Department of Planning and Environment

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Economic Base Case

South Coast

June 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 Yuin people as having an intrinsic connection with the lands and waters of the South Coast Regional Water Strategy area. The landscape and its waters provide the Yuin people 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.

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Contents

Executive Summary

This report details the economic base case that was used for the hydrological and economic modelling undertaken to support the assessment of the long list of options in the Draft South Coast Regional Water Strategy.

The first step in any economic analysis is to understand what the future could look like and the consequences if we do nothing. This is known as the base case.

For the purpose of the regional water strategies, we have looked at four different plausible futures. These futures include:

- historical data — the future based on what would happen if our future climate is similar to the last 130 years of observed data
- long-term climate projections (stochastic data) based on historic data — applied stochastic modelling to our 130-year picture of past climate (step 1) to develop 13,000 years of possible climate sequences. This approach provides more information on climate variability and shows the region could experience more severe drought and wet periods. Two climate change scenarios were developed based on work carried out through NSW Australian and Regional Climate Model (NARCliM), the Electricity Sector Climate Information project and research undertaken by the University of Newcastle. The scenarios were applied to the 13,000-year dataset, including:
    - a NARCliM-informed future climate scenario (based on a dry scenario for 2060 to 2079), which assumes there is a dry, worst-case climate change scenario in the future.
    - one less east coast low event per year. A potential reduction in east coast lows as well as intensity of rainfall associated with east coast lows is associated with concerns for water security.

Historically we have only ever assessed water infrastructure and policy changes against the historic data, but the long-term historic climate projection, the dry climate change scenario and the east coast low scenario give us a much better understanding of the water risks that could be faced by the region.

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

- towns (as water shortfall) — Brogo–Bermagui (regulated), Bega–Tathra, Bemboka and Tantawanglo–Kiah in the Bega catchment and Eurobodalla in the Tuross catchment.
- Irrigators of perennial pasture — assumed to be approximated by lucerne in the region.

Stock and domestic water users have also been included in the economic analysis, despite not being a significant water user in the region.

The first step in the base case is to understand how water availability changes for these water users – also known as hydrological modelling. The hydrologic results indicate that towns and agricultural producers are on average likely to experience a decrease in water supply reliability under the dry climate change scenario. A summary of the average water shortfall or usage impact on each aggregated water user can be seen in Table 1 below.

Table 1. Average yearly water provided to different water user groups

Water user group	Long-term historical climate projections (stochastic)	Climate change projections (NARCliM)	East coast low projections
Towns (shortfall ML/year)	35.7	99.0	79.9
Perennial pasture (supplied GL/year)	12.6	13.1	12.2

The second step is undertaking 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* (MJA, 2020). The evaluation period for each analysis was 40 years with a discount rate of 7%. Economic valuations per megalitre of water for each water user group were:

- towns — escalating cost dependent on (a) the size of the town, and (b) the length of the shortfall. Note this value is applied on volume of water not supplied (i.e. shortfall).
- perennial pasture (valued as lucerne at $150/ML)
- stock and domestic ($8000/ML within a shortfall).

The economic impacts on average are higher under the climate change scenario than under the stochastic scenario, reflecting the lower availability of water between the two estimates. The economic impacts are not as significant in the South Coast as they are in other regions. Average economic outcomes per water user group can be seen in Table 2 below.

Table 2. Average total (40 years) economic outcomes per water user group

Water user group	Long-term historical climate projections (stochastic)	Climate change projections (NARCliM)	East coast low projections
Towns ($, million)	-1.4	-6.5	-5.6
Perennial pasture ($, million)	309.6	302.6	306.1

Introduction

Economic base case

This report details the economic base case that was used for the hydrological and economic modelling undertaken to support the assessment of the long list options in the Draft South Coast Regional Water Strategy. This report has been prepared to document the process used and support decision-making on which options impacting the supply, demand or allocation of water should be progressed in the *Draft Regional Water Strategy- South Coast: Shortlisted Actions – Consultation Paper*[1], released in May 2022.

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

- 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 over the next four decades we do nothing to change our current approach to water management. 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 the current infrastructure and water policy settings are maintained but does include projected changes to population. User group water demands are generally set as fixed, with some exceptions for town population growth — where it is predicted to occur. This allows all potential options to be compared consistently and any benefits, costs or other impacts from an option can be assessed against its impact to the economic base case. The economic base case will be used as the central scenario that hydrologically modelled portfolios will be assessed against in cost benefit analysis.

The regional water value function places a value on the amount of water forecast to be available

The regional water value function[2] is used to value the amount of water that is forecast to be available. The forecasts are developed through hydrologic modelling. A key feature of the values estimated is that they:

- **focus on key water user groups** — not every water user in a region is analysed, as the hydrological 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's water models over decades.

The values produced in the regional water value function are for key water users, which in the South Coast region include:

- town water supply
- irrigators of perennial pasture — assumed to be lucerne given it is the primary use of water in the region

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[1] www.dpie.nsw.gov.au/water/plans-and-programs/regional-water-strategies/upcoming-public-exhibition/south-coast-regional-water-strategy

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

- stock and domestic water users.

The regional water value function values reflect how water is utilised in practice by the key water user groups. For example, irrigators of annual crops or perennial pastures scale their operations each year depending on water availability.

We recognise that this approach will not necessarily capture every detail, or every individual water user in the region. This level of detail is more appropriate to be considered in a detailed 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 future climate risks. The climate data has been scaled down to the regional level and used for the regional water strategy reliability assessments for towns and communities in the South Coast region. The new climate datasets included stochastic climate data without and with climate projection.

This data and modelling included three steps:

1. stochastic climate data without climate projection was generated using observed climate data of 130 years recorded at meteorological stations located within the region.

Stochastic climate data with climate projection were generated using two approaches.

