High discount rate (10%)	8.4	-73.9	-7.75	-512.8	123.4	62.0

Stochastic dataset

Option cost (+30%)	10.98	-19.6	-0.78	-466.5	127.4	62.3
Option cost (-30%)	5.9	-14.5	-1.45	-866.3	236.7	62.4
Economic values (high)	8.4	2,685	318.9	-658.6	576.3	86.7
Economic values (low)	8.4	285.3	34.77	-199.1	109.28	76.2

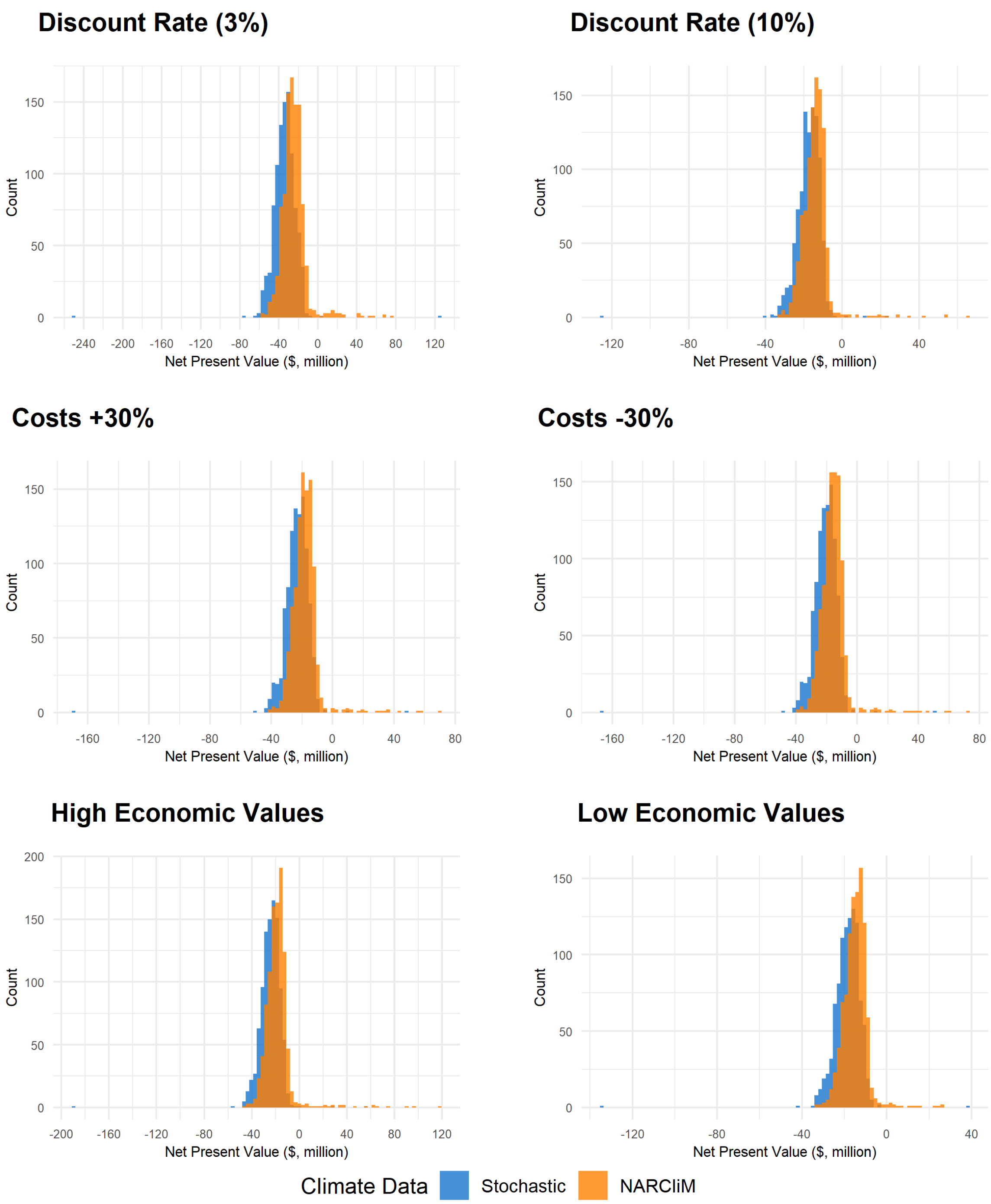

Figure 7. Option 29a sensitivity case net present value histograms

Distributional impacts

Table 22 highlights the distributional changes that would impact the Gwydir region if Option 29a was introduced. This option is based around the bulk conversion of general security licences to high security licences and, as such, a major shift away from annual crops such as cotton to permanent crops such as pecans, is assumed. Under the climate change dataset, the economic value of this shift is significantly lower (approximately 60%) than under the stochastic dataset.

