CLIMATE CHANGE & WATER: IRRIGATED AGRICULTURE ON THE FRONTLINE

2022

What's next

NEW SOUTH WALES IRRIGATORS' COUNCIL

Under legislation, water licence holders bear the risks of a reduction in water as a result of drought and climate change. This Report outlines the impacts of climate change on water licence holders in NSW, including both forecast and already observed impacts.

Climate Change & Water: Irrigated Agriculture on the frontline

WHAT'S NEXT

INTRODUCTION

Climate change is undoubtedly one of the greatest risks to water security in the 21st Century, and one of the most significant risks to water security for irrigated agriculture in NSW. An overall trend of reduced inflows is observable, and consequently, a trend of declining water licence reliability (i.e. a long-term trend of less water allocated to water licences).[1] This drying trend is interspersed with intense wet periods, dubbed 'wet' droughts as they can be as damaging to crops and production as 'dry' droughts.

The water management framework contains a hierarchy of water users, with the environment & critical human needs prioritised first, and lower-security water licences held by irrigators (and those bought back from irrigators for the environment) last in line for water, and only if there is water left over to be made available for farming[2]. The declining reliability of allocations means that low-security water licence holders such as **irrigators are the first and hardest hit by the impacts of climate change on water availability**.

The water management framework has automatic response mechanisms built in to change the amount of water allocated to water licences based on water availability. This enables water sharing to adjust automatically to climate variability and climate change. During drought, water allocations are reduced, even to zero for many licence types, often for consecutive years (as seen during the most recent drought).

This means that with climate change, and under current settings, irrigators (and other lower security licence holders) are receiving less and less water. **Under legislative frameworks**, water entitlement holders such as **irrigators carry the risks of reduced water from drought and climate change**.

This makes climate change an issue of utmost concern for the NSW irrigation farming sector. Climate change **mitigation, as well as adaptation**, is critical to protect water security for farming. For this reason, NSWIC supports an economy-wide target of **net zero emissions by 2050**, preferably earlier. NSWIC also adopts an aspirational target of **carbon neutrality for the NSW irrigation sector by 2030**, and calls for **government investment in carbon sequestration and other opportunities** for the irrigation sector **to be part of the solution**.

Irrigation provides more than 90% of Australia's fruit, nuts and grapes; more than 76% of vegetables; 100% of rice and more than 50% of dairy and sugar[3]. With the world population forecast to exceed 9 billion by 2050, the NSW irrigation sector has a critical role in responding to growing demand for food and fibre, contributing to every one of the **UN Sustainable Development Goals**, and in supporting Australia to meet its obligations on carbon emissions reduction. This means the trend of declining water for agriculture due to climate change and the need for action to mitigate this trend is of utmost importance to the industry.

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[1] Note: A number of policy drivers are also contributing to the decline in water licence reliability.
[2] With various licence categories prioritised accordingly.
[3] Data from 2018-19.

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WHY THIS REPORT

No one wants to have the conversation about climate change and water management more than irrigators do – because, under current policy settings, irrigators are hit first and hardest by the trend to drier, longer droughts interspersed with wetter wets.

Under law, water is allocated according to a strict hierarchy. First is critical human needs (drinking, bathing, sewage), then the environment so that rivers run, then livestock, and finally – if any water is left – irrigators.

Irrigators get the water left over, if any, after these higher priority needs have been met. In the recent 2018-2020 drought, as well as the Millennium drought, most inland irrigators were allocated no water at all to grow food and fibre.

So how do we know this hierarchy is what happens in practice? Well, the data speaks for itself. Irrigators in the NSW Murray were allocated, on average, 81% of their general-security licence volume before the turn of the century, but now their licence reliability is only around 57% even after two exceptionally wet seasons.

Similarly in the Namoi valley in the northern Murray-Darling Basin, reliability has declined from 77% to around 39%. These trends reflect the fact annual average inflows have almost halved across the Basin over the last 20 years. Climate change is well and truly already taking its toll.

The outlook is sobering. The Regional Water Strategy for the Lachlan valley forecasts that irrigators could experience a 60% decrease in their average water availability under long-term climate change projections.

So who bears the risk of climate change when it comes to water? Irrigators do. It's written into legislation. The Water Act 2007 specifically says "water access entitlement holders are to bear the risks of any reduction or less reliable water allocation… as a result of seasonal or long-term changes in climate; and periodic natural events such as bushfires and drought".

Irrigators accept this hierarchy, even though they are the last in line to be allocated water, and first to have the tap turned off when rivers start running low. It's why irrigators are very concerned about climate change, as they are on the frontline and already all too familiar with what it means.

With longer and more frequent droughts forecast, irrigators are also forecast to receive less and less water. This is because various mechanisms, which we can collectively call Automatic Climate Change Response Mechanisms (ACCRMs), are already built into water sharing plans. Primarily, the actual water allocated to irrigators is directly based on how much water is available, and forecast to be available into the future. This is why many irrigators had 0% allocations for years during the recent drought.

This does not mean there is nothing left to do when it comes to climate change and water. Climate change poses the greatest risk to water security for our nation, and the greatest risk to the many towns that rely on irrigated agriculture for jobs, income and services.

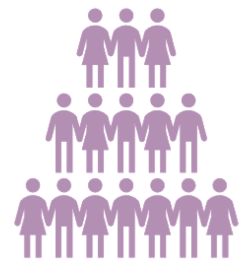
Our industry needs to be, and wants to be, part of the climate change conversation – for both mitigation and adaptation. Understanding how the system works is the first step towards better managing this precious resource. So let's talk about climate change and water. Irrigators sure want to.

OUR VISION

Be part of the climate solution

Net-zero emissions, economy-wide by 2050

Support our economy and communities



Feed and clothe the worlds growing population

Carbon neutrality of NSW irrigation farming by 2030

Contribute towards every UN Sustainable Development Goal

Remain at the forefront of resource-efficient, sustainable and ethical farming

Strengthen, adapt and enhance the resilience of our sector, to make it happen

What’s possible when we work together?

Our industry has plenty of success stories.

Climate positive cotton farming – meaning cotton production that actually reduces carbon emissions in the atmosphere. This means that the farm acts as a carbon sink, absorbing more carbon than it releases.

Water efficient farming -

“Australian cotton growers are now recognised as the most water-use efficient in the world and three times more efficient than the global average”[4]

“The Australian rice industry leads the world in water use efficiency. From paddock to plate, Australian grown rice uses 50% less water than the global average.”[5] The industry is aiming even higher, to double water productivity from 0.8t/ML to 1.5t/ML by 2026.[6]

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[4] https://www.awe.gov.au/agriculture-land/farm-food-drought/crops/cotton
[5] https://www.agriculture.gov.au/ag-farm-food/crops/rice
[6] AgriFutures Rice Program Strategic RD&E Plan (2021-2026).

EXECUTIVE SUMMARY

1. Climate change is already impacting water resources in NSW, with a step change in river inflows observable in the last two decades.

2. ABARES predicts climate change will reduce overall farm profits by 13% by 2050. Already, seasonal changes from 2001 to 2020 (relative to 1950 to 2000) have reduced annual average farm profits by 23%, or around $29,200 per farm, most significantly in south-western and south-eastern Australia.

3. The current water sharing framework has automatic adjustment mechanisms for climate variability and climate change, as water allocations are based on water availability, not licensed volumes. Water is allocated according to a hierarchy of priorities starting with critical human needs and the environment (to ensure rivers run). This water sharing framework means irrigators[7] are first to lose water with declining availability and are thus the first and hardest hit by climate change under current settings.

4. The impacts of this framework, under climate change, are already demonstrable with an observable trend in declining water availability for irrigators (and other licence holders). For example, irrigators in the NSW Murray were allocated, on average, 81% of their general security licence volume each year before the Millennium Drought but now their licence reliability is only around 57%. Similarly in the Namoi valley in the northern Murray-Darling Basin, reliability has declined from 77% to around 39%.

5. The NSW water sharing framework is best practice to maintain water security for higher priority users (such as critical human needs and the environment) with climate change. However, it paints a very concerning picture for lower priority users such as irrigators who face increased water insecurity.

6. Buying back more licences does not mean more water for critical human and environmental needs in droughts, as allocations in drought will likely be negligible or zero. But their purchase would mean less water for growing food and fibre in other times, with flow-on socioeconomic impacts on jobs, service industries and towns.

7. Even with a best-practice water sharing regime that prioritises higher priority users, water security for these users will still inevitably come under threat. This requires investment in additional measures outside of the water sharing framework as a matter of priority (such as secondary town water supply).

8. Government investment is required to explore opportunities for the irrigation sector to be part of the solution for climate change mitigation; and to support its transition to a carbon-neutral footprint.

9. The industry is concerned about the politicisation of the climate change conversation, which in itself presents a risk to our industry by stalling time-sensitive mitigation progress, and missing opportunities.

10. The irrigation industry already has great success stories in responding to climate change, including being world leaders in agricultural water efficiency.

[7] As well as other lower-reliability licence holders.

Part 1 Climatic trends & forecasts

CHAPTER 1) CLIMATIC TRENDS & FORECASTS

It is well known that Australia is characterised by climatic extremes of 'droughts and flooding rains', however, long-term trends show that Australia's weather and climate are changing in response to a warming global climate. This is not only forecast, but already observed.

Australia's climate has warmed on average by 1.44 ± 0.24 °C since national records began in 1910, leading to an increase in the frequency of extreme heat events. Most warming has occurred since 1950 (Australia's climate has warmed by more than 1°C since 1960), with every decade since then being warmer than the ones before.[8] Australia's warmest year on record was 2019, and the seven years from 2013 to 2019 all rank in the nine warmest years.[9]

This definite observable long-term warming trend has considerable and significant implications for irrigation farming in NSW, most profoundly on water availability.

Impacts of climate change on rainfall

Australian rainfall is highly variable, driven by El Niño, La Niña, the Indian Ocean Dipole and the Southern Annular Mode. Despite this natural variability, long-term trends show changes to Australia's rainfall record.[10]

Climate change is expected to lead to both more extreme droughts, and more extreme floods.

According to the BoM, in the State of Climate Report 2020[11]:

- *There has been a shift towards drier conditions across the southwest and southeast, with more frequent years of below average rainfall, especially for the cool season months of April to October. In 17 of the last 20 years, rainfall in southern Australia in these months has been below average.*
- *There has been a decline of around 16 per cent in April to October rainfall in the southwest of Australia since 1970. Across the same region May to July rainfall has seen the largest decrease, by around 20 per cent since 1970.*
- *In the southeast of Australia there has been a decline of around 12 per cent in April to October rainfall since the late 1990s.*
- *Rainfall has increased across most of northern Australia since the 1970s.*

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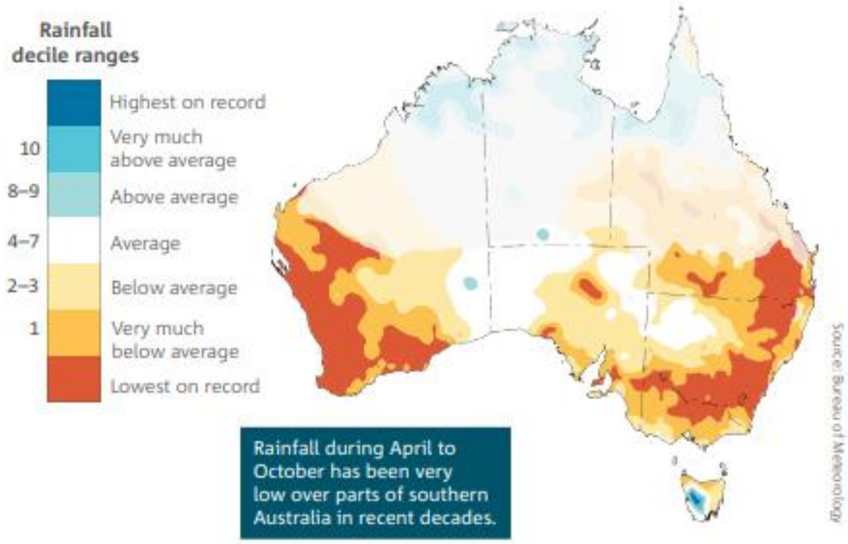
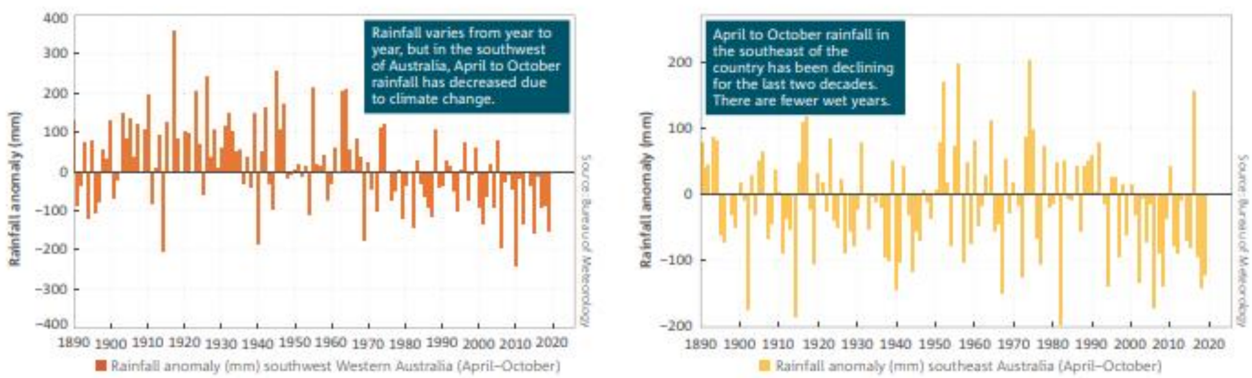
8 http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf [P4].
9 Ibid.
10 Rainfall analysis in southwest and southeast Australia dates back to around 1890 with greater data availability in these particular regions, allowing improved comparability of historic and contemporary droughts.
11 http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf



April to October rainfall deciles for the last 20 years (2000–19). A decile map shows where rainfall is above average, average or below average for the recent period, in comparison with the entire rainfall record from 1900. Areas across northern and central Australia that receive less than 40 per cent of their annual rainfall during April to October are faded.



Anomalies of April to October rainfall for southwestern (southwest of the line joining the points 30° S, 115° E and 35° S, 120° E) and southeastern (south of 33° S, east of 135° E inclusive) Australia, with respect to 1961 to 1990 averages.

In addition to this general warming, drying trend, records also show that heavy rainfall events are becoming more intense. The BoM forecasts that heavy rainfall events will continue to become more intense as the climate warms. Additionally, the BoM says "*multiple lines of evidence, including from observations and future climate change projections, point to a continuing trend of more frequent compound extreme events*"[12] beyond historical experience.