2. stochastic data generated by applying scaling factors based on NARCliM projection to the stochastic data generated in step 1.
3. two sets of stochastic data generation using 130 years of observed data with east coast low frequency adjustments (increased and decreased frequencies of east coast low/yr) (based on east coast low frequency change projection)

The streamflow — recorded at gauging stations across the catchment — is calibrated with historical streamflow data using the SOURCE streamflow modelling platform. The calibrated hydrologic model is then used to generate four series of streamflow sequences:

- **stochastic** — incorporating stochastically-generated long-term climate variability data
- **NARCliM** — adding climate change scenario impacts
- **east coast low model** — removing one east coast low event per year.

These models are used to illustrate expected amounts of water available in the future. The hydrologic modelling creates three groups of 1,000 replicates of 40 year-duration daily climate inputs sampled with a moving window of 10 years, to create a broad range of feasible possibilities for the next four decades.[3]

Translating hydrologic modelling to user group outcomes

The hydrologic modelling estimates town surface water availability over the 40 years. Town water availability was estimated by simulating extraction volumes and restrictions curves associated with the levels of storage in the major dam — Brogo Dam. The various assumptions of these restrictions

[3] See *New climate analysis informs NSW's regional water strategies* (DPIE, 2020)

are detailed in section 0. Where towns do not have local storages, the water availability highly depends on natural river flows. The extraction then, is estimated by demand and cease to pump rules from those water sources.

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

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.[4]

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

The economic base case does not capture every user of water in a region given the regional water strategies are a region wide, strategic study. It also does not include quantitative analysis of groundwater. Rather, it provides an indication of surface water risks. Future business cases and studies will need to do further analysis on how far groundwater or other alternative water sources can go to fill the gaps shortfalls identified in this analysis. It represents a robust estimate of future surface water availability and the economic value of that availability.

[4] *Regional Water Value Functions* (MJA, 2020)

Key details about the South Coast

The South Coast region (Figure 1) covers around 11,950 km^2, stretching from the Victorian border to the Clyde River catchment and Jervis Bay area. The area is located within the traditional lands of the Yuin Nation.

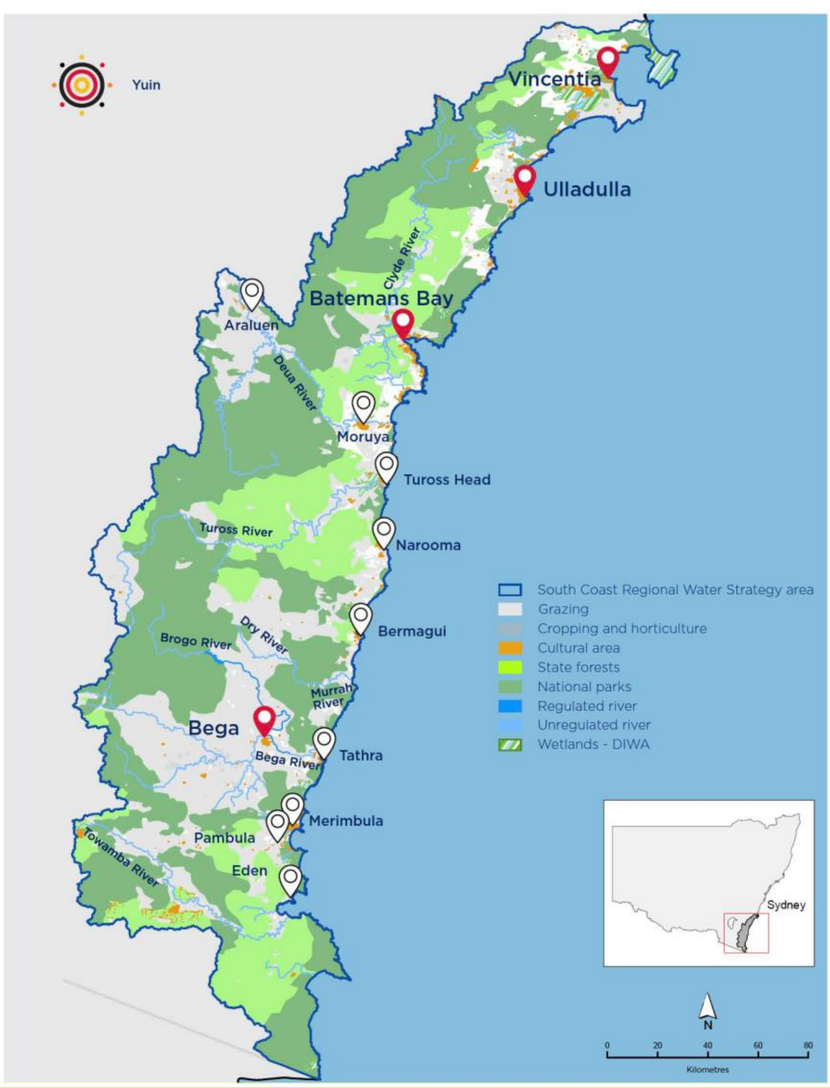

Figure 1. Map of the South Coast region

The South Coast region includes the 6 major catchments of the Clyde, Deua (Moruya), Tuross, Murrah, Bega and Towamba rivers and 48 smaller coastal-draining catchments.

The region encompasses the local government areas of Eurobodalla Shire Council and Bega Valley Shire Council and the southern part of Shoalhaven City Council. The village of Araluen and its surrounding area — within Queanbeyan-Palerang Regional Council's boundary — is also covered by this regional strategy. The region stretches across the South-East Tablelands and Illawarra-Shoalhaven planning regions.

Extractive users of water

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

- town water supply
- agricultural users, considered as producers of perennial pasture
- stock and domestic water users.