Table 22. Distributional impacts from Option 29a compared to the economic base case across both datasets

Stochastic dataset

	Towns ($m)	Annual crops($m)	Permanent crops ($m)	Totals ($m)
Economic base case	0	1,995	137	2,132
Option 29a	-4	1,039	1,758	2,789
Change ($m)	-4	-957	1621	657
% Change	N/A	-48%	1182%	31%

NARCliM dataset

	Towns ($m)	Annual crops($m)	Permanent crops ($m)	Totals ($m)
Economic base case	-0.1	1532	136	1,668
Option 29a	-19.4	821	870	1,659
Change ($m)	-19.4	-711	734	-8.6
% Change	NA*	-46%	538%	-0.5%

*Note: due to being a small figure initially the percentage change is very large, despite the change not being material.

The results in this table further highlight the unique situation in the Gwydir region where cotton growers are not just earning their economic wealth from general security licences but also a large proportion from supplementary licences (when water is available) and floodplain harvesting opportunities. This is demonstrated by the fact that annual cropping farmers will still be, on average, contributing between 30 and 50% of the economic benefit to the region, even when all general security licences have been replaced with high security licences. As the region moves into a drier climate the actual outright level of this economic benefit that the region will suffer becomes more pronounced.

The economic cost of town shortfalls also increase on average under both climate datasets, most noticeably under the NARCliM dataset. This is a result of the increased demand on secure water supplies due to the new high security licences.

Breakeven analysis

This option involves a policy change, converting general security licences to a lower number of higher reliability high security licences. The detailed analysis on this option was undertaken assuming that the producer surplus associated with high-value horticulture was equivalent to $800/ML.

The breakeven price levels, and the calculated average benefit-cost ratio using this price level, for the economic benefit associated with permanent agriculture for Option 29a are given in Table 23. Note that although the benefit-cost ratio's are not equal to the breakeven level of 1.0, the price level given is within $10 of the price required to achieve this level.

Table 23. Breakeven price level Option 29a

Climate dataset	Benefit-cost ratio average	Required economic value of high security entitlements ($/ML)
Stochastic	1.9	$500
NARCliM	1.5	$810

The results of the breakeven analysis show that the stochastic breakeven point is almost half that of the initial assumption in the detailed analysis. This suggests that the option will yield more consistently improved results under the stochastic dataset.

It should be noted that while the initial detailed analysis had a more complicated value function, with losses associated with not meeting the high security requirement, the value associated with a water supply shortfall has not been changed in the breakeven analysis. As a consequence, the NARCliM breakeven value of $810/ML is slightly higher than the $800/ML assumed in the detailed analysis. This suggests the result is sensitive to assumptions regarding the marginal benefit of water use.

Option 29b: Investigation of licence conversions (partial licence conversion)

Option 29b was previously listed as Option 29 in the draft Gwydir Regional Water Strategy and is a policy-related change requiring minimal capital costs.

This option is similar to Option 29a but would involve the partial conversion (10%) of licences, not all of the licences. Under this option, 41 GL of current general security licences would be converted to create an additional 18 GL of high security licences within the region to facilitate the growth of high-value crops that require a higher level of water reliability for establishment and ongoing production. Pecans are one of the high value crops that was identified as being suitable for growing in the Gwydir region using high security licences.[19]

While bulk conversion is possible, providing for a small amount of conversion may be more consistent with industry needs and could support industries setting up in the Moree Special Activation Precinct. There is often concern that converting a part of General Security to High Security licences could adversely affect the water available to the remaining general security licences in dry years.

The analysis has shown that converting 10% (41 GL) of general security licences to 18 GL of new high security entitlement would:

- reduce the time that Copeton Dam sits at or below 25% by 6% based on the historical data (from 29% to 23%) and 5% under a dry climate change scenario (from 55% to 50%). This is typically when drought operation measures commence in this valley to extend water supplies for essential and critical needs.
- reduce the water supplied to general security licence holders by 6-8% each year on average, based on the historic, long-term climate, and climate-change scenarios.
- increase general security end-of-year effective annual allocation by approximately 2% under the historic and long-term climate (up to 102 and 98%, respectively), and remain unchanged under a dry climate scenario (71%).
- have negligible impact (< 1%) on net evaporation from on-farm storages.