Climatic projections for the coming decades show continued decrease in cool season rainfall across many regions of southern and eastern Australia, likely leading to more time in drought interspersed with yet more intense,

[12] http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf

short duration heavy rainfall events.[13] The extent of impacts varies depending on the climate change scenario. For example,

- Under a global average temperature increases by 1°C, average annual rainfall in south-eastern Australia is expected to decline by between 0% to 9%, and average annual runoff is expected to decline by between 2% to 22% for the southern section of the SEACI region (south of 33° latitude). (Note that Australia's climate has already warmed by more than 1 °C since 1960.)
- Under a global average temperature increases by 2°C, reductions in rainfall and runoff are projected to be approximately double the above.[14]

The Intergovernmental Panel on Climate Change (IPCC) indicates that for Eastern Australia, agricultural and ecological droughts are projected to increase at 2°C global warming and greater (medium confidence).[15]

Impacts of climate change on inflows

The observed long-term reduction in rainfall across many parts of southern Australia has subsequently led to reduced inflows and streamflow in these catchments.

With climate change, average surface water availability across the entire Murray-Darling Basin for 2030 is projected to fall by 10%. The impact is expected to be greater in the southern Basin, and these predictions are also more reliable in the south.[16]

In the Murray–Darling Basin, evaporation rates are high with 94% of the rainfall that falls in the Basin being used by plants (transpired) or evaporating from the land and surface water.[17] This is due to the Basin's characteristics of low-lying topography, warm to hot semi-arid conditions in most regions, and the meandering and slow-flowing nature of the creeks and rivers. Around 86% of the Basin contributes almost no runoff to the river system, except in times of flood. This means that changing climatic trends will significantly impact flows.[18]

The BoM reports that in the Murray–Darling Basin and the NSW South East Coast drainage divisions, annual median streamflow has declined, with between half and three-quarters of gauges showing a declining streamflow trend since 1975. In particular, in the Murray–Darling Basin:

- More than three-quarters of the long-term streamflow gauges show a declining trend since records began in 1970.[19]
- The trend is most severe in the northern Basin with 94% of gauges showing a declining streamflow.
  - Statistically significant declining trends are observable in the headwaters, including the Namoi, Condamine–Culgoa and Gwydir River catchments.[20]

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[13] http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf
[14] https://www.mdba.gov.au/importance-murray-darling-basin/environment/climate-change; Projected changes across the northern half of the SEACI region are less certain, with some models projecting an increase, and some a decrease in rainfall and therefore runoff.
[15] https://www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_Australasia.pdf
[16] https://www.mdba.gov.au/importance-murray-darling-basin/environment/climate-change
[17] https://www.mdba.gov.au/importance-murray-darling-basin/environment/climate-change
[18] https://www.mdba.gov.au/importance-murray-darling-basin/environment/climate-change
[19] http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf
[20] http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf

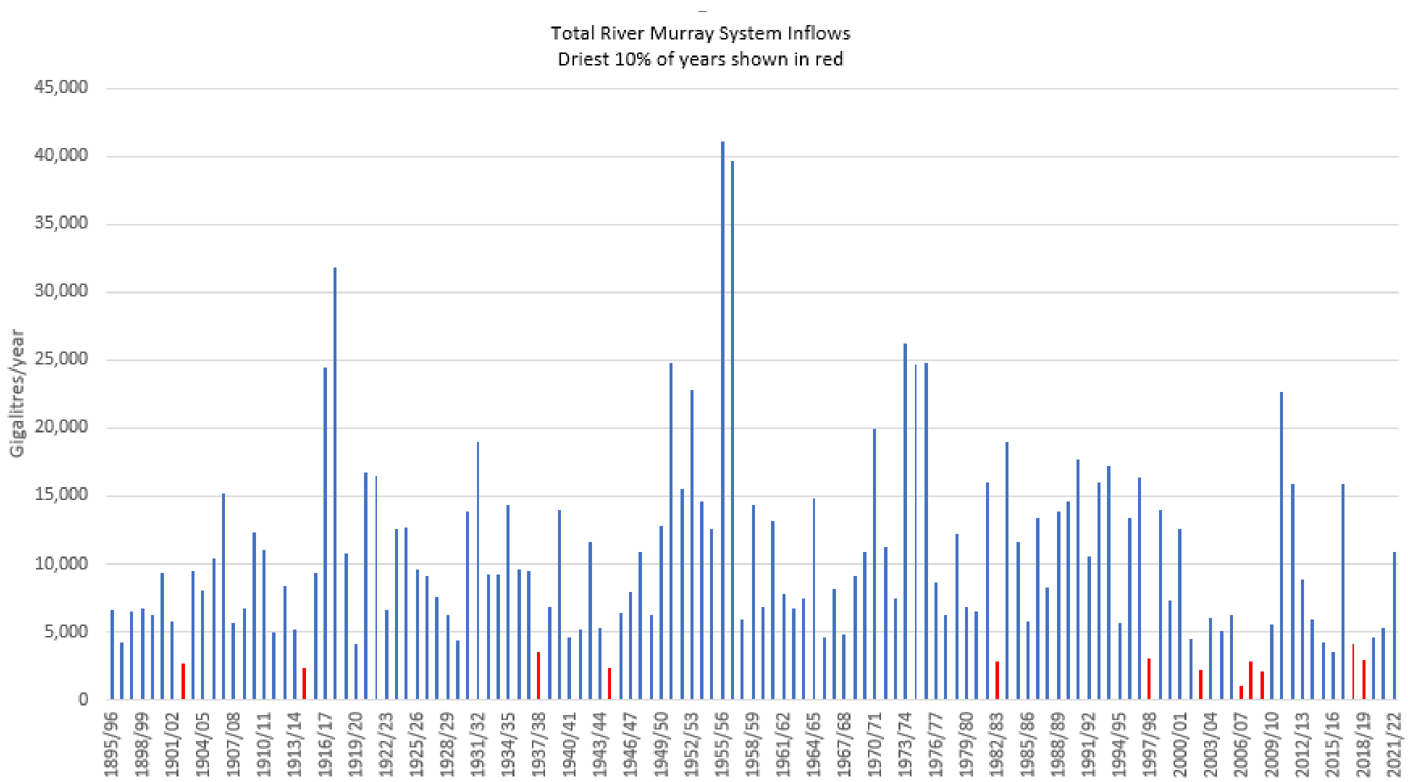
  - In the Darling River, declining trends were observed in all 19 streamflow gauges, of which half are statistically significant.[21]
- In the Murrumbidgee, Lachlan, Goulburn and Loddon River catchments of the southern Basin, more than three quarters of the streamflow gauges show a declining trend, of which one-third are statistically significant.[22]

Case Study 1: River Murray

The past two decades have seen a step change in water availability in the River Murray, with data showing median annual inflow is approximately half that of the preceding century. More than half of the driest 10% of years in the historical record have occurred in the past two decades.[23]

The Inspector-General of Water Compliance in 2020 stated that: "*While there may be many factors contributing to the extent of observed inflow reductions, the lack of rainfall and runoff has been the primary driver for the conditions being experienced by many across the Basin in recent times.*"[24]

Figure 1: Total River Murray system inflows, 1896 - 2022[25]



Changes to inflows from the various tributaries to the Murray is also of importance. Data shows that there has been a significant reduction across all tributary sources to the Murray. Whilst the greatest proportionate

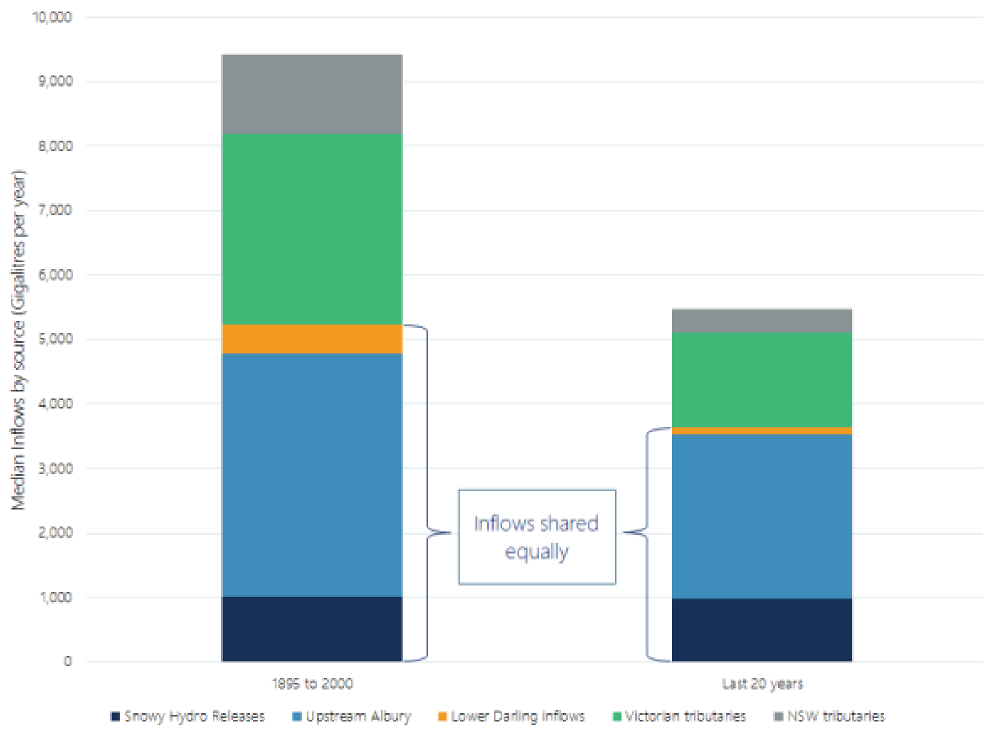
21 http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf
22 http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf
23 https://www.igwc.gov.au/sites/default/files/2020-09/iig_final_report.pdf [P7].
24 https://www.igwc.gov.au/sites/default/files/2020-09/iig_final_report.pdf [P8].
25 Murray Darling Basin Authority; driest 10% of years in red.

reductions are from the NSW tributaries and lower-Darling, the greatest volumetric change has been from sources that tend to contribute the greatest flows.

The Inspector-General in 2020 stated: *"More than two-thirds of the decline in median total system inflow volumes is attributable to changes in flows from the Murray upstream of Albury and the Victorian tributaries."*

Median inflows in these sources (i.e. upstream of Albury) have decreased by about one-third in the 20 years to 2020 compared with the preceding century, while half of the driest years on record have occurred in the past 25 years.[26]

Figure 2: Change in River Murray system inflows relative to pre-2000



Source: Interim Inspector-General of Murray–Darling Basin Water Resources, based on data provided by the MDBA.

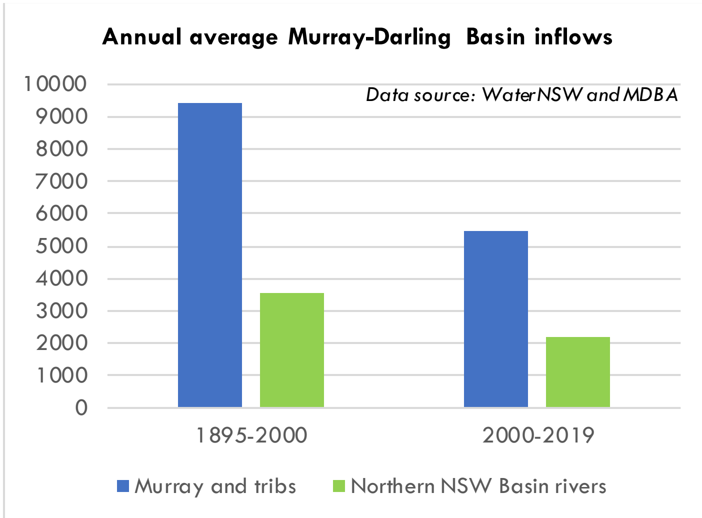
Case Study 2: Northern NSW rivers

The northern NSW Basin rivers have faced similar trends. The Inspector-General in 2020 found that: ""*Median inflows into the Menindee Lakes have reduced by about 80% in the last 20 years relative to the recorded period prior. Eight of the 13 driest years on record occurred in this period, most yielding zero or close to zero inflows. Although years of low inflows to the Menindee Lakes are common in the historical record, the dry years in the past two decades have been much more severe. The frequency of wetter years with flows that reliably fill the Menindee Lakes has also reduced, with longer durations between wet years*."

The below figure shows annual average Murray-Darling Basin inflows for both the Murray and tributaries, and the northern NSW Basin rivers.

[26] https://www.igwc.gov.au/sites/default/files/2020-09/iig_final_report.pdf [P 9].

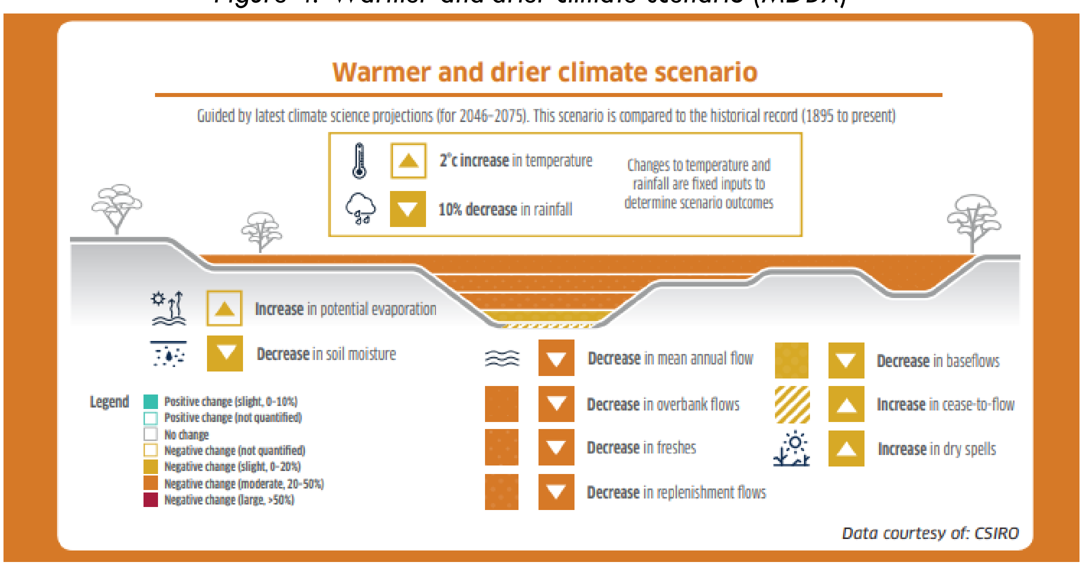
Figure 3: Annual average Murray-Darling Basin inflows



Future Projections

The CSIRO has developed climate scenarios for the Basin with a range of plausible climate futures. This shows that the latest climate projections (for 2046-2075) compared to the historical record (1895 – present), will lead to a (moderate) decrease in mean annual flow, overbank flows, freshes and replenishment flows; and a (slight) decrease in baseflows, cease-to-flows and dry spells.

Figure 4: Warmer and drier climate scenario (MDBA)[27]



[27] https://www.mdba.gov.au/sites/default/files/pubs/bp-eval-2020-snapshot-climate.pdf {P3].