The approach taken in each case is to quantify the economic benefit or cost of water supplied or not supplied in $/ML for each user.[5]

Towns and communities

The economic base case for towns and communities are developed according to the systems where they draw their surface water supply. In the South Coast region, town water supply is drawn from unregulated systems and one relatively small regulated system (Bega–Brogo), however there are several locally operated storages. There are several simplifications in the hydrologic modelling of town water supply in the South Coast that are detailed in the South Coast Hydrology Report. These simplifications may result in overestimating town water shortages. Towns water supply systems represented within the hydrologic models are:

- Bega catchment —
    - Brogo–Bermagui (predominately supplied from the regulated Bega–Brogo system)
    - Bega–Tathra
    - Bemboka
    - Tantawanglo–Kiah
- Tuross catchment —
    - Eurobodalla.

The Eurobodalla system is only partially represented within the hydrologic modelling.

The economic base case assigns different values for the replacement costs of 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 local water utilities can manage brief periods of shortfalls through water carting. The management response to longer shortfall periods is assumed to require a more permanent, expensive solution. For larger towns, carting may not be a feasible option. Details of towns considered within this document and their associated shortfall costs can be seen in Table 3 below.

The concept of town shortfall in the context of the regional water strategy differs from that referenced in the water security/secure yield analysis completed as part of the integrated water cycle management plan for each town. Shortfalls for towns within the regional water strategy considers the availability of licensed extracted surface water only. Due to the different

[5] 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).

considerations between the two metrics, town shortfalls considered within this document should not be viewed as a replacement for a water security/secure yield analysis. It provides insights into surface water availability risks for towns and may be considered in future revisions of the integrated water cycle management plans.[6]

Table 3. South Coast township water supply shortage economic costs

Time in water shortage	Brogo-Bermagui	Bega–Tathra	Bemboka	Tantawanglo -Kiah	Eurobodalla
Population*	3,166	6,629	12,652	12,652	35,741
System type	Regulated	Unregulated	Unregulated	Unregulated	Unregulated
0 - 6 months (restrictions)	$1,500/ML	$1,500/ML	$1,500/ML	$1,500/ML	$1,500/ML
6 to 12 months (restrictions)	$3,500/ML	$3,500/ML	$3,500/ML	$3,500/ML	$3,500/ML
Greater than 12 months	$16,000/ML (Alternative Water Source)	$16,000/ML (Alternative Water Source)	$16,000/ML (Alternative Water Source)	$16,000/ML (Alternative Water Source)	$16,000/ML (Alternative Water Source)
Continued shortages (greater than 24 months)	$16,000/ML (Alternative Water Source)	$16,000/ML (Alternative Water Source)	$10,000/ML (Carting)	$16,000/ML (Alternative Water Source)	$16,000/ML (Alternative Water Source)

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

The population forecasts are based on the NSW Government's common planning assumption population projections.

Within the South Coast, water supply restrictions are based on cease-to-pump rules or local independent water supply sources where they exist.

[6] For more details on how the IWCM and RWS relate refer to *Water security analysis and water availability modelling – FAQs for local water utilities* (NSW DPIE, 2020)

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 perennial pasture is assumed not to change with a shortfall in supply. Table 4 highlights the most significant agricultural uses in the South Coast region, water licenses and its economic value.

Table 4. South Coast agricultural water supply economic benefit[7]

	Agricultural activity	Water licence
Lucerne*	Perennial pasture	General security, Supplementary, Uncontrolled flow, Unregulated

* Lucerne harvested as hay is assumed as a proxy to perennial pasture. We note that water is typically underutilised in this catchment, so water availability is usually not a limiting factor for herd size.

The adopted economic value for perennial pasture in the South Coast region is approximated by lucerne ($150/ML for water supplied).

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

Hydrologic and economic base case outcomes

The estimated hydrologic and economic outcomes from the economic base case hydrologic modelling are given for the key extractive users in the South Coast region for both the observed historical, long-term data (stochastic), climate change (NARCliM), and east coast low model predictions in the following section.

All economic calculations use a discount rate of 7% as recommended by the NSW Treasury.[8]

Town and community hydrologic base case outcomes

The hydrologic modelling indicates towns within the region are likely to experience low levels of surface water supply shortfalls, with a moderate increase in magnitude predicted during NARCliM and east coast low scenarios. The average length and magnitude of the expected annual shortfalls for each town of the 1000 realisations for the stochastic, NARCliM, and east coast low climates are given in Table 5 to Table 7. Table 8 and Table 9 provide a summary of the difference between the stochastic results and the NARCliM and east coast low results.

Average water supply shortfalls as a percentage of unrestricted demand is typically less than 1% under the stochastic climatic conditions. The only exception is Eurobodalla which experiences a higher shortfall of 3.7% as a fraction of unrestricted demand. All towns, with the exception of Bemboka, see an increase in shortfalls (typically between 1–2%) under NARCliM and east coast low conditions.

The amount of time that towns are expected to spend within a period of surface water supply shortfalls varies depending on the town. Bega–Tathra and Tantawanglo–Kiah may experience more reoccurring water supply shortfalls than other towns, registering approximately 8% and 7% under the stochastic climate conditions and extending to more significant lengths of approximately 15% and 19% once climate change is introduced in the NARCliM dataset. The east coast low prediction lies between these two results with shortfalls for these two towns expected to occur approximately 12% and 13% of the time.

The east coast low results typically show worsening water security outcomes for towns within the region than the stochastic results. When the east coast low results are compared to the NARCliM results it can be seen that the shortfall as a share of the towns demand is similar however, towns are not expected to experience shortfall conditions as frequently within the east coast low climate as in the NARCliM.