The cost associated with this option is solely the effort required to implement the policy change. This is estimated to cost about $8.4 million and is considered as an up-front cost similar to capital expenditure for the infrastructure options. No recurring costs are considered for this option, because any changes in actions relating to the execution of the water sharing plan (which will take place regardless of the policy implementation) are considered insignificant.

Results

Table 24 and Table 25 provides the summary data for the modelled option, with Table 24 providing the results of the rapid assessment while Table 25 provides the average outcomes of the detailed assessment. The results represent the averages across all 1,000 realisations undertaken in the analysis. Because each 40-year analysis period has an equal likelihood of occurrence, the averages also represent the expected values (or outcomes) for the option.

[19] See the *Regional Water Value Functions* (MJA, 2021)

Table 24: Rapid economic assessment results for 29b: investigation of licence conversions (partial licence conversion)

Option cost ($m)	Net present value ($m)	Benefit-cost ratio
-$8.4	$121.4	15.4

The option is assumed to have the same costs as the full license conversion. It also produces a positive net present value and a very favourable benefit cost ratio. Consequentially it was determined to examine the performance of the option under the stochastic and NARCliM datasets.

Table 2526. Average detailed economic analysis results for Option 29b: investigation of licence conversions (partial licence conversion)

Net present cost ($m)	Stochastic net present value ($m)	NARCliM net present value ($m)	Stochastic benefit-cost ratio	NARCliM benefit cost ratio
8.4	121.7	128.2	15.4	16.2

This option produces the best results of the detailed analysis. It has a positive net present value of $121.7 million under the stochastic dataset which rises by approximately 5% to $128.2 million using the NARCliM dataset. The benefit-cost ratio remains fairly consistent and very high at approximately 16 under both datasets. Although these the average outcomes seem extremely beneficial to society, they are subject to some key assumptions and limitations as explained in Option 29a. Those assumptions and limitations have large impacts on the results, and, as such, the results should be taken as a potential direction for positive change rather than relying on the magnitude of benefit.

The hydrologic record includes a great deal of variation, not fully represented in average values. With 1,000 realisations of each hydrologic dataset, examining the range of potential outcomes of the option is important. Table 26 presents the range of possible outcomes for the option's performance over any 40-year period. The 1st percentile is effectively the worst outcome while the 99th is the best.

The table shows far reduced variability than those of the comparable Option 29a, and importantly no negative outcomes up to the extreme range of the 1st percentile. The variability and net present values or benefit-cost ratios seen at each percentile level are similar between the two climate datasets, with the NARCliM results showing better results over the stochastic dataset at higher deciles.

Table 27. Decile and extreme centile results for Option 29b: investigation of licence conversions (partial licence conversion)

Percentile	Stochastic net present value ($m)	Stochastic benefit-cost ratio	NARCliM net present value ($m)	NARCliM benefit-cost ratio
1%	99.8	12.81	100.4	12.88
10%	110.4	14.07	118.2	14.99
20%	114.8	14.6	122.5	15.51

30%	117.4	14.9	124.6	15.75
40%	120.5	15.26	127	16.03
50%	122.7	15.52	128.8	16.25
60%	125.1	15.81	131	16.51
70%	127.2	16.06	133.4	16.79
80%	129.9	16.38	135.6	17.06
90%	132.7	16.7	138.6	17.41
99%	140.6	17.65	144.1	18.06

The information presented in the above table is given graphically in the histogram of net present values under both climate datasets in Figure 8. The histogram does not show the left-skewness seen in Option 29a, indicating that improved reliability due to the fewer high security licences created reduces the probability of negative impacts occurring for the region. There remains a small chance of negative net present values in both the stochastic and NARCliM datasets as seen by the outliers visible in the far left-hand side of the histogram.