Part 2 Climate change & variability built into water sharing arrangements

CHAPTER 2) HOW CLIMATE CHANGE IS ALREADY FACTORED INTO WATER MANAGEMENT

Climate change is automatically factored in under the current water management framework in NSW. This report will call these measures/systems **Automatic Climate Change Response Mechanisms** (ACCRMs). The most significant of these is **Available Water Determinations** (AWDs).

Water allocations

The volume of water that water entitlement holders can access is determined through an Available Water Determination (AWD), or commonly known as a water allocation. Given water availability is variable, water allocations vary each year, based on the rules set out in the relevant Water Sharing Plan (WSP) and based on the water available, and forecast to be available, in the water source.

This means that a water licence does not guarantee a fixed volume of water, but rather, it is a share of what water becomes available to that licence category up to the volume specified in the licence. For example, whilst a farmer may have a 10ML water licence, a 30% allocation in a given year means they effectively can only take 3ML. If they have a 0% allocation, they cannot take any water and that licence is effectively 'switched off' in that season.

AWDs are based on factors including:

- Dam storage levels and how much water unused from previous years is carried over in public storages;
- The condition of the catchment and river system river (wet/dry) and forecast inflows;
- The estimated volume required to run the river, including end of system flows, transmission losses and evaporation losses; and,
- Other requirements, such as storage reserves and environmental water allowances.

AWDs are also based on a hierarchy or order of priority of water users, which is outlined in the *Water Management Act 2000*. Under normal circumstances, this means the needs of the environment (ie, water to ensure rivers run) are the highest priority, followed by basic landholder rights, town water supply and stock & domestic licences, and then high security water licences (typically for permanent plantings such as orchards or vineyards), and finally, last in line is lower security licences (which are typically used for annual crops like cotton or rice).

During extreme events, such as droughts, critical human water needs (i.e. town drinking water) becomes highest priority, then the needs of the environment, followed by stock, high-security licences, and still last in line (and only if any water is left over, which it typically is not) are the lower security licences like general-security.

This hierarchy is outlined in Figure 5 below.

Figure 5: Hierarchy of NSW water allocation

Priority	Extreme events	Normal circumstances
Highest	• Critical human water needs	• Needs of the environment
High	• Needs of the environment	• Basic landholder rights
	• Stock • High security licences • Commercial and industrial activities authorised by local water utility • Water for electricity generation on a major utility licence • Conveyance in supplying water for any priority 3 take	• Local water utility access licences • Major utility access licences • Stock and domestic access licences
	• General security licences	• Regulated river (high security) access licences
Low	• Supplementary licences	• All other forms of access licences • Supplementary access licences

Source: Based on priorities table in *Macquarie-Castlereagh Surface Water Resource Plan: Schedule G—Macquarie-Castlereagh Incident Response Guide*

The allocation process ensures that high priority water requirements for the next 24 months can be met (including carryover). This means State water managers must be confident enough water will be available to meet high priority needs 'next year' – including environmental needs prescribed by Water Sharing Plans; basic landholder rights and high priority licences (domestic and stock, town water supply); and, high security licences and water carried over in general security accounts – before further allocation to general security licences 'this year'.

This system ensures that 'high priorities' needs are met first, before any **leftover water** (if any) gets allocated for 'lower priority' needs such as growing annual crops. The irrigation industry respects this hierarchy of priority, despite being at the bottom. Irrigators would not want to be using water for crop production if water for town supply and rivers is under threat. This system ensures that situation does not occur.

Once this system of water allocations is understood, it becomes clear that efforts to get more water to the top of the priority hierarchy, by taking water from the bottom of the allocation hierarchy, are generally misguided and would be ineffectual.

That is, because: (i) those licences at the bottom of the priority hierarchy only receive water once other higher priority needs are met first, and (ii) in situations of scarcity where critical human or environmental needs are under threat, those licences at the bottom of the hierarchy generally do not have any water either, and are effectively 'switched off'.

This effective 'switching off' of lower priority licences during droughts is a very important point to understand when it comes to developing climate change policy. As shown in Table 1 on page 23, general security licences across most of NSW were on 0% allocations (or exceptionally low) during the recent drought years.

This means, hypothetically, even if all these entitlements were 'bought back' by government, they would not have delivered more water for critical human needs and the environment during the drought (as those licences were not allocated any water). However, their purchase would mean less water at other times for growing food and fibre, with severe flow-on socioeconomic impacts on jobs, service industries and towns. This quashes commonly suggested notions that call for more buybacks as a climate change mitigation measure.

Water allocations to water licences are directly related to water availability. Less water availability automatically means less water allocated to irrigators, who are at the bottom of the hierarchy.

Since water entitlements are the lower-priority users, these users are the first and hardest hit by climate change reducing inflows.

Buying back licences does not mean more water for critical human and environmental needs in droughts, as allocations in those conditions will likely be negligible or zero. But their purchase does mean less water for growing food and fibre at other times, with severe flow-on socioeconomic impacts on jobs, service industries and towns.

Risk assignment

Water licence holders (such as irrigators), bear the risks of climate change, and this is written into legislation. This decision to assign the risks of climate change and drought to water licence holders like irrigators stems from (clauses 48 to 50) of the National Water Initiative (the blueprint to Australia's water reform). This has been adopted into Schedule 3A of the federal Water Act 2007:

> 48. *Water access entitlement* holders are to bear the risks of any reduction or less reliable water allocation, under their *water access entitlements*, arising from reductions to the consumptive pool as a result of:
>
> (i) seasonal or long-term changes in climate; and
>
> (ii) periodic natural events such as bushfires and drought.

This means that not only is irrigators' water access directly and automatically reduced as a result of reduced water availability from droughts and climate change, but irrigators (and other entitlement holders) bear the full risk of it.

The risk assignment frameworks also outlines distinct arrangements for assigning the risks of any reduction or less reliable water allocation arising from improvements in the knowledge of water systems' capacity to sustain particular extraction levels, or from changes in government policy.

Under legislation, irrigators (and other water licence holders) bear the full risks of any reduction or less reliable water allocation arising from reductions to the consumptive pool as a result of seasonal or long-term changes in climate, and periodic natural events such as bushfires and drought.

This means irrigators are at a very high risk when it comes to climate change.

Climatic data

Climate data in WSPs

Water Sharing Plans (WSPs) are the mechanism on which water sharing decisions on water availability are based. WSPs implicitly adjust for both climate variability and climate change in their fundamental existence and operation.

The climatic record used as input for these planning decisions is based on the full available climate record.

This includes in determining the Long-Term Annual Average Extraction Limit (LTAAEL) and the priorities according to which allocations must be adjusted if extraction limits are exceeded.

This is based on modelling of inflows and extraction over the full climatic record held by the Department up to the date of the finalisation of the relevant hydrological model (for example, in the Border Rivers, this is up to 2019 which includes the most recent worst drought on record).

For example: Extract from Border Rivers WSP, Division 2 Long-term average annual extraction limit:

27 Calculation of the long-term average annual extraction limit

(3) For the purposes of subclause (2), the long-term average annual extraction limit is to be calculated **over the duration of available climate records** using the plan limit hydrological computer model approved by the Minister.
Notes. 2 The long-term average annual extraction limit recognises the effect of climatic variability on the availability of water in accordance with section 20 (2) (c) of the Act, as historic climate and river flow information is used in its determination.

28 Calculation of long-term average annual extraction

The Minister, using the current conditions hydrological computer model approved by the Minister, is to calculate the long-term average annual extraction following the end of each water year, calculated **over the duration of available climate records** and based on the following…

As new climate information becomes available (including during the term of the WSP), the LTAAEL is updated (i.e. it is not a fixed number but is determined by the model).

Whilst there is currently no explicit mechanism to adjust input data (or selective sequencing from the data) into the planning process to allow for potential future climate change, the WSP implicitly allows for both climate variability and change by dynamically incorporating new climate information as it comes into existence on a rolling basis (including in the setting of LTAAELs). More on this is below.

Water Sharing Plans implicitly adjust for both climate variability and climate change.

Water Sharing Plans are based on the full available climatic record, including in the setting of extraction limits.

Incorporating future climate modelling

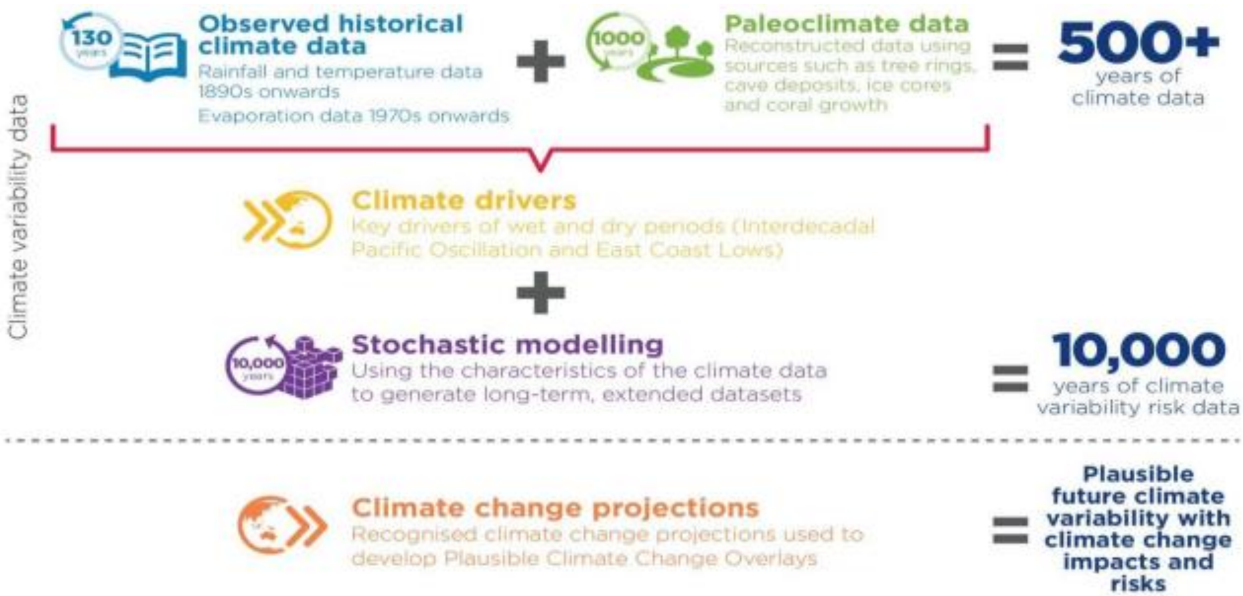
The NSW DPE-Water is developing new climate data and modelling which improves understanding of both past climate conditions and plausible future climatic conditions and risks (such as extreme events).[28] This is based on:

1. Historical data – analysis of 130 years of recorded climate data.
2. Paleoclimatic data – 500 years of climate data is then added to the dataset, which is reconstructed using scientific methods (sources such as tree rings, river sediments and ice cores).
3. Stochastic methods - stochastic modelling is applied to the new 500 years of climate data, to look for climate sequences over 10,000 years. This type of modelling assists to show climatic variability and extremes.
4. Climate projections – this new data set is then subjected to climate change projections from global and regional climate models.

[28] The detailed outcomes of this work are available through the draft Regional Water Strategies. It shows that NSW's surface water supplies will be less secure. In summary, the modelling forecasts:

- Southern inland NSW - winter and spring rains are likely to decrease;
- South coast - changes in the patterns of east coast lows are likely, with an increase in the intensity of rainfall, but the potential for fewer events.
- North of NSW - there is a lower likelihood of significant changes in average annual rainfall in the north of the state.

Figure 6: New four-step approach to better understand past and future climate risk[29]



This method (and its implementation) has been reviewed by an independent panel of experts coordinated by the Office of the Chief Scientist and Engineer, who found it fit for purpose for providing the best available climatic knowledge to inform the development of Regional Water Strategies (long-term 20-year planning documents), and consistent with best practice in the field.

However, the Panel also noted that this is an area of science which is still developing, and further work is required to continuously improve the methods. In particular, at this point in time, this method is not yet able to be used to underpin water planning/allocation decision making, as the levels of uncertainty are too great.

That is why, whilst all available climate information can continuously be built into water planning decision-making through WSPs (which includes data spanning exceptionally dry and wet periods), potential future climate change scenarios cannot yet be incorporated at this point in time. However, and of importance, is that the WSP will implicitly adjust for both climate variability and climate change by basing its operation on water availability in real-time.

Setting reserves

The term 'reserves' typically refers to how much water should be set aside (or reserved) for basic rights, stock and domestic, town water supply and high security licences before allocating water to lower priority general security licences.

There has been recent public discussion about a decision in 2014 to fix the drought-of-record for the purposes of determining reserves (i.e. clause 57 of the Border Rivers WSP), as per the commencement of each WSP. This

[29] https://www.industry.nsw.gov.au/__data/assets/pdf_file/0005/314285/new-climate-analysis-informs-nsw-rws-fact-sheet.pdf

was through the *Water Management Amendment Act 2014* (cl 28 [1] of Schedule 2) which amended all NSW Basin WSPs in force in 2014 to maintain reserves based on the "*worst period of low inflows into this water source (based on historical flow information held by the Department when this Plan commenced)*".

This decision was made because of concerns that failure to do so would trigger calls from industry to open up existing bulk sharing arrangements between high-security and general-security entitlement holders in southern Basin WSPs.

Importantly, the setting aside of reserves does not require actual storage – it just allows for 'assumed inflows' to be taken into account (based on modelling of the lowest inflow sequence – i.e. that assumes the drought of record for that WSP will occur that year regardless of the actual climatic conditions).

This practice of planning ahead (based on a highly conservative assumption of a very dry period) means that general security entitlements can receive their allocations earlier in the water year – because, assumed inflows can be taken into consideration.

Environmental water holders have large portfolios of general security entitlements (and often Planned Environmental Water is linked to general security allocations, too), so environmental water is understood to benefit from this current system by receiving water from its general security entitlements and EWA accounts earlier than otherwise would occur.

For farmers, this current system allowing allocation announcements to be made earlier is also important for summer crops (as farmers need certainty of water access to make planting decisions), and later allocation announcements would miss the window of opportunity for decision-making on-farm.

Changing this practice would not only change the timing of access, but would also lead to significant reductions in entitlement reliability. For example, modelling by DPE-Water following the Millennium Drought showed that reversing this decision would reduce annual general security allocations by approximately 13% on average and up to 25% in some years. This impacts water allocated to both farmers and the environment.

The concerns regarding this practice generally ask what happens if the climatic conditions experienced in a given year are worse than the lowest inflow sequence planned for (i.e. if even the very low assumed inflows do not occur). The concern is a perception that this would result in a situation where either (i) reserves set aside are insufficient, or, (ii) general security allocations cannot be delivered. However, mechanisms are in place to act if this situation develops, including:

- AWDs are made at the start of the water year (1 July), and are adjusted periodically throughout the year (i.e. monthly) as more information comes to hand about water availability that year. The initial AWD at the start of the water year assumes the lowest inflows will be experienced as the year progresses, but if an even lower inflow sequence transpires (i.e. worst-ever), subsequent allocations may be made more conservatively (i.e. no further inflows assumed, or delay further allocations until/if higher inflows return).
- The Minister may make a temporary water restriction (under S324 of the NSW Water Management Act) prohibiting or restricting the take of water, in all or specified circumstances. This provision has been enacted already, when assumed inflows have not occurred, to suspend access to water. Note: S324s also suspend (adversely impact) environmental water in accounts.