Table 5. Town water supply hydrologic 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
Brogo–Bermagui	2.9	330.2	0.9	0.2	1.4

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

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
Bega–Tathra	9.3	948.7	1.0	1.0	8.3
Bemboka	0.0	33.5	0.0	0.0	0.0
Tantawangalo-Kiah	14.5	1860.4	0.8	0.9	7.1
Eurobodalla	8.9	245.6	3.6	0.3	2.6

Table 6. Town water supply hydrologic 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
Brogo-Bermagui	7.3	334.5	2.2	0.4	3.3
Bega–Tathra	24.9	969.0	2.6	1.8	14.7
Bemboka	0.0	33.5	0.0	0.0	0.0
Tantawangalo-Kiah	52.2	1906.3	2.7	2.2	18.6
Eurobodalla	14.6	247.9	5.9	0.5	4.1

Table 7. Town water supply hydrologic outcomes — east coast low 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
Brogo-Bermagui	7.9	330.3	2.4	0.4	3.5
Bega–Tathra	21.2	949.7	2.2	1.4	11.7
Bemboka	0.0	33.5	0.0	0.0	0.0
Tantawangalo-Kiah	36.9	1862.4	2.0	1.6	13.4
Eurobodalla	13.8	245.7	5.6	0.5	4.1

The difference between the average annual demand in the stochastic/east coast low and NARCliM models is due the differing levels of evaporation forecast within the models, with NARCliM having the highest evaporation. The estimate for how demand for towns increases under NARCliM is due to towns experiencing higher evaporation when watering gardens and using water generally, and has been calculated in accordance with the Allen, Pereira, Raes, and Smith (1998) estimates.[9]

Table 8. Town water supply hydrologic 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
Brogo-Bermagui	4.4	4.4	1.3	0.2	2.0
Bega–Tathra	15.5	20.3	1.6	0.8	6.5
Bemboka	0.0	0.0	0.0	0.0	0.0
Tantawanglo–Kiah	37.6	45.9	2.0	1.4	11.5
Eurobodalla	5.7	2.4	2.3	0.2	1.4

Table 9. Town water supply hydrologic outcomes–difference (east coast low — 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
Brogo-Bermagui	5.0	0.2	1.5	0.3	2.1
Bega–Tathra	11.9	1.0	1.3	0.4	3.4
Bemboka	0.0	0.0	0.0	0.0	0.0
Tantawanglo–Kiah	22.4	2.0	1.2	0.7	6.2
Eurobodalla	4.9	0.1	2.0	0.2	1.5

Error! Reference source not found. Figure 2. Town supply cumulative 40-year shortfall series (ML)

Figure 2 illustrates six key town water supply shortfalls scenarios of the 1000 realisations[10] for individual towns, and the combination of all towns, in the stochastic (in yellow), NARCliM (in blue), and east coast low (green) models. It gives these scenarios as cumulative totals over the 40-year simulation period. The key scenarios are:

[9] Allen, R.G., Pereira, L.S., Raes, D., and Smith, M., Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56, 1998, accessible here: www.fao.org/3/x0490e/x0490e00.htm

[10] Realisation refers to a single 40-year hydrologic simulation. There are 1,000 realisations for each of the stochastic and NARCliM datasets. The realisations are drawn from 40-year rolling windows out of the 10,000-year generated climatic datasets, with an approximate 9-year overlap between windows.

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

These scenarios illustrate the spread of what could happen over all of the 40-year periods simulated for the region and how towns might experience the predicted economic outcomes of the climate models over time as they occur. 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.

The graphs indicate that all towns, with the exception of Bemboka which shows a fully secure water supply (no shortfalls), are expected to experience worsening conditions under the NARCliM and east coast low scenarios than the stochastic, however the magnitude of the impact varies from town to town. For instance, the cumulative shortfall in the worst-case scenario for Eurobodalla in the stochastic climate set is approximately 1,500 ML and this increases to marginally above 2,000 ML in the worst-case NARCliM scenario, amounting to a near 33% increase. The worst-case east coast low result for Eurobodalla is between these two at approximately 1,900 ML cumulative shortfall. Comparing this result with the worst-case town water supply shortfalls for Tantawanglo–Kiah shows a jump from nearly 5,000 ML in the stochastic scenario to roughly 11,000 ML in the east coast low and well above this number in the NARCLiM, well over a 100% increase in both cases. This would indicate that Tantawanglo–Kiah is more at risk from east coast low conditions and severe climate change in comparison to Eurobodalla.

The worst-case outcome for individual towns out of all climate scenarios considered alternates between the east coast low and NARCliM predictions, however both are typically much higher than the stochastic result. The worst-case result for the region as a whole occurs under the NARCliM climate change scenario.

All towns show very low median shortfalls in the stochastic results, meaning that nearly half of all these runs record zero, or very close to zero, shortfalls. In most cases the NARCliM and east coast low median outcome gives a similar result with generally only short periods of shortfalls occurring and longer periods of continuous supply. Using Brogo–Bermagui as an example to illustrate this point, the first nearly 15 years of the NARCliM median run records no shortfalls. Following a shortfall event at approximately year 15 and a smaller dry event roughly 4 years later at year 19, there is another extended period of high water security of nearly 20 years. This behaviour of discrete dry events causing significant shortfalls rather than smaller reoccurring events is evident for at least half of the events examined and is replicated across most other towns considered within the study. The exception to this may be Eurobodalla which shows some shortfall occurring roughly every 5–10 years.

It should be noted that in the worst-case outcomes, shortfall periods can be extensive and may last several years.

Town and community economic base case outcomes

The estimated average economic impact of water supply shortfalls for towns within the South Coast over a 40-year period are provided in Table 10 below. All towns, with the exception of Bemboka, are predicted to experience economic costs due to water restrictions and the requirement to source alternative water supplies under both scenarios. Under the NARCliM and east coast low scenarios the economic costs are typically multiples higher than that of the stochastic model results. Tantawanglo–Kiah sees the largest increase from stochastic to NARCliM and east coast low scenarios moving from an average of $600 thousand to $4.1 million (NARCliM) and 3.1 million (east coast low), a nearly 550% increase and 400% increase respectively.