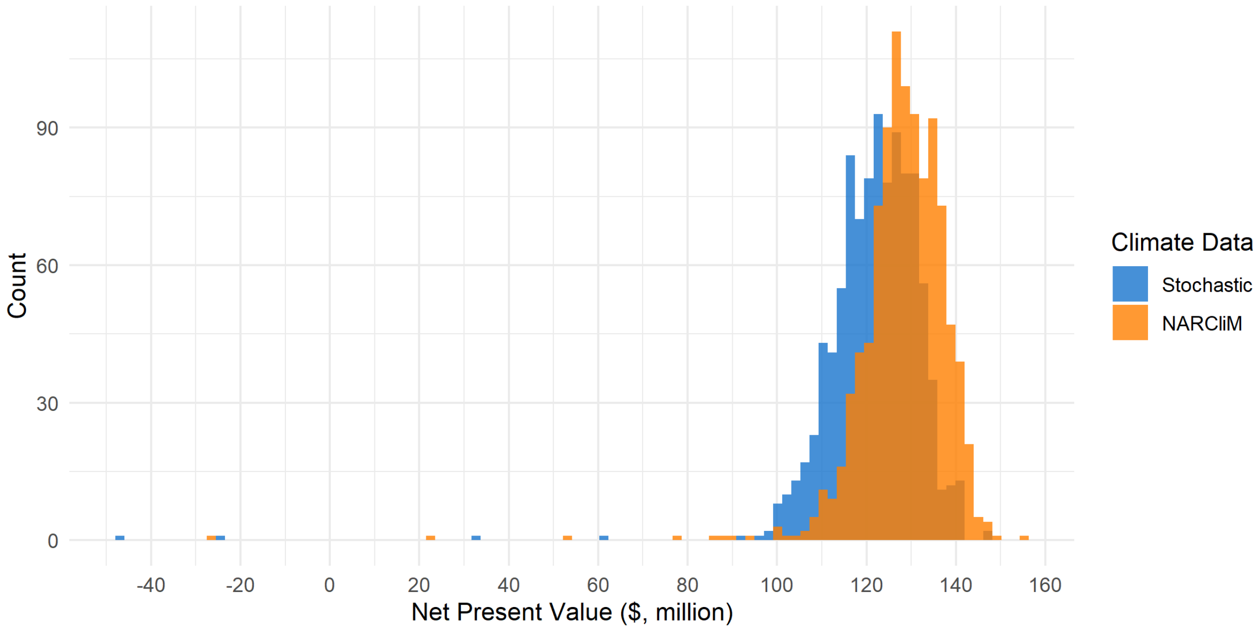

Figure 8. Option 29b net present value histogram

Sensitivity analysis

Sensitivity analysis was undertaken for the option which included the following cases:

- higher (10%) and lower (3%) discount rates
- higher (+30%) and lower (-30%) option costs

- higher and lower economic costs, the magnitude of which varies depending on the marginal value altered

Table 27 provides the summary results data for Option 29b for the central case and sensitivity analysis for the stochastic and NARCliM datasets. This option is similar to Option 29a with a partial conversion (10%) of general security licences, not all of the licences. Under this option, 41 GL of current general security licences would be converted to create an additional 18 GL of high security licences within the region to facilitate the growth of high-value crops requiring a higher level of water reliability for establishment and ongoing production.

Lowering the discount rate increases the future economic benefits, therefore increasing the average net present value by nearly $90 million. A higher discount rate has the opposite impact, reducing the average net present value by nearly $30 million. In both cases, there remains potential for negative outcomes to occur under the stochastic dataset; however, a lower discount rate removes any potential negative economic outcomes under the NARCliM dataset.

Increasing or decreasing the cost of implementation by 30% either way has a $2 million to $3 million impact, depending on the direction. This amounts to a 2.5% average net present value decrease in the case of a higher implementation cost, or a 1.6% average net present value increase if the cost was lower. In comparison to the remainder of the sensitivity analysis, the results are not sensitive to the cost of the option.

The greatest variation is seen in the sensitivity analysis regarding the marginal economic values of water use, particularly when considering the higher bound economic values. Under this case the average net present value increases by nearly four times to $467 million under the stochastic dataset, and $474 million under the NARCliM dataset. This is a far greater deviation from the results of the central case compared to those arrived at when adopting the lower bound economic values of water use, which result in average reductions of between 36% and 38% across the two climate datasets.

These results highlight the high sensitivity to the assumptions regarding the marginal economic value of water use, particularly for the permanent plantations.