- The Minister may declare a severe water shortage (under 49A or 49B of the WM Act) and suspend the operation of part or all of the WSP. There is precedent for where this has been enacted, when town water supply has been considered at risk, or when environmental water provisions (such as an end of system flow or the accrual of water to an Environmental Water Allocation (EWA)) have not been able to be met. Note: declaration of a severe water shortage may also have adverse environmental impacts as it changes the priorities of water access (i.e. basic rights and town water supply precede the environment (section 60 of the Act)).
- The Minister also may amend the WSP if considered in the public interest.

Importantly, whilst fixed at the worst drought on record at the commencement of that Plan, this includes exceptionally dry periods throughout the historical climatic experience of severe droughts. This practice also only applies to the setting of reserves, and the **LTAAEL continues to be based off all available climatic information.**

The LTAAEL is based off all available climatic information.

Reserves for higher priority needs are set aside based on a very conservative assumption of severely low inflows (the worst drought conditions ever experienced at the time when the WSP was originally made).

This benefits both the environment and irrigators who own water entitlements by allowing for allocations to be made earlier in the water-year, based on a very low-risk and highly conservative assumption that very low inflows will occur that year.

If inflows are lower than the extremely low conditions the WSP covers, there are a range of options available to intervene.

Establishing this practice was necessary to preserve bulk water access arrangements between general and high-security users in the WSP.

Reviews

The new Border Rivers WSP includes a review of the climate data used in the setting aside of reserves 57(4). The WSP outlines that the intended outcome of this review is to ensure reserves are sufficient for high-priority needs. This review clause states:

(4) During the first 5 years of this plan, the Minister will undertake a review of this clause that considers the following:
(a) options for redefining the period of lowest accumulated inflows to the water source,
(b) whether different periods should apply to different categories of access licences,
(c) the impact of any options for change on planned environmental water and each category of access licence, and

(d) the views of stakeholders and the broader community.[30]

This review is intended to provide certainty that following the finalisation of the climate change work being conducted under the Regional Water Strategies, that outcomes for WSPs will be taken into account. It has long been foreshadowed that the new modelling data formed through the development of Regional Water Strategies will inform changes to WSPs.

[30] Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021, Division 3 General system operation rules, 57 Maintenance of water supply (4). Available here: https://legislation.nsw.gov.au/view/pdf/asmade/sl-2021-370

Part 3 Impacts of climate change on water licences – already observed

CHAPTER 3) OBSERVED IMPACTS OF CLIMATE CHANGE ON WATER LICENCES

Given the existing system of water management, which directly and automatically factors reduced water availability into water allocations, climate change is having significant impacts on water entitlement holders.

This can be measured by the long-term trends in water allocations (i.e. the actual amount of water that gets allocated to these licences).

Across all NSW valleys there is a **trend of a long-term decline in water allocations** to general security licences. This means that irrespective of the licence volume, the amount of water these licence holders are actually allocated to use is declining over time.

It is important to note that this declining trend is attributable to two key factors:

1. **Climate change** – and the automatic response mechanisms responding to declining inflows and less water availability;
2. **Policy drivers** – such as rule changes or more conservative reserve policies that cumulatively erode reliability of water allocations over time.

At this point in time, there has been little investigation conducted to unpack the relative weighting of these two key factors. This report will present the declining trend, noting that whilst climatic factors are major factor, they are not the only driver. It is recommended that the relevant agencies conduct further investigations into the cumulative impacts of drivers such as policy decisions and river operation changes over the past 20 years (what we refer to as 'cracking open the allocation blackbox').

The below graphs show general-security allocations over time in two valleys: the NSW Murray and Murrumbidgee. The trend line (blue-dotted) shows the declining trend.

Key findings:

☐ **NSW Murray General Security licence holders were allocated, on average, 81% of their licence volume before the Millennium Drought. Their licence reliability is now around 57%.**

☐ **Namoi General Security licences in the northern Basin, have similarly declined from 77% to around 39% reliability.**

☐ **During drought years (including both the recent drought, and the Millennium drought) General Security allocations across most inland NSW valleys were on 0% - that is, no water was made available to those water users.**

Figure 7: NSW Murray General-Security

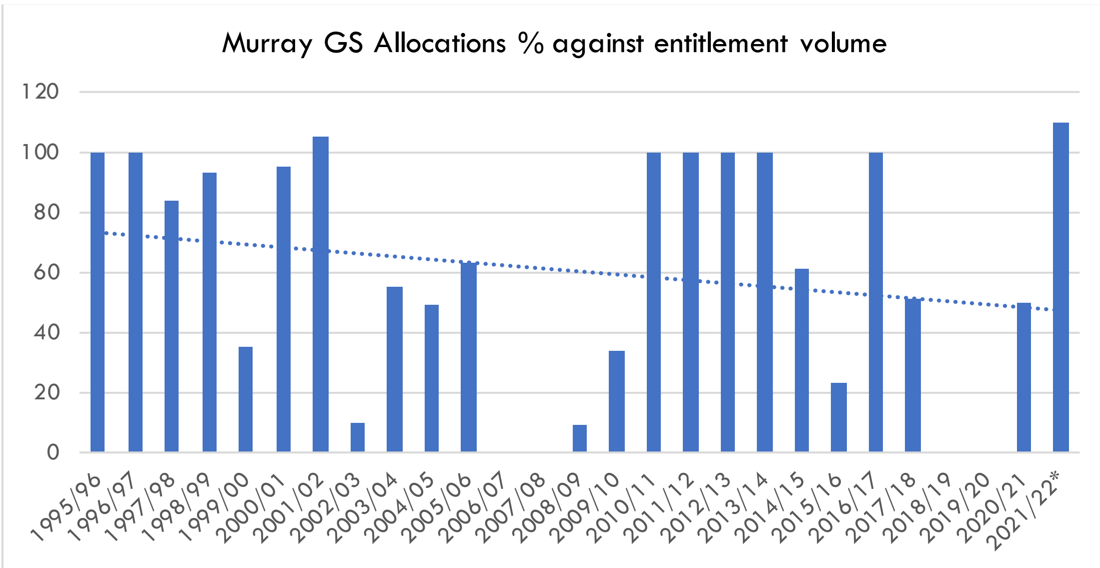
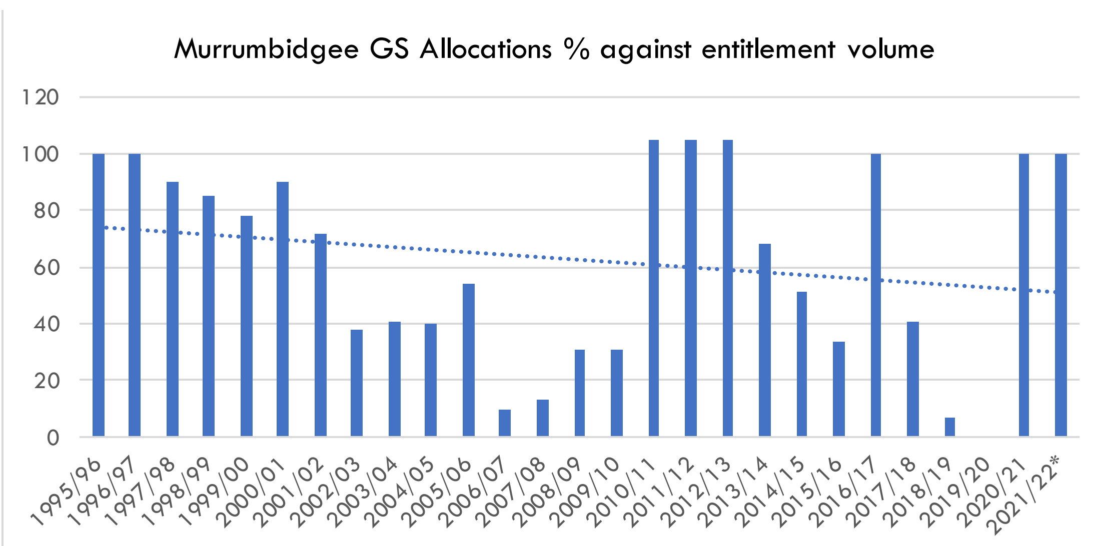


Figure 8: Murrumbidgee General-Security



Impacts during droughts

The impacts of climate change on water licences is most stark during droughts. During these periods:

- Low-security licences such as general security face very low, or often zero, allocations;
- High-security licences also tend to face reductions, albeit not as significant as lower-security licences;
- Water access from supplementary events or floodplain harvesting cannot happen by default, as these events require floods (i.e. if there is no flood, there cannot be floodplain harvesting – and if floods are fewer and further between this will also face automatic default declines).

The below table shows general security closing allocations during the most recent drought period, from 2017-18 to 2020-21. It must be noted that the below data shows the closing allocation, and in most instances the allocations were considerably lower during the earlier phases of the water year before increasing to the closing allocation (and thus the below table tends to over-represent actual water availability for most of the water year). The Allocations Dashboard on the DPIE-Water website shows the full data for each licence type and water source over the course of each water year (thus including opening allocations and inter-year variability, as well as carryover).[31]

However, the key trend below is clear – that during and preceding the key droughts year of 2018 and 2019, general-security allocations in the impacted valleys were severely reduced, most on 0% – meaning, they got no water. These 0% general security allocation years are marked in red.

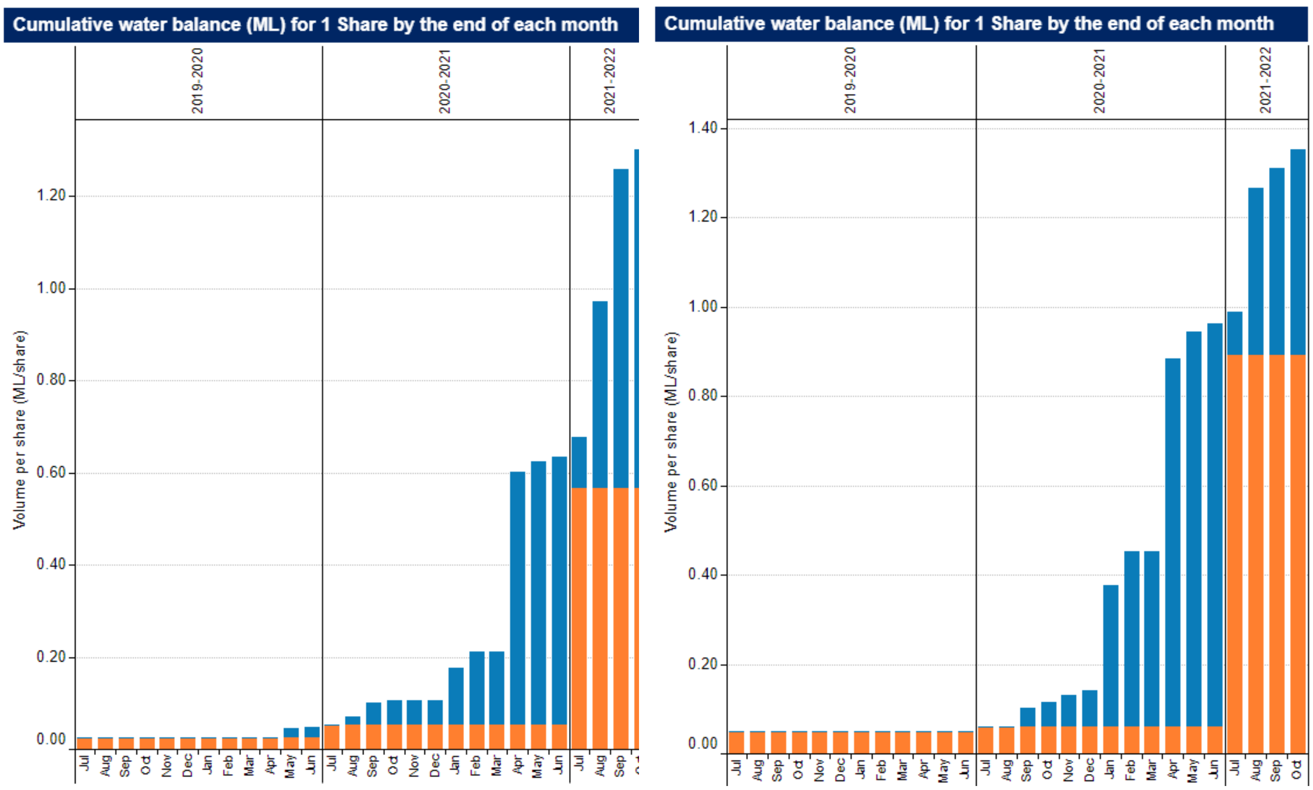
Table 1: General security closing allocations (2017-18 to 2021-22)

Valley	2017-18	2018-19	2019-20	2020-21	2021-22
INLAND					
Border Rivers (GS B)	16%	0%	0%	47%	100%
Belubula	0%	0%	0%	0%	83%
Cudegong	38%	0%	0%	68%	100%
Gwydir	18%	0%	0%	58%	150%
Lachlan	2%	0%	0%	70%	121%
Lower-Darling	96%	0%	30%	52%	100%
Macquarie	38%	0%	0%	68%	100%
Murray	51%	0%	3%	50%	110%
Murrumbidgee	45%	7%	11%	82%	100%
Namoi (lower)	7%	0%	0%	90%	105.3%
Namoi (upper)	95%	100%	50%	72%	100%
Peel	100%	38%	0%	84%	100%
COASTAL					
Bega / Brogo	75%	65%	60%	50%	50%
Hunter	100%	100%	95%	100%	100%
Paterson	100%	100%	100%	100%	100%
Richmond	100%	100%	100%	100%	100%

31 https://www.industry.nsw.gov.au/water/allocations-availability/allocations/dashboard

The below figures show this occurring diagrammatically in the Gwydir and Lower Namoi valleys, as case studies. During the drought, there was 0% general security allocations (i.e. no blue columns) and negligible unused general security allocations from previous year carried over (orange columns; this water could not be delivered, however, as most would be lost in seepage and evaporation from drought-affected rivers). As conditions began to improve (i.e. the drought began to break) particularly in 2021-22, water allocations then increased (i.e. shown by the appearance of blue columns).

Figure 9: General-security water allocations over drought period 2019-20 to 2021-22, Gwydir (left) and Lower Namoi (right).