The increase in economic cost to towns are on average similar between the NARCliM and east coast low scenarios. The magnitude of average difference in economic cost is within $100 thousand except for Tantawanglo–Kiah which shows a $1 million higher average difference under NARCliM than east coast low.

Table 10. Economic base case outcomes key user group: town water supply average 40-year shortfall net present costs ($, Mil)

Town	Stochastic	NARCliM	East coast low	Difference (NARCliM – stochastic)	Difference (%) (NARCliM – stochastic)	Difference (east coast low – stochastic)	Difference (%) (east coast low – stochastic)
Eurobodalla	-0.2	-0.3	-0.3	-0.1	64.8	-0.1	55.6
Brogo-Bermagui	-0.1	-0.2	-0.2	-0.1	169.3	-0.2	223.1
Bega–Tathra	-0.5	-1.9	-2.0	-1.4	305.8	-1.5	322.8
Bemboka	0.0	0.0	0.0	0.0	NA	0.0	NA
Tantawanglo–Kiah	-0.6	-4.1	-3.1	-3.5	547.8	-2.5	388.4
Total	-1.4	-6.5	-5.6	-5.2	379.2	-4.2	311.9

The distributions of the expected economic outcomes for each model, stochastic in orange, NARCliM in blue, and east coast low in green, can be seen in a histogram in Figure 3. The histogram condenses town shortfall economic costs for all 1000 realisations by grouping results into ranges of values — in this case 20 ranges per data series. The figure illustrates that both the magnitude and uncertainty (ie the spread) of the average cost of town shortfalls is greater in the NARCliM forecasts than the in east coast low or stochastic climate. The spread of economic costs to towns is also greater under the east coast low scenario than the stochastic.

The graph indicates that most of the economic costs related to water supply shortfalls for the stochastic dataset were less than $1 million, with the NARCliM and east coast low majority being less than $5 million. The results for the NARCliM outcomes are typically higher than those of the stochastic outcomes.

The worst economic outcome for towns is shown to occur under the east coast low climate scenario and amounts to approximately $93 million. In contrast, the worst case NARCliM scenario is approximately $88 million.

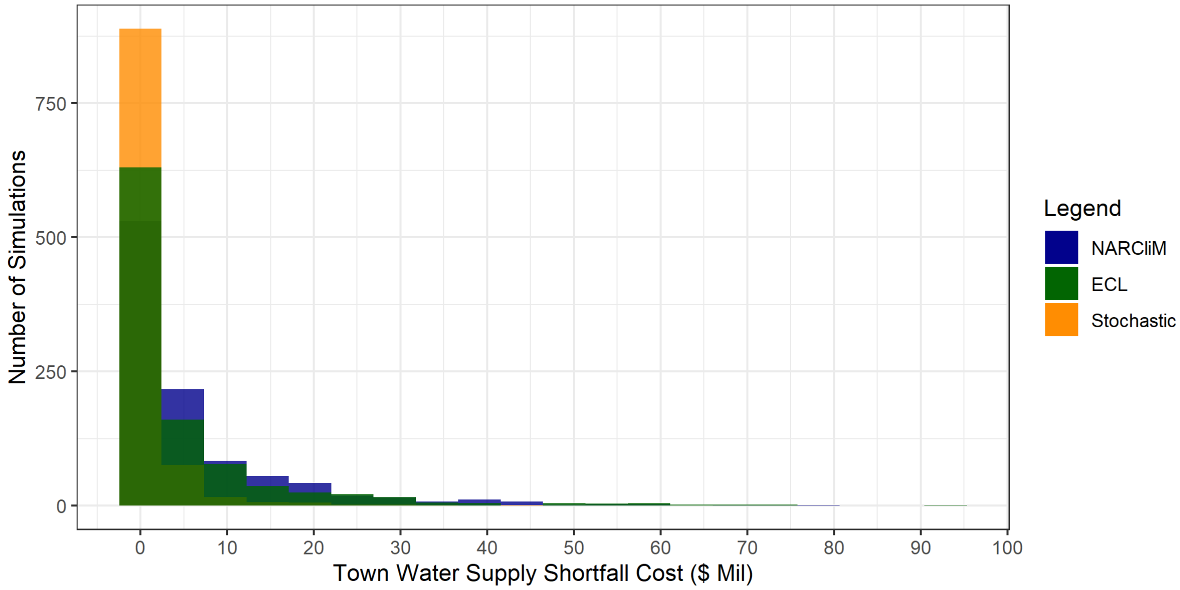

Figure 3. Total average towns water supply net present costs

Error! Reference source not found.to Table 13 provide additional information on the length of shortfalls and the percentage of time that each town spends under each restriction regime. It indicates that the average length, and therefore the average economic cost per megalitre, of shortfalls increase from the stochastic simulations to the NARCliM and east coast low simulations. Typically, the length of time that towns continuously have no access to surface water increases as the droughts lengthen slightly in the climate change scenario.

Take Tantawanglo–Kiah as an example, it can be seen that it experiences a decrease in shortfall durations lasting 0-6 months (incurring an economic cost of $1,500/ML) of 12% from stochastic to NARCliM climate model and 8% when moving to the east coast low model. This reduction is offset by the equivalent increase in longer droughts, those lasting 6-12months (costing $$3,500 /ML) by 5% (NARCliM) and 4% (east coast low) and even longer droughts by 6% (NARCliM) and 4% (east coast low). This shows that Tantawanglo–Kiah is slightly likely to experience longer and more expensive droughts under NARCliM climatic conditions.

The time spent in various stages of shortfalls on average are similar between the NARCliM and east coast low models.