Table 28. Sensitivity analysis on Option 29b across the stochastic and NARCliM datasets

Stochastic dataset

Sensitivity case	Present value capital cost ($m)	Average net present value ($m)	Benefit-cost ratio Average	Benefit-cost ratio Minimum	Benefit-cost ratio Maximum	% of benefit cost ratio with benefit-cost ratio > 1
Central	8.4	121.7	15.4	-4.54	18.42	99.8
Low discount rate (3%)	8.4	212.9	26.2	-7.18	30.84	99.8

Stochastic dataset

High discount rate (10%)	8.4	88.3	11.5	-2.4	14.0	99.8
Option cost (+30%)	11.0	119.2	11.85	-3.49	14.17	99.8
Option cost (-30%)	5.9	124.2	22.0	-6.49	26.31	99.8
Economic values (high)	8.4	467.3	56.3	33.7	60.2	100
Economic values (low)	8.4	76.0	10.0	-5.96	12.3	99.8

NARCliM dataset

Sensitivity case	Present value capital cost ($m)	Average net present value ($m)	Benefit-cost ratio Average	Benefit-cost ratio Minimum	Benefit-cost ratio Maximum	% of benefit cost ratio with benefit-cost ratio > 1
Central	8.4	128.2	16.18	-2.07	19.4	99.9
Low discount rate (3%)	8.4	224.8	27.62	4.43	31.6	100
High discount rate (10%)	8.4	92.9	12.0	-3.48	14.88	99.9
Option cost (+30%)	11.0	125.7	12.5	-1.6	14.9	99.9
Option cost (-30%)	5.9	130.8	23.1	-2.96	27.7	99.9
Economic values (high)	8.4	474.3	57.2	28.4	61.7	100
Economic values (low)	8.4	81.5	10.65	2.9	12.5	100

The distinguishing characteristics of this option that differentiate it from all the other options that were considered is that it performs very strongly across both the stochastic and NARCliM datasets across all outcomes. This is further supported by the histograms of the results of the sensitivity, can be seen in Figure 9. From this it can concluded that these results should encourage further investigation into the practicality of implementing a policy change based on this approach.