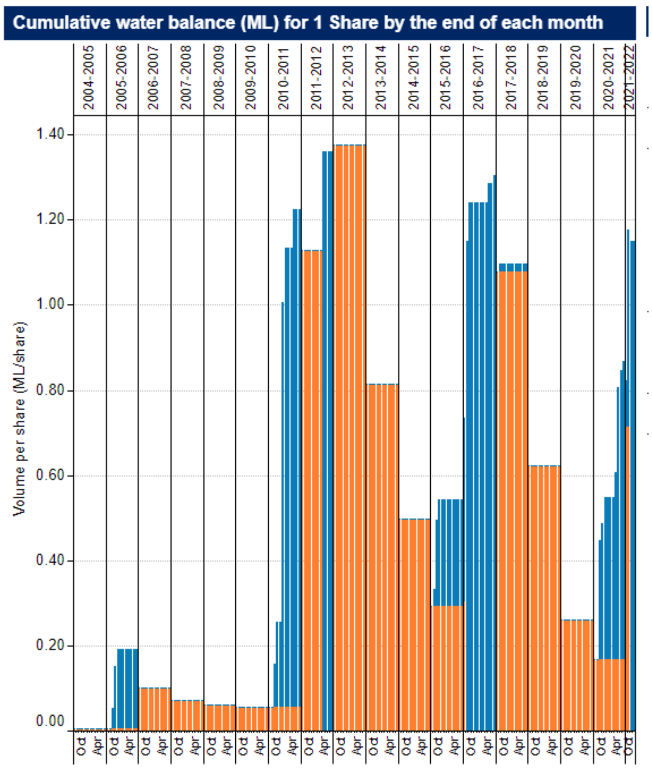
The occurrence of zero or low allocations during drought is not unique to this most recent drought. In fact, data available on the NSW DPE-Water allocations dashboard[32] back to 2004, shows fluctuating water allocations based on water availability.

The below figures show cumulative water availability, including both the AWD for the current water year (shown in blue) and carryover (shown in orange), with the data spanning from the 2004-2005 water year to the present 2021-22 water year.

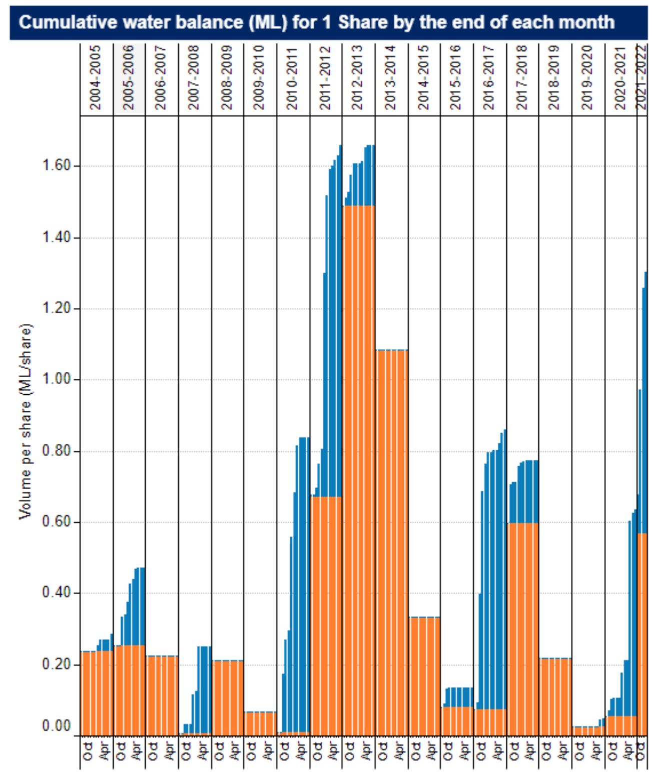
These figures show very low water allocations during dry periods such as the Millenium Drought, with higher allocations during wet years.

Figure 10: Water availability 2005-2022

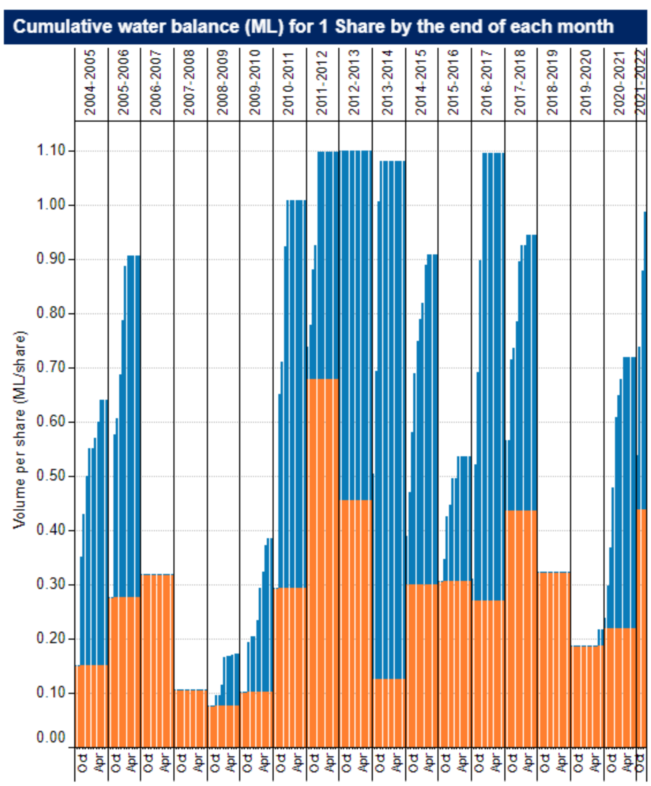
32 https://www.industry.nsw.gov.au/water/allocations-availability/allocations/dashboard



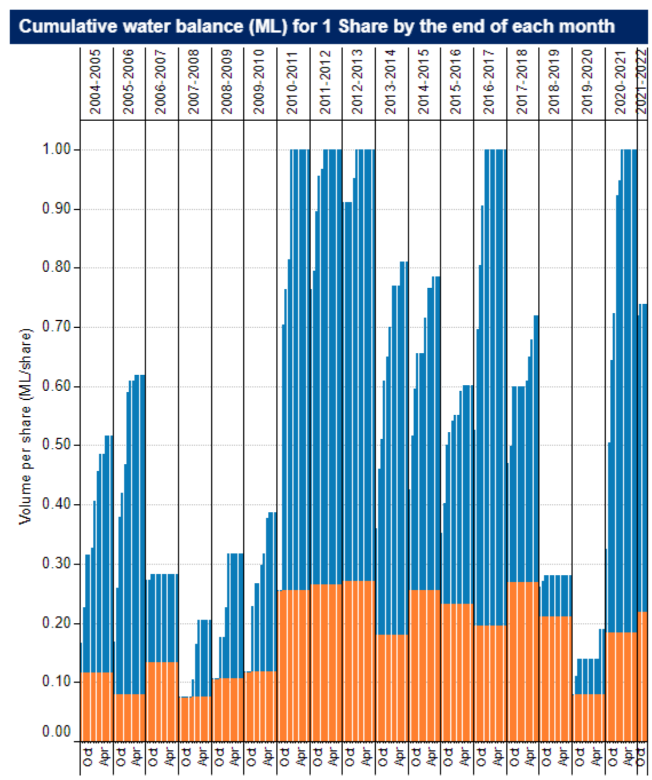
(a) Lachlan



(b) Gwydir



(c) Murray



(d) Murrumbidgee

Part 4

Impacts of climate change on water licences – forecast

CHAPTER 4) FORECAST IMPACTS OF CLIMATE CHANGE ON WATER LICENCES

The Regional Water Strategies (RWS) include forecasts for actual water available for water licences under various climate change scenarios. Importantly, these findings show declines to the amount of water allocated to water licences based on existing climatic adjustment mechanisms. Key findings are shown below.

Table 3: Modelled impacts of climate variability & climate change on average annual extraction

Valley	Average water availability at the beginning of each water year based on long-term climate change
Lachlan	- 60%
Gwydir	- 26%
Macquarie-Castlereagh	- 40%
Border Rivers	- 40%

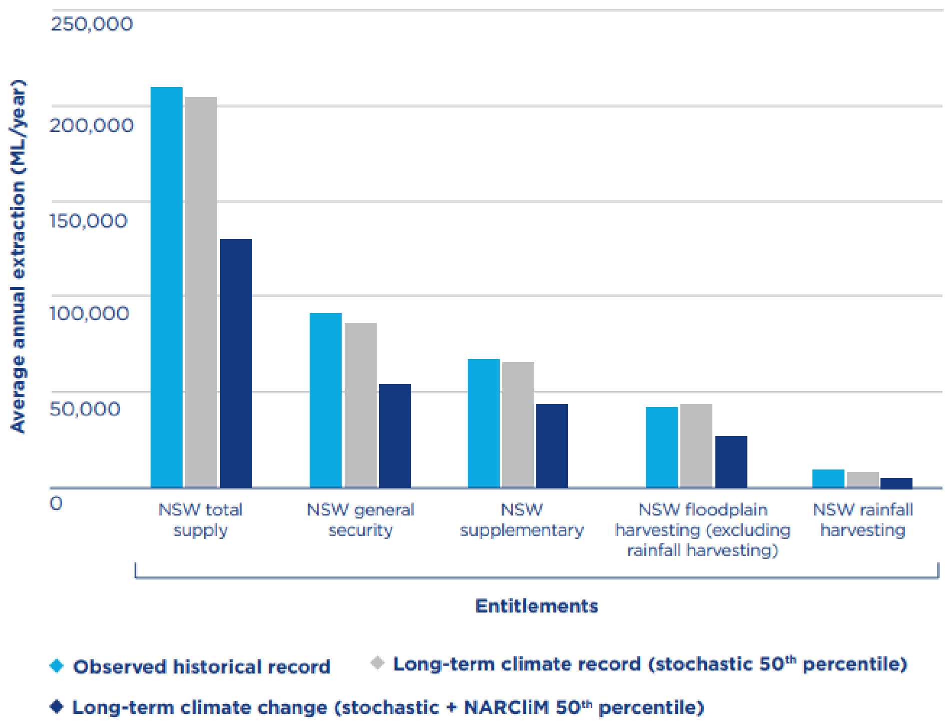
Note: Final Regional Water Strategies for many valleys are yet to be published, and data is based on draft RWS on public exhibition, and data informing this process.

Put simply –this table shows that general-security water licences in the Lachlan valley are forecast to experience a 60% reduction in average water availability based on long-term climate change scenarios.

Images: Climate change is forecast to lead to more intense extremes, both droughts and floods.

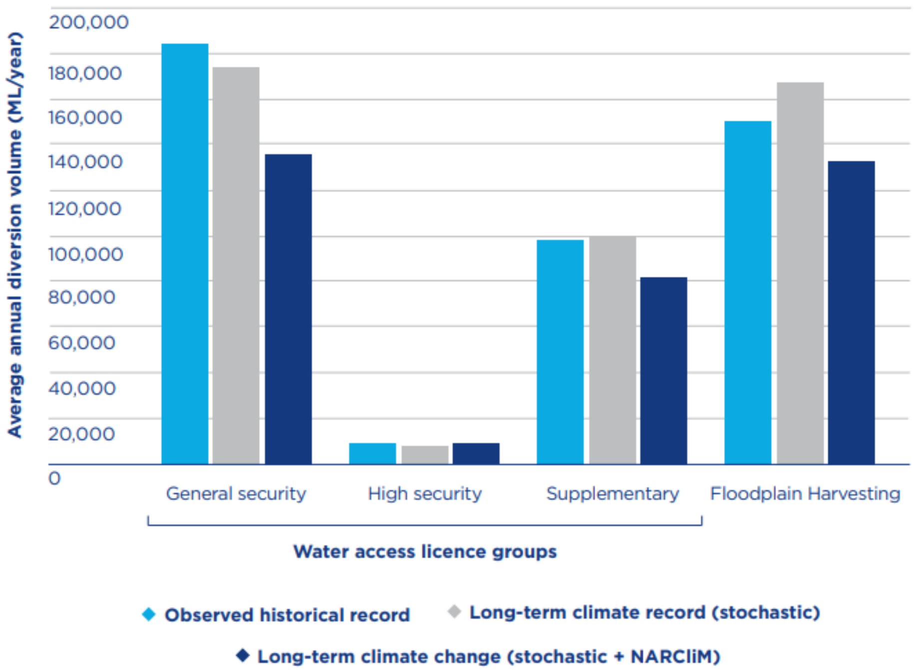
The below diagrams, sourced from the draft Regional Water Strategies, show possible impacts on average annual extractions under various scenarios: observed historical record, long-term climate record and a long-term climate change scenario.

Table 4: Extracts from (draft) Regional Water Strategies of modeled impacts of climate variability and climate change on average annual extraction from water sources

Valley	
Border rivers	**Figure 29. Possible impacts on average annual extractions from the Border Rivers regulated rivers (ML/year)** 

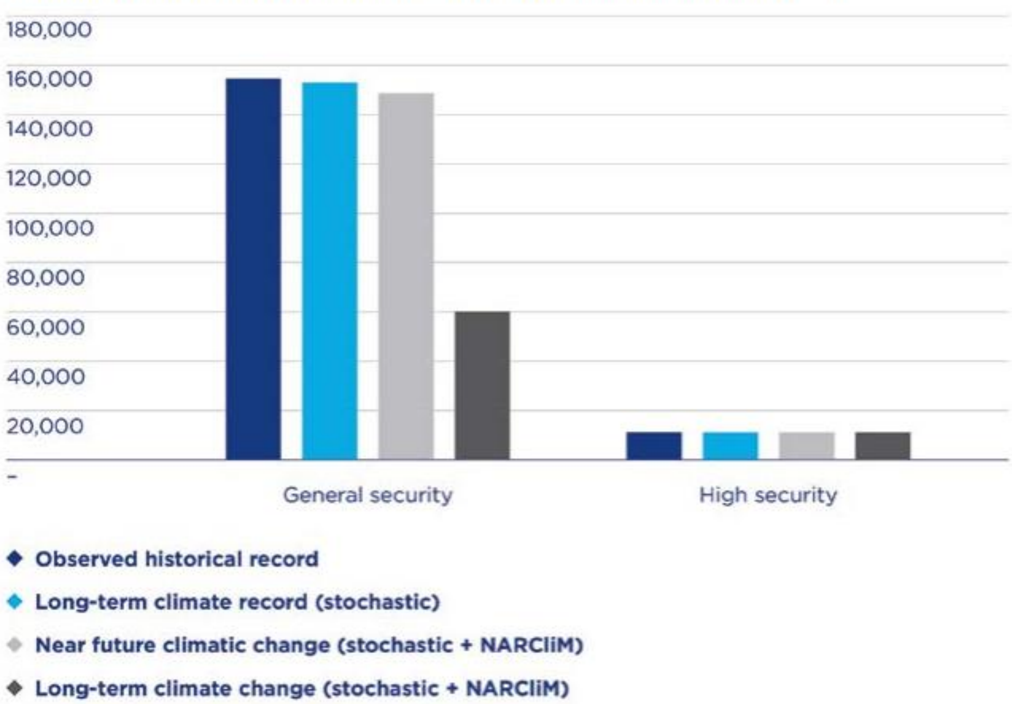
Gwydir

Figure 20. Impacts on Gwydir regulated river water access licences under the 'average' 130-year period of the future climate change projection period compared with the observed record