Bemboka recorded no shortfalls in any of the stochastic or NARCliM runs and is therefore not included in the tables below.

Table 11. Economic base case outcomes key user group: town water supply average share of restriction level — stochastic model

Town	Shortfall duration (economic cost $/ML)			
	0 - 6 months ($1,500/ML)	6 - 12 months ($3,500/ML)	> 12 months ($16,000/ML)	> 24 months ($10,000/ML)
Eurobodalla	100%	0%	0%	0%
Brogo-Bermagui	94%	6%	0%	0%
Bega–Tathra	95%	4%	1%	0%
Bemboka	-	-	-	-
Tantawanglo–Kiah	93%	6%	1%	0%

Table 12. Economic base case outcomes key user group: town water supply average share of restriction level — NARCliM model

Town	Shortfall duration (economic cost $/ML)			
	0 - 6 months ($1,500/ML)	6 - 12 months ($3,500/ML)	> 12 months ($16,000/ML)	> 24 months ($10,000/ML)
Eurobodalla	100%	0%	0%	0%
Brogo-Bermagui	92%	7%	1%	0%
Bega–Tathra	88%	7%	5%	0%
Bemboka	-	-	-	-
Tantawanglo–Kiah	81%	11%	8%	0%

Table 13. Economic base case outcomes key user group: town water supply average share of restriction level — east coast low model

Town	Shortfall duration (economic cost $/ML)			
	0 - 6 months ($1,500/ML)	6 - 12 months ($3,500/ML)	> 12 months ($16,000/ML)	> 24 months ($10,000/ML)
Eurobodalla	100%	0%	0%	0%
Brogo-Bermagui	89%	9%	2%	0%
Bega–Tathra	88%	7%	5%	0%

Town	Shortfall duration (economic cost $/ML)			
Bemboka	-	-	-	-
Tantawanglo–Kiah	85%	10%	5%	0%

Table 14. Economic base case outcomes key user group: town water supply average share of restriction level — difference (NARCliM – stochastic)

Town	Shortfall duration			
Ashford	0%	0%	0%	0%
Boggabilla	-2%	1%	1%	0%
Mungindi	-6%	3%	4%	0%
Glen Innes	-	-	-	-
Tenterfield	-12%	5%	6%	0%

Table 15. Economic base case outcomes key user group: town water supply average share of restriction level — difference (east coast low–stochastic)

Town	Shortfall duration			
Ashford	0%	0%	0%	0%
Boggabilla	-5%	4%	1%	0%
Mungindi	-7%	3%	4%	0%
Glen Innes	-	-	-	-
Tenterfield	-8%	4%	4%	0%

Agricultural hydrologic base case outcomes

The following section describes the hydrologic impacts on the agricultural industry within the South Coast. Agriculture has been represented in the region by perennial pasture, which has been assumed to be represented by lucerne at $150/ML. Stock and domestic water users have also been considered in the economic analysis at a value of $8000/ML during water supply shortfalls.

The estimated annual average volume of water that these producers use under the stochastic, NARCliM (climate change), and east coast low scenarios, are given in Table 16.

The results show an increase in water use for perennial pasture from the river systems on average in the region in the drier NARCliM climate region when compared with stochastic. This is due to increased evaporation and evapotranspiration rates due to increasing temperatures within the region. For the same crop production more water is now required which leads to a greater reliance on the river systems.

The east coast low model shows a reduction in average annual usage of water being used for perennial pasture growth of approximately 3.3% when compared to the stochastic scenario. This is due to reductions in supplementary allocations and access to unregulated flow. The decreased storm events within the east coast low model are reducing the number of spill events and water available in a river reach, negatively impacting these usages.

Table 16. Average annual agricultural water usage volumes: stochastic and NARCliM

Water Usage	Usage Metric	Stochastic	NARCliM	East coast low	Difference (NARCliM – stochastic)	Difference (%) (NARCliM – stochastic)	Difference (east coast low-stochastic)	Difference (%) (east coast low-stochastic)
Perennial pasture (GL/Year)	Average	12.6	13.1	12.2	0.5	4.1	-0.4	-3.3
	Maximum	14.4	14.8	13.6	0.5	3.2	-0.7	-5.0
	Median	12.6	13.1	12.2	0.5	4.2	-0.4	-3.3
	Minimum	10.8	11.5	10.8	0.7	6.6	0.0	0.0
	Standard deviation	0.5	0.5	0.5	0.0	-6.2	0.0	-8.4

Histograms of the modelled perennial pasture water usage within the South Coast (orange for stochastic, blue for NARCliM, and green for east coast low) can be seen in Figure 4. The figure groups the results of the realisations into 20 categories to provide an overview of the outcomes for 1000 realisations of each model. Figure 4 indicates that the amount of water used on average for perennial pasture increases in the climate change scenario, as more water is required during the dryer climate conditions within the NARCliM model and there is reduced availability of water present within the east coast low model.