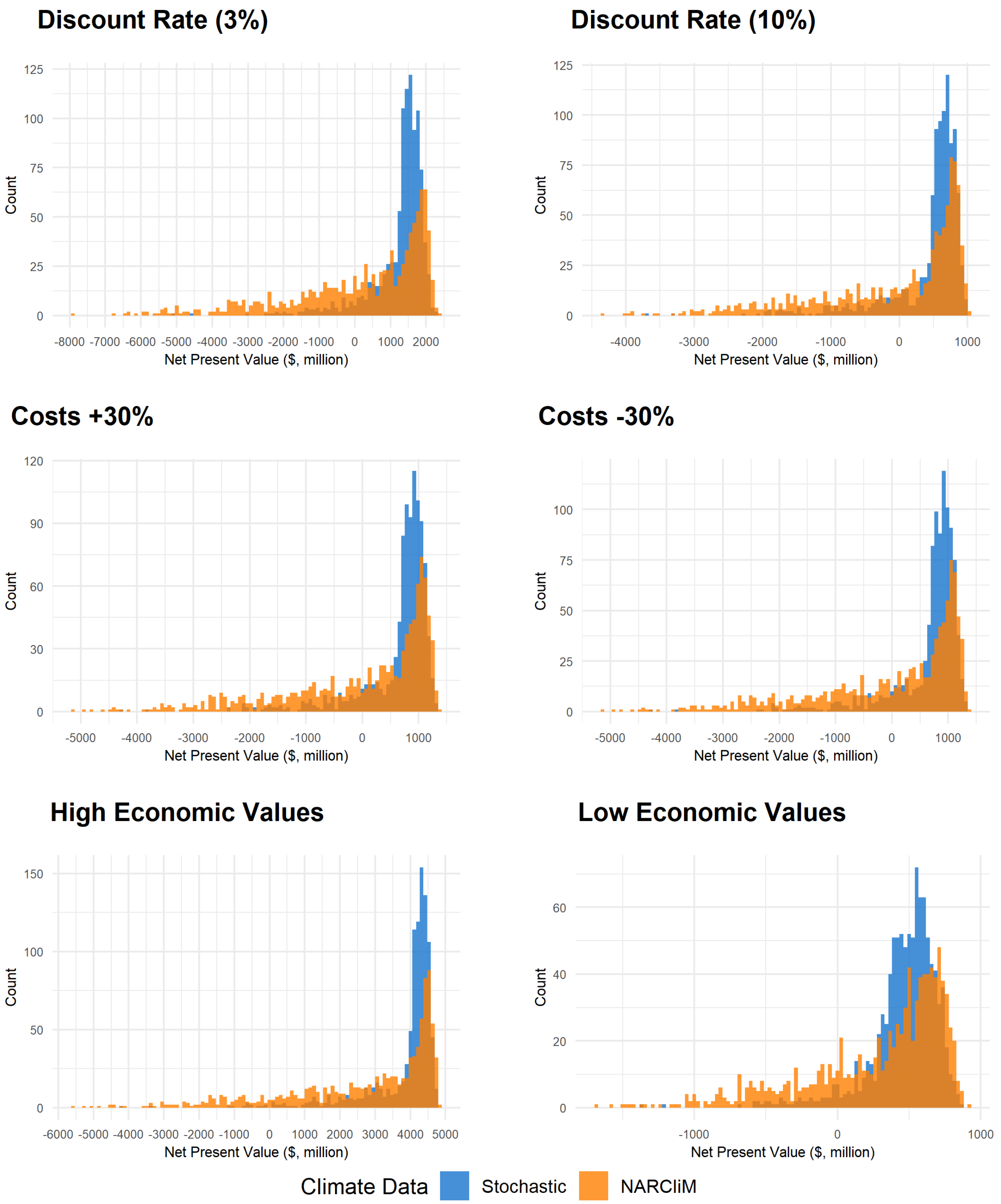

Figure 9. Sensitivity case net present value histogram for Option 29b: investigation of licence conversions (partial licence conversion)

Distributional analysis

Table 28 highlights the distributional changes that may impact the Gwydir region if Option 29b was introduced. It highlights an increase in permanent crops relative to the size of the partial conversion (10%, not 100% as in Option 29a), with less high security water being made available. Under a drier climate, the economic benefit of this shift is also reduced.

Table 29. Average distributional impacts from Option 29b compared to the economic base case across both datasets

Stochastic dataset

	Towns ($m)	Annual crop producers ($m)	Permanent crop producers ($m)	Totals ($m)
Economic base base	0	1,995	137	2,132
Option 29b	0	1,928	334	2,263
Change ($m)	0.0	-66.8	196.9	130
% Change	40%	-3.3%	143.7%	6.1%

NARCliM dataset

	Towns ($m)	Annual crop producers ($m)	Permanent crop producers ($m)	Totals ($m)
Economic base case	-0.1	1532	136.2	1,668
Option 29b	-0.1	1,472	332.3	1,804
Change ($m)	0.0	-59.5	196.1	137
% Change	16.9%	-3.9%	144.0%	8.2%

The distributional results suggest that cotton growers will continue to contribute a similar amount of economic benefit (under both climate scenarios) to the economic base case, experiencing marginal impacts less than 4% on average.

The results further highlights the situation in the Gwydir region where cotton growers are not just earning their economic wealth from general security licences but also a large proportion from supplementary licences (when water is available) and floodplain harvesting opportunities. This is demonstrated by the fact that annual cropping farmers will still be contributing approximately 50% of the economic benefit to the region when 10% of general security licences have been replaced with high security licences. As the region moves towards a drier climate, the actual outright level of this economic benefit that the region will suffer becomes more pronounced.

In contrast to Option 29a, towns within the region realise an increase in water supply reliability and subsequently a decrease in the economic costs of shortfalls.

Breakeven analysis

The purpose of this option is to improve the productivity of the use of water by creating high security entitlements in exchange for general security entitlements. This involves a transition of 41 GL of general security to 18 GL of high security. In the detailed assessment the improved economic value was $800/ML.

The breakeven price levels, and the calculated average benefit-cost analysis using this price level, for the economic benefit associated with permanent agriculture for Option 29b are given in Table 29. Note that although both benefit cost ratios are not equal to the breakeven level of 1.0, the price level given is within $10 of the price required to achieve this level.

Table 30. Breakeven price level Option 29b: investigation of licence conversions (partial licence conversion)

Climate dataset	Benefit-cost ratio average	Required economic value of high security entitlements ($/ML)
Stochastic	1.1	$310
NARCliM	1.0	$280

The results suggest that under the stochastic dataset, the marginal value of water use by permanent agricultural users (i.e. users of high security entitlements) only needs to be less than half of the value adopted in the central case. ($800/ML). This suggests significant variation could occur in the economic values in the detailed analysis, and the option would still be viable. It is *more* viable than the option to convert all general security to high security. The NARCliM dataset suggests that the breakeven price is even lower, at $280/ML, which again indicates a more attractive option.

Conclusions

The information presented in this technical document has helped provide a strategic analysis of options that could merit further investigation through the Gwydir Regional Water Strategy.

The conclusions from this report should be read in conjunction with the following accompanying technical documents:

- Economic Base Case: Gwydir region
- Hydrologic analysis of options for the Gwydir Regional Water Strategy
- Detailed ecological analysis: Gwydir