Lachlan

Figure 22. Impacts on Lachlan general security and high security regulated river water access licences under an 'average' 122-year period from the future climate change projection period (near future and long-term) compared with the observed and long-term record



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Macquarie

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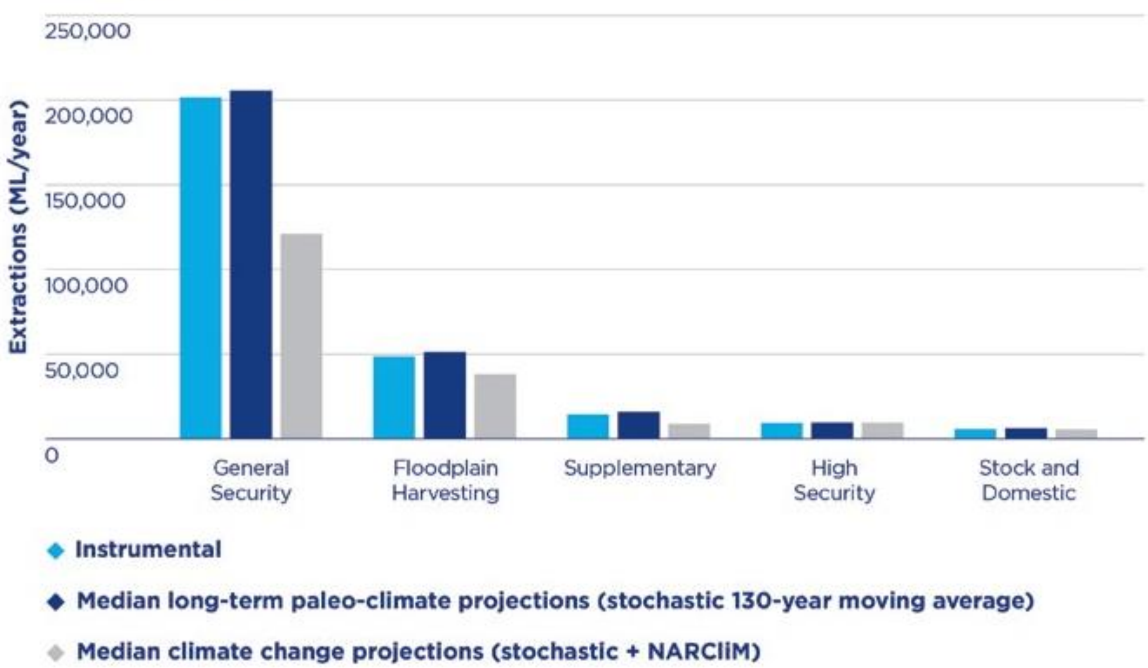
Figure 26. Impacts on average annual extractions from the Macquarie-Castlereagh region's regulated river (ML/year)



Source: Department of Planning, Industry and Environment—Water 2020, hydrological modelling

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Namoi

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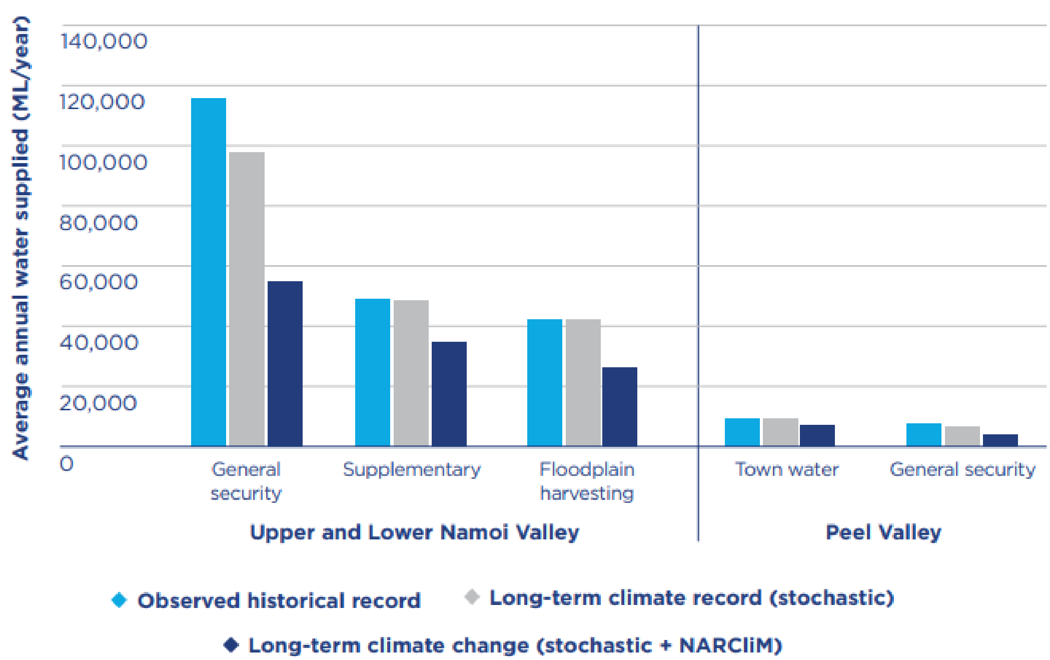
Figure 45. Average annual water supplied under different climate scenarios—general security, supplementary, floodplain harvesting and town water



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<td>Coast (Far North)</td>
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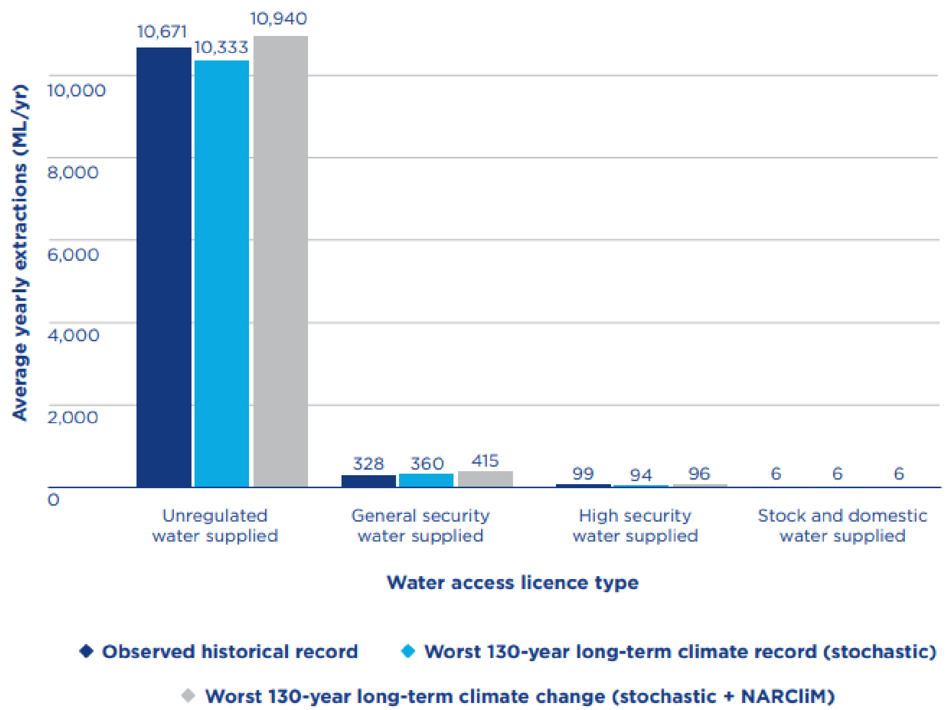
Figure 24. Mean annual extraction in the Richmond River catchment under the 'worst' 130-year period of the future climate change projection period compared with the observed record



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<td>Coast (South)</td>
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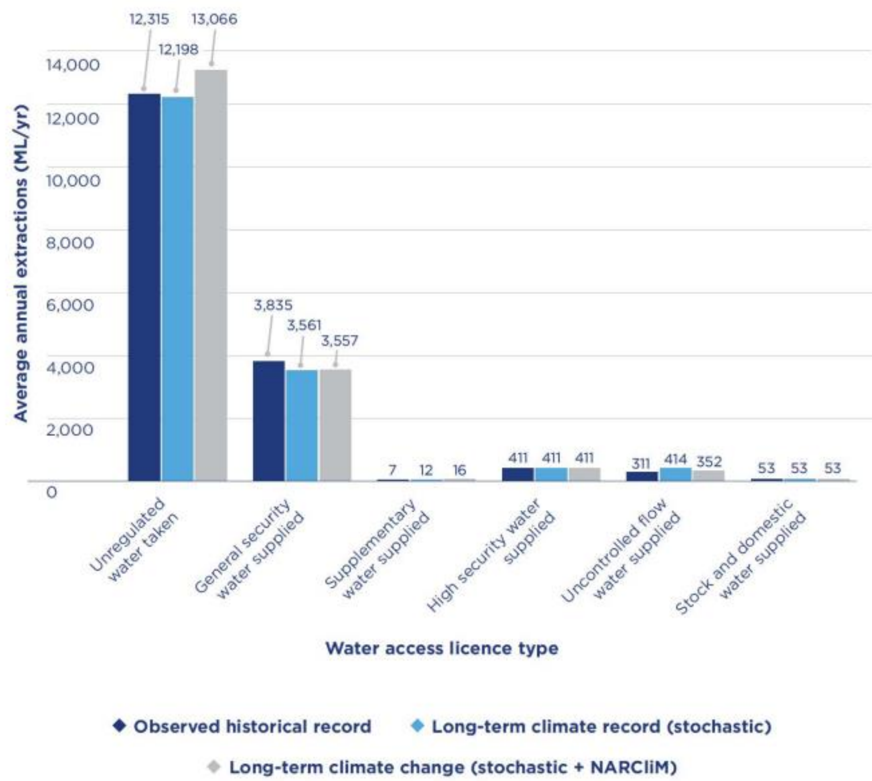
Figure 24: Modelled impacts of climate variability and climate change on average annual extraction from unregulated and regulated water sources



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Forecasts for water licences under climate change scenarios show the impacts of climate change on the actual amount of water available to water licences, given the existing automatic response mechanisms built into water sharing arrangements.

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Part 5 Impacts on agriculture

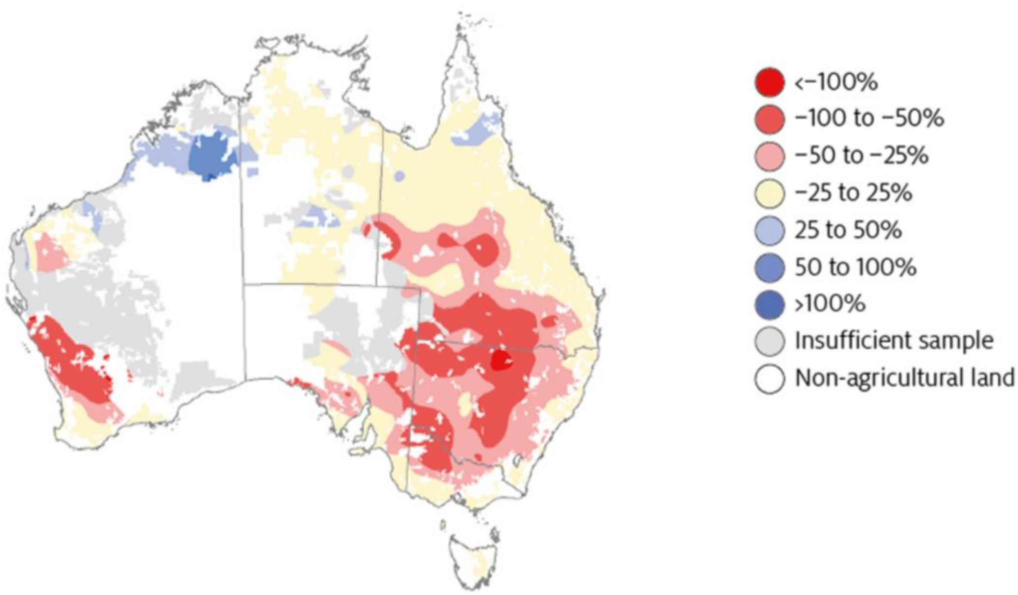
CHAPTER 5) IMPACTS ON AGRIUCLTURE

Climate change is already posing a significant risk to agriculture.

ABARES predicts overall farm profits will fall by 13% by 2050.

Already, changes in seasonal conditions over the period 2001 to 2020 (relative to 1950 to 2000) have reduced annual average farm profits by 23%, or around $29,200 per farm, most significantly in south-western and south-eastern Australia.[33]

Figure 11: Effect of Recent (2001 to 2020) seasonal conditions on farm profit (ABARES)[34]



The conditions post-2000 also have contributed to increased risk in terms of more variable cash income and profits. ABARES reports that in the 20 years since 2000, the risk of very low farm returns (due to climate variability) essentially doubled (relative to the period 1950 to 2000), increasing from a 1 in 10 frequency to more than 1 in 5.[35]

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[33] https://www.awe.gov.au/abares/products/insights/climate-change-impacts-and-adaptation#future-changes-in-climate-could-make-conditions-tougher-for-australian-farms
[34] https://www.awe.gov.au/abares/products/insights/climate-change-impacts-and-adaptation#future-changes-in-climate-could-make-conditions-tougher-for-australian-farms
[35] Ibid.

Looking to the future, modelling shows the impacts of future climate change on farm profits, using two Representative Concentration Pathways (RCPs): RCP4.5 (global emissions peak by 2040, and CO2 concentrations reach around 485 ppm by 2050) and RCP8.5 (assumes limited curbing of global emissions, such that CO2 concentrations reach around 540 ppm by 2050). The results show a broad range of outcomes, varying across regions and industries:

- Rainfall:
  - Under RCP4.5 average declines in winter (April to October) season rainfall for Australian farmers of between 2.7% and 20.6% are projected for 2050, compared with an observed decline since 2001 of 16.2%.
  - Under RCP8.5 larger reductions of between 6.1% to 30.1% on average are projected.
- Simulated changes in average farm profits:
  - Under RCP4.5 scenario ranging from -31.9% to -2.0%.
  - Under RCP8.5 scenario ranging from -49.9% to -10.7%.[36]

What this shows is that under higher emission scenarios, the impacts on Australian agriculture will be more significant – thus, climate change mitigation measures are of economic importance to Australian agriculture.

This also shows that continued significant adaptation responses from the agricultural industry will be needed. ABARES indicates that "*there is already evidence of strong farm adaptation responses to the recent climate shifts with improvements in technology and management practices helping to increase farm productivity*".

Climate change is already having, and is forecast to continue to have, significant impacts on Australian agriculture – making both mitigation and adaptation important for our industry.

For the irrigation industry more specifically, the decline in the reliability of water licences as a direct and automatic response to climate change poses one of the greatest (if not the greatest) risks to the productivity and profitability of the sector. Given current water sharing arrangements, the licences on issue (such as to irrigators) effectively serve as a buffer before higher priority needs face the impacts of reduced water availability. This makes irrigators the most vulnerable to climate change of all water users. They will be the first and thus hardest hit (noting that at times of extreme scarcity all users are impacted).