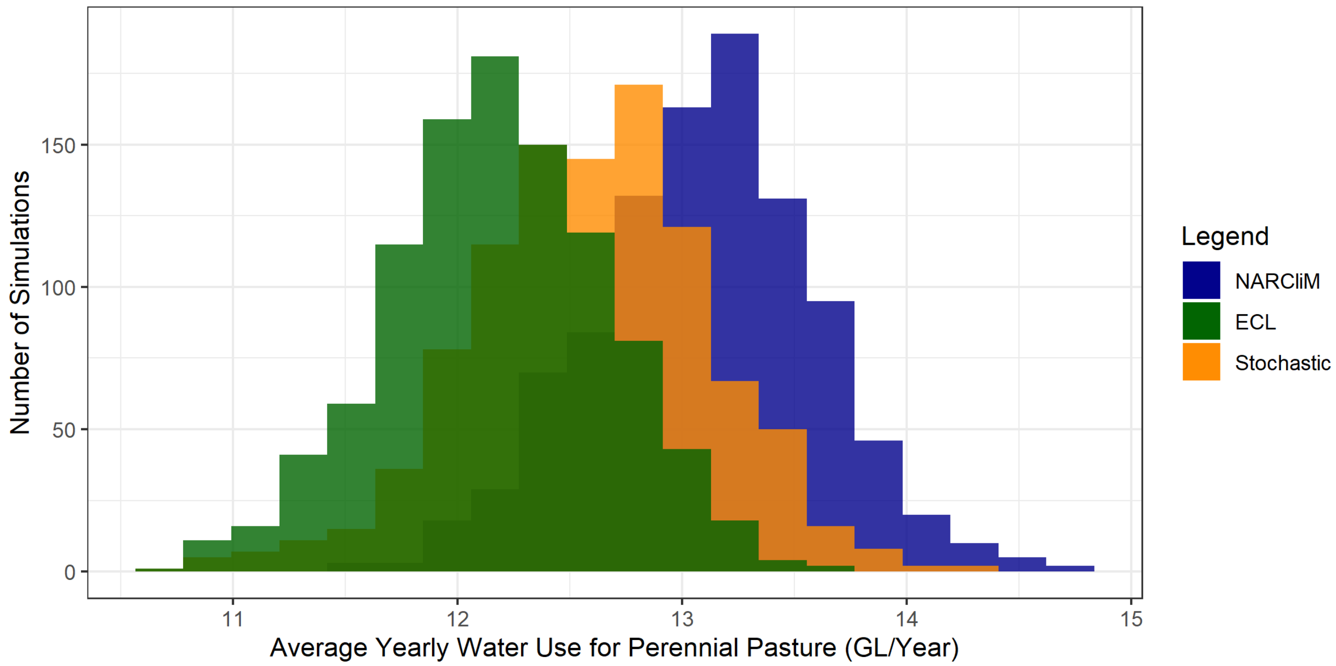

Figure 4. Stochastic, NARCliM, and east coast low perennial pasture (lucerne) water use

Three scenarios of expected cumulative water usage for producers of perennial pasture are presented in Figure 5 for the stochastic (orange), NARCliM (blue), and east coast low (green) hydrologic models. The scenarios are:

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

These results seem to indicate that there will be more water available under the climate change predictions than under the stochastic predictions. However, that is because the hydrologic model also forecasts rainfall on farms. What is occurring is that, under the NARCliM scenario, the modelling predicts less total water availability for the production of perennial pasture. The median cumulative expected water usage for perennial pasture in the climate change scenario is slightly above the minimum result for the stochastic climate conditions. This reflects the increased reliance on water from the river to maintain agricultural activity.

The ECL results of usage for perennial pasture are lower for each scenario of both the stochastic and NARCliM results indicating a reduction in water availability due to the reduction of large rainfall events.

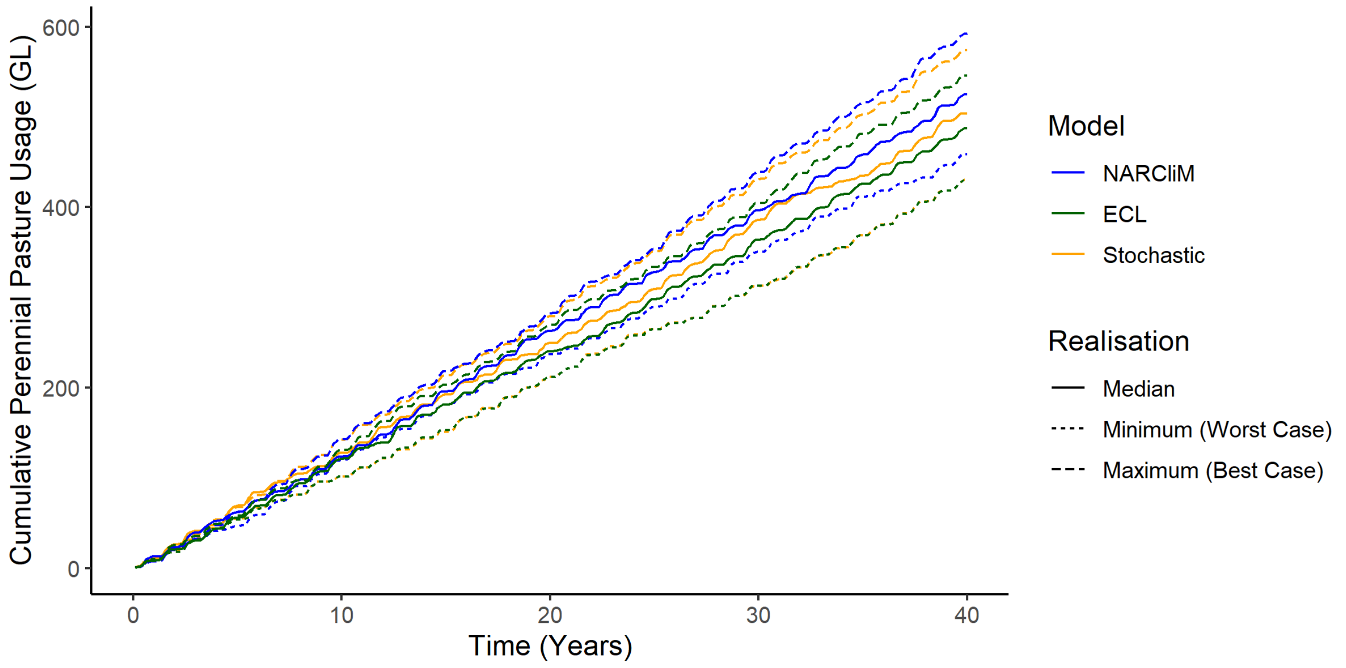

Figure 5. Stochastic, NARCliM, and east coast low cumulative perennial pasture (lucerne) agriculture water use

Agricultural economic base case outcomes

Under the NARCliM scenario, a reduction in the average economic value for perennial pasture (2%), and a decrease in stock and domestic water use. The increase in water use reflects the reduction of agricultural production due to increased evaporation and decreased water supply under a climate change scenario.

Despite water usage for perennial pasture being higher within the NARCliM scenario this usage is required partly due to decreased rainfalls and partly due to higher evaporation rates. A decrease in rainfall requires more water to be extracted from the river, which is accessed at a higher marginal cost per megalitre than a megalitre of water falling as rain. Additionally, a higher amount of evaporation will occur for each megalitre of water applied to the pasture area from any source, therefore the productivity of each megalitre of water is lower within the NARCliM scenario than under the stochastic or east coast low scenario, which share the same evaporation rates. Both impacts are accounted for in the economic modelling of the NARCliM climate, resulting in a lower economic output for agriculture.

The reductions in economic output seen within the east coast low model — 1% for perennial pasture and 73% for stock and domestic — are due solely to reduced access to water resulting from less rainfall events.

In all scenarios the impact to perennial pasture is relatively small as a shift in value moving from stochastic to either of the NARCliM or east coast low data climate sets. Perennial pasture dominates water usage within the region and the magnitude of change within the economic output of the perennial pasture ultimately determines the impact of all climate scenarios on regional agriculture.

Table 17. Economic base case outcomes key user group: agriculture net present producer surplus averages over 40 years ($, Mil)

Usage	Stochastic	NARCliM	East coast low	Difference (NARCliM – stochastic)	Difference (%) (NARCliM – stochastic)	Difference (east coast low – stochastic)	Difference (%) (east coast low – stochastic)
Perennial pasture	309.6	302.6	306.1	-7.0	-2.3	-3.5	-1.1
Stock and domestic	-0.01	-0.03	-0.01	-0.02	-248.3	-0.01	-73.4
Total	309.6	302.6	306.1	-7.0	-2.3	-3.5	-1.1

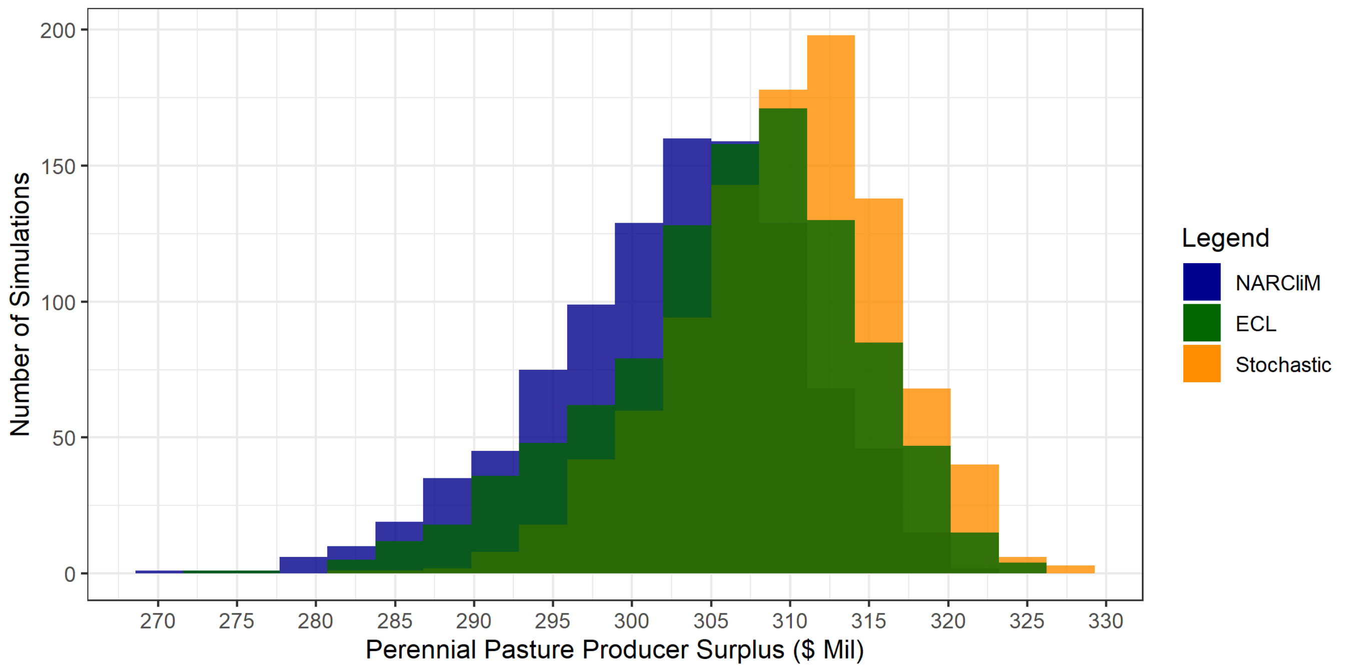

Figure 6. Perennial pasture (lucerne) net present producer surplus over 40 years

Assumptions and uncertainties

The assumptions, uncertainties, and qualifications surrounding the results presented within this document include:

- town shortfalls consider only modelled surface water availability and do not include any consideration of existing alternative supply sources such as groundwater
- it is assumed that the current use of water will be consistent over the 40 years examined. In practice it is likely technology and global demand for food and fibre will change the nature of the crops produced in the South Coast. Estimating these changes is beyond the scope of the regional water strategies program.

Uncertainties and qualifications relevant to this study include:

- town shortfall analysis presented is not a replacement for secure yield analysis undertaken as part of the councils' integrated water cycle management plans
- 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 program.