The risks of climate change to the NSW irrigation farming industry include:

- The direct and automatic impact of lower rainfall and inflows, leading to reduced water access for irrigation (i.e. the long-term trend of declining water allocations against licences);
- More frequent, severe and prolonged droughts, interspersed with more intense rainfall and flooding;
- Higher water prices driven by scarcity;
- Potential impacts on gross value of irrigated agricultural production (depending on adaptation);
- Increased pressure on water resources, and heightened sensitivity to the use of water for farming;

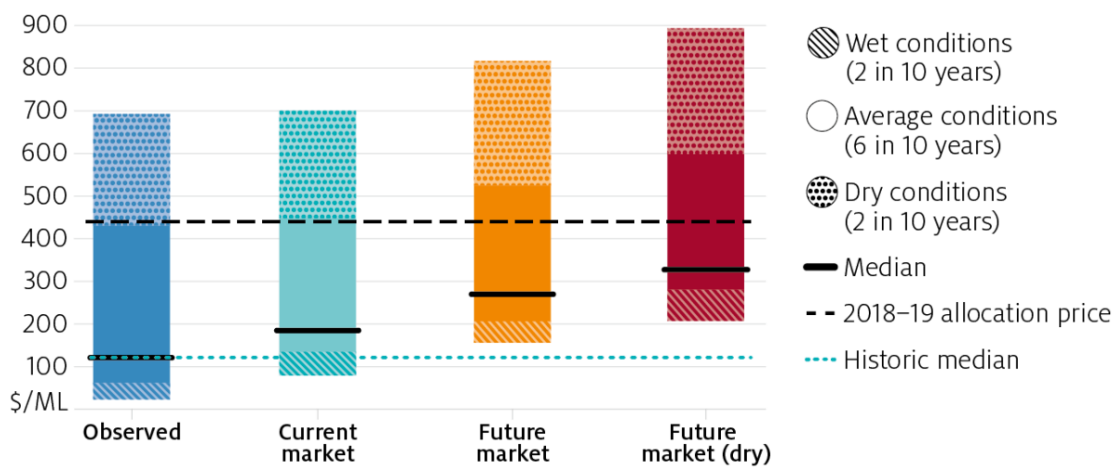
[36] https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1032401/0

- Broader declines in regional communities, affecting supply chains and community networks.

Modelling prepared for the *Independent Assessment of Social and Economic Conditions in the Basin* suggests that under a "future market (dry) scenario" (an 11% reduction in water supply and a 3% reduction in rainfall)[37] will mean:

- **Total water use is expected to decrease by around 12%** in the future market (dry) scenario compared to the current market scenario.
- **Water availability for irrigation** in the southern Basin is expected to **decrease on average by 700GL.**
- **Water supply** across the southern basin is expected to be **lower than 3800GL in 8 out of 10 years.**
- **Allocation prices** (which are sensitive to changes in rainfall and water supply), will **increase by 17%** on average (mostly due to a reduction in the availability of surface water). Prices above $200/ML were modelled to occur in all years under a future market (dry) scenario, with an average annual price of around $445/ML.
- The **Gross Value of Irrigated Agricultural Production** (GVIAP) across all sectors is modelled to **decrease by 4.1%.** [38]

Figure 12: Weighted water allocation price by scenario, southern Murray-Darling Basin[39]



There is a concerning relationship between the impacts of climate change and irrigated agricultural production, which makes irrigators highly vulnerable to the impacts of climate change.

[37] This scenario also includes: full maturity of recently established almond plantings, and future water recovery to meet Basin Plan requirements (3,200 GL target) via on-farm infrastructure upgrades.
[38] https://www.awe.gov.au/sites/default/files/documents/abares-future-scenarios-for-southern-mdb.pdf
[39] https://www.awe.gov.au/sites/default/files/documents/abares-future-scenarios-for-southern-mdb.pdf

Part 6 Impacts on environmental water

CHAPTER 6) IMPACTS ON ENVIRONMENTAL WATER

There are two types of water for the environment:

1. **Planned Environmental Water** (PEW) - Under WSPs, water above the LTAAEL is "preserved" for the environment to "contribute to the maintenance of basic ecosystem health". This is by far the vast majority of water in the water source (as a general rule, about three-quarters of water in the water source, but this varies by valley). This therefore provides the greatest relative opportunity for improvements.
2. **Held Environmental Water** (HEW) – this is additional environmental water, which comes from water licences bought back from irrigators, for the environment, through water recovery programs, such as the Murray-Darling Basin Plan, Water for Rivers and The Living Murray program. This means the environment owns 28% of water licences, in addition to water above extraction limits that is not on a licence.

Planned Environmental Water

PEW (defined under NSW law as, in essence, water above extraction limits, distinct from PEW under Commonwealth law for the purposes of the Basin Plan) represents by far the largest share of water in any water source.

Table 5: Percentage of water above extraction limits[40]

Water Source	Long-term Average Annual Extraction Limit (megalitres/year)	Long-term average annual flow not extracted	% of long-term average annual flow not extracted
Barwon-Darling	214,000	2,607,000	**94%**
Gwydir	392,000	1,141,000	**66%**
Lachlan[41]	305,000	1,212,000	**75%**
Macquarie[42]	391,900	1,448,000	**73%**
Murrumbidgee[43]	1,925,000	4,360,000	**50%**
Namoi	238,000	870,000	**73%**

[40] Note the LTAAEL is not a fixed number, but a modelled output, which varies based on varying climatic inputs.

[41] https://legislation.nsw.gov.au/view/html/inforce/current/sl-2016-0365#sec.16

[42] https://legislation.nsw.gov.au/view/html/inforce/current/sl-2015-0630#sec.13

[43] https://legislation.nsw.gov.au/view/html/inforce/current/sl-2016-0367#sec.16

This is specifically written into WSPs. For example, the below is a screenshot from the Lachlan WSP:

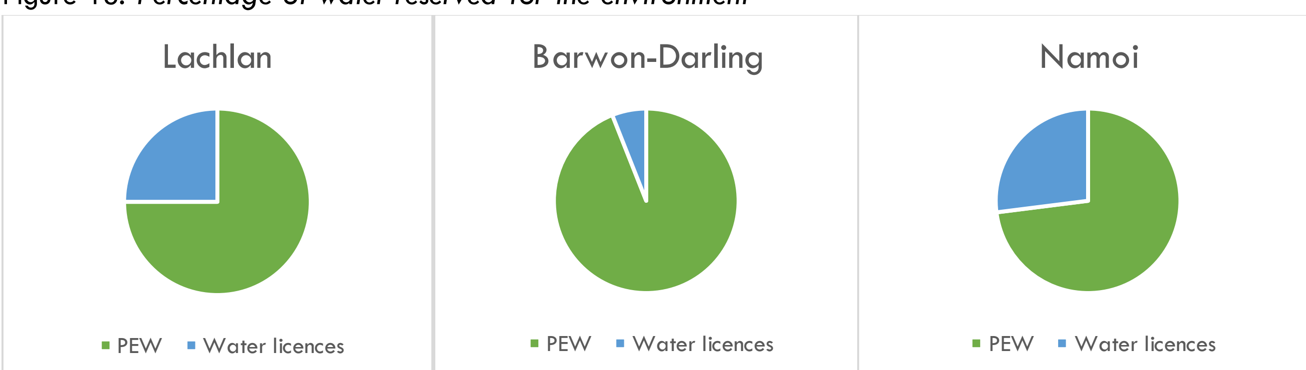
> (b) it is the long-term average annual commitment of water as planned environmental water in this water source that results from the application of the long-term average annual extraction limit and compliance rules as specified in Division 1 of Part 7 of this Plan and the available water determination rules as specified in Division 2 of Part 7 of this Plan,
>
> **Notes—**
>
> 1 By limiting long-term average annual extractions to an estimated 305,000 megalitres per year, this Plan ensures that approximately 75% of the long-term average annual flow in this water source (estimated to be 1,212,000 megalitres per year) will be preserved and will contribute to the maintenance of basic ecosystem health.
>
> 2 The rules in Part 7 of this Plan ensure that there will be water remaining in this water source over the long-term by maintaining compliance with the long-term average annual extraction limit. The rules in Part 7 of this Plan provide for a reduction in available water determinations when the long-term average annual extraction limit has been assessed to have been exceeded.

Similarly, the below is a screenshot from the Macquarie WSP:

> **13 Planned environmental water**
>
> This Plan establishes the following planned environmental water rules:
>
> (a) water volume in excess of the long-term extraction limit established in clause 29 of this Plan shall not be taken from this water source and used for any purpose, and
>
> (b) water availability shall be managed as specified in clause 31 to ensure water volume in excess of the long-term extraction limit is not being taken.
>
> **Note—**
>
> By limiting long-term extractions to an estimated 391,900 megalitres per year this Plan ensures that approximately 73% of the long-term average annual flow in this water source (estimated to be 1,448,000 megalitres per year) will be preserved and will contribute to the maintenance of basic ecosystem health.

The below diagrams show the significance of water above extraction limits (i.e. not on a license), as the largest component of water in a water source.

Figure 13: *Percentage of water reserved for the environment*



In the above diagrams, the portion shown in blue represents the amount of water that can (on average) be extracted through licences by all water users (not just irrigators - including town water supply, stock and domestic, as well as water licences additionally purchased for the environment).

To be clear – what this shows is that the water licences for irrigation and other purposes (such as bought back water from irrigators for the environment) sit within the blue portion – i.e. within the remaining 6% for the Barwon-Darling, or within the remaining 25% for the Lachlan.

There tends to be significant focus on the blue portion. However, given the sheer size (both proportionately and absolutely) of water above extraction limits (i.e. not on a license), there must be enhanced focus on how this water can be best managed and utilised. Such focus is needed both now and even more so with climate change, as the ability for water above extraction limits to be managed to meet environmental objectives effectively and efficiently will have increasing importance. Similarly to how the irrigation sector has had to improve efficiency to adapt to less water availability, managers of water above extraction limits will also need to improve management practices to 'do more with less', particularly under climate change scenarios.

Recommendations include: (i) improved measurement and metering (gauging) of PEW to account for every drop; (ii) continual review and evaluation of PEW management with adaptive management where opportunities for enhancement are identified; (iii) improved communication of PEW management objectives and outcomes; and (iv) feasibility studies of what will be possible for PEW managers to manage for under climate change scenarios.

Held Environmental Water

As a general rule, HEW makes up approximately 25% of irrigation licences (varying by valley).[44] This makes the Commonwealth Environmental Water Holder (CEWH) the largest irrigator in NSW. It is crucial to note that this water is in addition to water above extraction limits (outlined above).

Water licences bought back from irrigators, for the environment, face the same challenges.

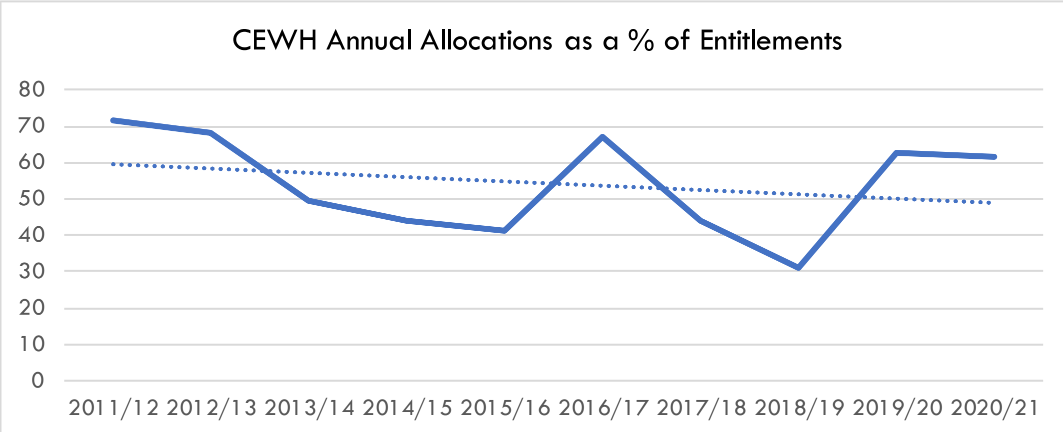
Environmental water holders are subject to the same long-term trends of declining water licence reliability as experienced by irrigators (as outlined in Part 3). Simply – water licences bought back from irrigators for the environment maintain their characteristics, including their place in the water allocation hierarchy.

This means that during droughts, when allocations for lower security licences are on a zero allocation, these same licences owned by the environment also do not receive an allocation. This is because the licence remains the same 'product' regardless of who owns it – irrigator or environmental water holder.

This also means that over the long term, just like irrigators, the CEWH (and state environmental water holders) will also need to adapt to a future of declining water allocations against its held entitlements. The below diagram shows the CEWH's actual annual allocations as a proportion of entitlements owned, showing a declining trend.

[44] https://www.awe.gov.au/water/cewo/about/water-holdings

Figure 14: CEWH Annual Allocations as % of entitlements[45]



Similarly to other water users, environmental water holders will need an emphasis on 'doing more with less'. Recommendations include: (i) a dedicated climate change work program by the CEWH to identify, and continue to improve, best management practices to optimize environmental outcomes with this public asset under climate change scenarios; and (ii) collaboration with other water users to better understand climate change risks to water licences, and how and when co-beneficial outcomes can be achieved.

Image: Black cockatoos near a cotton crop (Barwon-Darling)

Whilst HEW has undoubtedly delivered many well-documented positive environmental outcomes as an <u>environmental management tool</u> since these water recovery programs were initiated under the Murray-Darling Basin Plan and earlier programs, the ability for 'buybacks' to act as a <u>climate change management tool</u> is highly doubtful. This is because:

[45] Notes:

1. The CEWH owns a portfolio of various entitlements, of varying forms of security, across all valleys.
2. During this period, entitlements were continuing to be purchased and were accumulating.
3. This trend is impacted by both climatic and policy drivers, and thus is indicative only.

- ☐ The declining trend of water allocated to water licences, means diminishing returns for the asset;
- ☐ The relative proportion of water within a water source that is ‘licensed’ is relatively small, and there are greater opportunities for environmental improvement through the management of water above extraction limits, such as PEW.
- ☐ The automatic climate change response mechanisms already reduce (or even cut off) extractive water users during droughts – including environmental water holders (arguably counter to objectives if it is used in future as a climate change management tool);
- ☐ Water is not actually available to lower-security licences when it is arguably needed most (i.e. during droughts), regardless of who owns the licence.
- ☐ The increasing price of water because of decreasing supply and increasing demand raises questions of cost-effectiveness.

Part of ‘doing more with less’ will also require collaboration and partnerships to maximize opportunities.

Part 7 What's next

CHAPTER 7) WHAT'S NEXT

The **key recommendation** is that future water management decisions (including any 'Basin Plan 2.0') must be informed and evidence-based, including by: recognizing this existing framework and automatic response mechanisms and the impacts this will already have under current settings. This is critical not only for water security for agriculture, but to ensure any measures can even be effectual.

This is, of course, not to suggest there's nothing more that needs to be done. In fact, even with this advanced system of water sharing, the highest priority users will still face water insecurity at times. Further ways to support those users are necessary, such as secondary town water supply options, town water delivery efficiencies, and ensuring infrastructure is adequate across regional and remote areas to supply current and future demand.

Further, the trend of declining reliability of water licences means irrigators want to be, and must be, at the forefront of conversations on climate change – both mitigation and adaptation. Further progress is needed to support the industry to both adapt to a changing climate, but also to be part of the solution.

MITIGATION

- An economy-wide target of **net zero emissions by 2050**, preferably earlier, must be set and met at the earliest feasible opportunity.
- Support the **industry to transition to a carbon-neutral footprint** (which we recognize as both a responsibility, but also essential so our industry remains globally competitive to meet shifting consumer demands and expectations into the future). For example, Government investment to:
    - Develop and deliver a simple and practical tool for farmers to calculate their carbon footprint;
    - Subsidise farmers to transition to achieve best-management-practices with respect to carbon management.
- Explore currently under-utilised opportunities for the **industry to be part of the solution** for mitigation.

ADAPTATION

- Re-introduce government extension officers to assist farmers to adapt to continually improving best-management-practices, particularly relating to water and carbon management.
- Greater investment in Research, Development & Extension.
- Maximise food and fibre production at times when water is available:
    - Ensure irrigators can use up to Sustainable Diversion Limits;
    - Crack-open the allocation blackbox to identify and address additional policy drivers that are eroding water reliability beyond climatic drivers.
- Incentivise renewable-energy sources on-farm, for both farm and other purposes (such as to supplement agricultural income, particularly in years of low production).
- Investment in secondary town water supplies for regional communities will be necessary, particularly in drought-prone regions, or towns with dated infrastructure

- Exploration of improvements to the management of water above extraction limits to better achieve environmental outcomes.

OTHER - WATER LITERACY

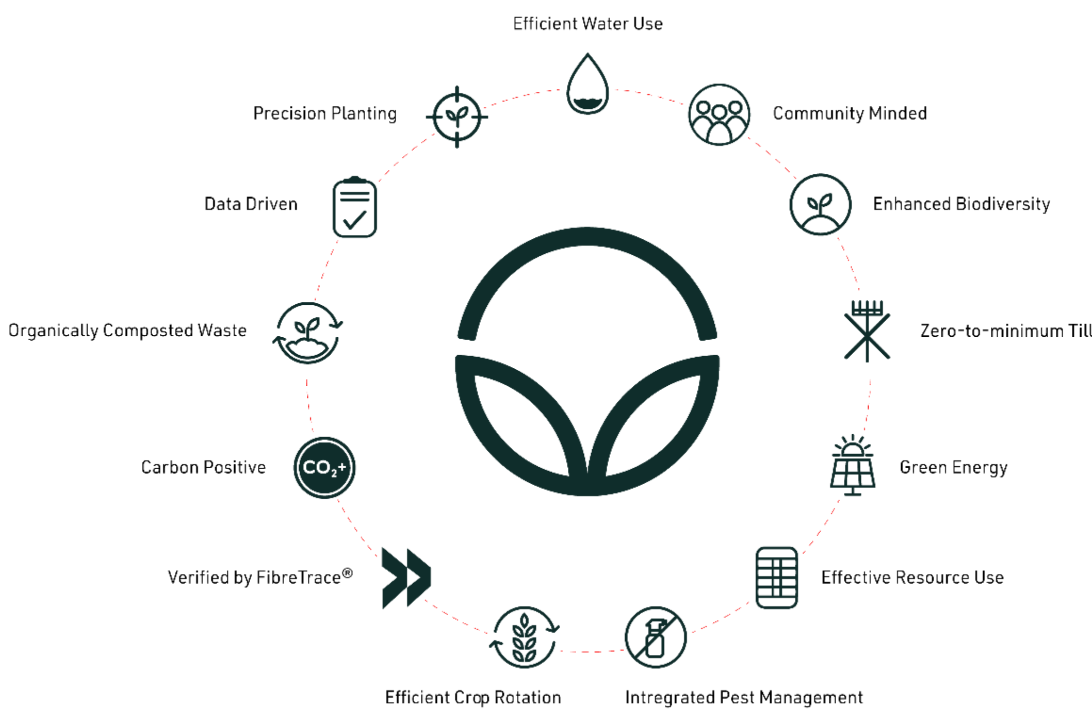
- Educate people about water sharing arrangements, and what this means for water users, to avoid ‘conflicts’ or ‘antagonisms’ towards industry based on misunderstandings of water sharing frameworks;
- Agencies to take a more active, and proactive, role to counter misinformation about water management, and rebuild confidence through education.

CASE STUDY OF WHAT'S POSSIBLE: (1) CLIMATE POSITIVE FARMING

" Good Earth Cotton® sequesters more carbon than it emits through its entire life cycle, creating a net climate positive result."

"Good Earth Cotton®"[46] is a modern regenerative farming program that empowers global producers, communities, and members of the textile supply chain as agents of change through an environmentally beneficial approach to global cotton and agriculture.

The home of Good Earth Cotton® ("Keytah") is located near Moree in north-western NSW, between the Gwydir and Mehi rivers, and is one of the largest cotton producing properties in Australia.



46 https://www.goodearthcotton.com/

The farm reliably produces cotton with a ***climate positive*** result.

Climate positive goes a step beyond 'carbon neutral' (where net greenhouse gas emissions are equal to zero), in that total carbon sequestered is more than total carbon emissions. This climate positive output contributes to offsetting subsequent emissions per bale associated with shipping and downstream processing of the cotton lint.

Good Earth Cotton® is third party audited by Carbon Friendly (Dr Francois Visser), utilising an Australian developed but internationally accredited (ISO14064-2) best practice methodology.

The results are very positive with the latest data from 2021-22 showing **net GHG emissions of -248.6 kg CO2e per bale!**

Net GHG emissions of the reporting year *(Accounting for emissions sources and sinks)*	**-248.6 kg CO_2e** per bale
Total GHG emission reductions *(Accounting for uncertainty)*	Keytah cotton production system: **4,983 tCO_2e** per year
Total GHG emission removals *(Accounting for uncertainty)*	Keytah cotton production system: **5,054 t of CO_2e** removal in 2020/21 compared to 2017/18

Good Earth Cotton® is driven by data and transparency, with rigorous measurement. The below figures show some of this data from the "Keytah" farm.

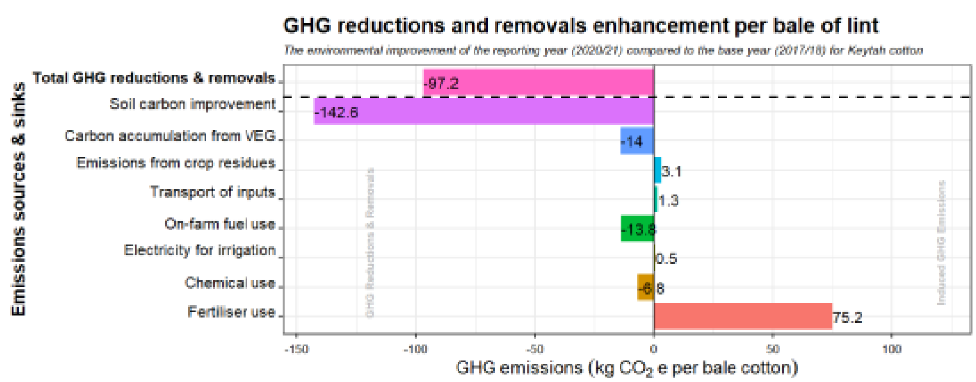


Figure 3. Greenhouse gas emission reduction and removal enhancements per bale of cotton produced between the base year (2017/18) and the reporting year (2020/21)

2019

Max % SOC = 0.613%
Min % SOC = 0.174%
Average % SOC = 0.439%

2022

Max % SOC = 0.686%
Min % SOC = 0.0239%
Average % SOC = 0.528%

This is a great example showcasing what's possible (and already underway) at the climate change and agriculture nexus.

CASE STUDY OF WHAT'S POSSIBLE: (2) GLOBAL LEADERS IN WATER EFFICIENCY

Irrigation farmers in Australia are recognised as world leaders in water efficiency.

For example, according to the Australian Government Department of Agriculture, Water and the Environment:

"Australian cotton growers are now recognised as the most water-use efficient in the world and three times more efficient than the global average."[47]

"The Australian rice industry leads the world in water use efficiency. From paddock to plate, Australian grown rice uses 50% less water than the global average."[48]

Annual crops such as cotton or rice are entirely dependent on water for irrigation being made available. When there is low or zero water availability, these crops are not grown.

[47] https://www.awe.gov.au/agriculture-land/farm-food-drought/crops/cotton
[48] https://www.awe.gov.au/agriculture-land/farm-food-drought/crops/rice

Rice

Did you know?

Australian grown rice uses 50% less water than the global average.

Australian rice growers have improved their water use efficiency for rice production in Australia by 60% in the last 10 years. Australian rice growers on average have increased their water use efficiency from 0.5 tonnes of rice produced per megalitre back in 1991 to close to 1 tonne per megalitre in recent years.[49]

The industry is now aiming even higher, to double water productivity from 0.8t/ML to 1.5t/ML by 2026.[50]

Water use per hectare of rice grown continues to decline because of the industry's commitment to developing high yielding rice varieties that use less water, and the use of world's best management practices.[51] Australian rice growers surpassed the international average production of 5.4 tonnes per hectare 45 years ago.

The water efficiency and highly regarded sustainability of Australian grown rice is a result of the industry' research and development investment and partnerships.

For example, direct drilling has become a widely adopted method of planting in the industry (a method of planting rice that involves directly placing the seed into dry ground before then flushing the paddock with water) as it allows the rice farmer to use less water – but additionally, can produce two and half times less methane emissions from rice production than aerial seeding.[52]

The type of rice grown in Australia is different to that which is grown in Asia (we specialise in medium grain rice - a niche variety of rice only grown in a handful of countries). Rice varieties grown in Australia have been specially developed to the conditions of southern NSW, the main growing region.

Around 2,000 family-operated farm businesses grow rice in the Murrumbidgee and Murray valleys of NSW.

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49 https://www.sunrice.com.au/water-efficiency/
50 AgriFutures Rice Program Strategic RD&E Plan (2021-2026).
51 https://www.rga.org.au/common/Uploaded%20files/RGA/Publications%20and%20Factsheets/Rice-and-Water-2014_Web.pdf
52 https://www.sunrice.com.au/water-efficiency/

Bitterns in Rice Project

Image: Sourced from Bitterns in Rice Project[53]

The Bitterns in Rice Project is about farming and wildlife conservation working together.

The Bitterns in Rice Project is a collaboration between the Rice Growers' Association of Australia and Birdlife Australia.

"Since 2012, we have been uncovering the well guarded secrets of Australia's Bunyip Bird – the ***globally endangered Australasian Bittern*** *– and raising awareness of its plight. We now know there is a large breeding population that descends on the rice crops of the NSW Riverina each year. In most years, it numbers between 500 and 1000 mature individuals. This is remarkable, as there are only 1500-4000 remaining in the world; Australia, New Zealand and New Caledonia."*

"Our vision is to see bitterns and other significant wildlife prosper alongside rice-growing in the Riverina. We want to demonstrate that ***food production and wildlife conservation can work together****, building on the existing habitat values of rice crops. As global demand for food continues to grow, the* ***need to better incorporate biodiversity into agriculture*** *also grows. Dedicated conservation areas, such as fenced-off wetlands or national parks, are central yet inadequate in conserving biodiversity, and the potential role of agricultural wetlands to complement traditional conservation reserves is increasingly recognised in Australia. Much of the land and water in the Murray-Darling Basin is managed for either food production or the environment, yet here is a clear* ***opportunity for co-management****."*

"Crucially, we have the ***support of hundreds of rice farmers****, many of whom feel the habitat values of rice-growing have been overlooked and are delighted to be able to produce a high quality food, supporting threatened species at the same time."*[54]

[53] https://www.bitternsinrice.com.au/about-birp/
[54] https://www.bitternsinrice.com.au/about-birp/

Cotton

Did you know?

Australian cotton growers are three times more water efficient than the global average.

This makes Australia's cotton industry is one of the most water efficient industries in the world.

Cotton water-use efficiency has increased by approximately 240% since the 1970's.

Water-use productivity by Australian cotton growers improved by 48% since 1992.

Cotton's average irrigation requirement is 6-7 megalitres per hectare (ML/ha), which is comparable to other irrigated crops (i.e. not particularly 'thirsty' as is often described).

NSW DPI, in partnership with the Cotton Research and Development Corporation, has been monitoring water productivity in irrigated cotton over the past three decades. This shows that:

- There has been a 97% increase since 1992 in the number of 227kg bales of cotton lint produced per megalitre of water, meaning growers are using just about half the water they used to, to produce each bale. Leading cotton producers can now grow nearly two 227kg bales of cotton per megalitre of water – almost double the industry average of a decade ago.
- The industry's Whole Farm Irrigation Efficiency has significantly improved and is now 81% compared to 57% in the late 1990s, indicating more water than ever is being used by the crop instead of being lost on-farm.

The Australian cotton industry has achieved a steady increase in yield from less water over time, meaning more cotton fibre can be produced using less water per hectare than ever before.

The CSIRO breeds cotton varieties appropriate for Australian and regional conditions.

Industry-wide water productivity is now being monitored and benchmarked annually.

Approximately 90% of Australia's cotton businesses are family farms.

Part 7 Conclusion

CONCLUSION

Climate change is undoubtedly one of the greatest risks to water security in the 21st Century, and one of the most significant risks to the future of irrigated agriculture in NSW.

Our industry needs to be, and wants to be, part of the climate change conversation – for both mitigation and adaptation.

Irrigators are on the frontline of climate change, and when it comes to water resources, are the first to have the tap turned off when conditions turn dry.

The industry and our regional communities are concerned that the systems of water sharing in NSW are not well understood, and some of the (albeit well-intended) calls for changes to water sharing would not be able to provide any more water to higher-priority needs at times of water scarcity – because quite simply – the industry does not have water at these times either.

The recent experience of our industry over the past two decades has been concerning, and the future outlooks are sobering, at both ends of the climate extremes.

There are also currently under-utilised opportunities for the industry to be part of the solution for mitigation and scope to support the industry to transition to a carbon-neutral footprint (which we recognize as both a responsibility, but also essential so our industry remains globally competitive to meet shifting consumer demands and expectations into the future). Water security is key to underpin this role.

With the automatic climate response mechanisms already in place in our water sharing frameworks, new and innovative approaches will be needed to ensure the industry can continue to feed and clothe the world's growing population and contribute to every one of the UN Sustainable Development Goals under climate change scenarios.

This calls for both mitigation and adaption measures. It also calls for a more sensible, informed, and effective conversation on the climate change and water management nexus.