Hughenden Irrigation Project - Detailed Business Case

Sustainability Report

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HIPCo

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Contents

1. Energy

1.1 Floating Solar PV

One of the bigger sustainability issues that surface water schemes face in this part of Australia is evaporative losses. This section considers the opportunity for a floating solar photovoltaic scheme that will take advantage of the dam surface area, provide low-carbon energy for the scheme operation and reduce evaporative losses for the project. A land based solar scheme has already been included in the base costs however further work will be required to assess if a floating solar scheme will provide benefit over and above the land-based variant.

The average annual evaporative storage losses from the project will represent a significant loss from the system at ~38 GL/y of the average irrigation supply for the grazier support scenario and 44 GL/y for the diversified cropping scenario. These losses are 28 and 24 per cent of average annual diversion inflows to the water storage.

The relatively high evaporative losses are a contributing factor behind the costly need to augment the project with groundwater to ensure irrigation water supplies in years of consecutive drought and failed wet season rains. HIPCo is continuing to look at ways of minimising these losses including more efficient/deeper/less surface area refinements to the base case. HIPCo are also working with council to assess the potential for Managed Aquifer Recharge (MAR) opportunities.

One possible option to reduce evaporative losses at least partially and potentially eliminate or significantly reduce the need for groundwater is to utilise the dam (and weir) as a platform for floating solar PV. It is impractical to consider a proposal to completely cover the impoundment area with panels, but a more modest solar PV installation may reduce evaporative losses in cost effectively way.

For reference, the largest floating solar PV project in the world is being constructed on the Indonesian island of Batam at 2.2GW and when completed will cover 16km2 of a local reservoir or about one third the size of the proposed Saego Dam at full capacity. The project cost is $2.7 billion and is paired with 4,000MWh of battery storage. The project will provide renewable energy to Singapore via an undersea cable, a component and cost that is not suitable or required at Hughenden.[1] Accordingly, if a floating solar PV sub-project is pursued it would be a smaller, fit-for-purpose scale.

Matters of efficiency, costs and comparisons with land-based systems will be undertaken during the remaining phases of the project. Given this level of detail is yet to be completed, no decision has yet been made on implementing a floating solar project. However, given the significance of the evaporation rates it will be assessed further post DBC Figure 1.1 shows an example floating solar PV installation.

Figure 1.1: Floating solar PV installation (Source: Offshore Engineer)

Renew Economy. 2021. World's largest floating solar farm – more than 2 GW to supply Singapore.

[1] Renew Economy. 2021. World's largest floating solar farm – more than 2 GW to supply Singapore.

Renew Economy. 2021. World's largest floating solar farm – more than 2 GW to supply Singapore.

Renew Economy. 2021. World's largest floating solar farm – more than 2 GW to supply Singapore.
https://reneweconomy.com.au/worlds-largest-floating-solar-farm-more-than-2gw-to-supply-singapore/amp/

1.2 Kennedy Energy Park

Kennedy Energy Park is a wind, solar and energy storage facility at Hughenden. The wind and solar resources are world class and are complementary to such an extent that when combined they can supply energy to the grid with reliability beyond the capability of other Australian based projects.[2]

Commencing with the "proof-of-concept" Kennedy Energy Park project of 15 MW solar, 43.2 MW wind, plus 2 MW of storage, the ultimate plan is to construct up to 1,200 MW of renewable energy generation in the region, which would deliver significant benefits to North Queensland and Australia in reduced emissions and sustainable energy generation.

Collectively the renewable energy generation would provide electricity for an equivalent of 800,000 homes. The improvements in reliability and reduced dependency on power from the southeast of the state will also greatly assist to promote industry and business development in the region.

The location for Kennedy Energy Park at Hughenden was selected by Windlab as the region has one of the nation's highest levels of solar irradiance that can be connected into the electricity network and possesses a world class complementary wind resource.

On a typical day the solar resource increases in the morning as the wind slows down, and in the evening as the sun is setting the wind picks up and continues to generate steady power throughout the night. The result of this complementary relationship is highly reliable renewable electricity generation that overcomes the intermittency so often associated with wind energy or solar energy alone.

Kennedy Energy Park will connect into the Cape River to Hughenden 66 kV transmission line, which runs adjacent to the project site and the electricity generated will meet the demand of the local region stretching from Julia Creek through to Charters Towers.

The installation has only recently commenced operation and in a limited capacity. HIPCo will consider approaching Windlab to discuss opportunities to purchase power as opposed to establishing renewable infrastructure on the project itself. Windlab may also be interested in the available surface area of the dam for panel installations. This could provide economic benefits and efficiencies to both organisations.

1.3 CopperString 2.0

The proposed high voltage transmission network that will connect Queensland's North West to the National Electricity Market, the CopperString 2.0 project, is due for completion in 2024, supporting 750 construction jobs and 3,560 long-term indirect jobs. This timing aligns well with HIPCo construction schedules and may allow access to long term renewable energy sources.

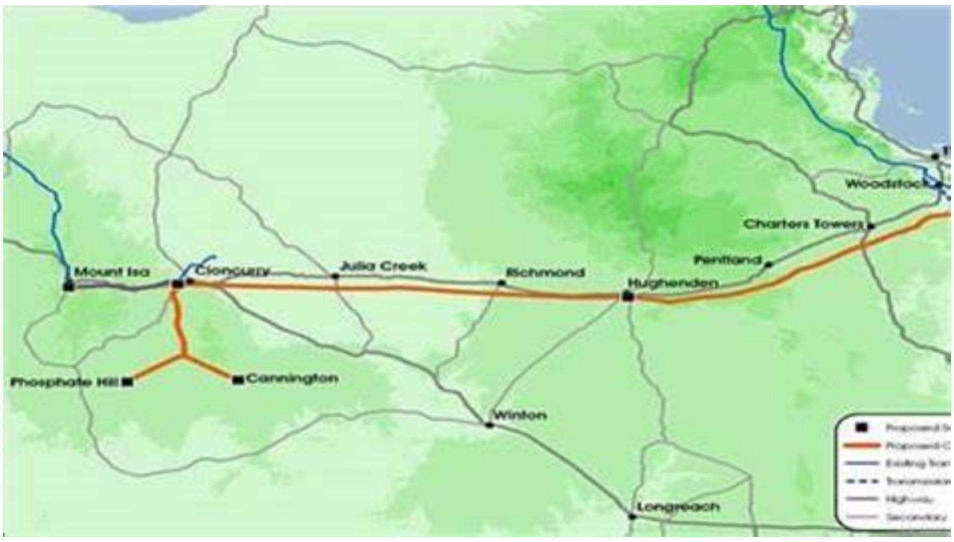
CopperString 2.0 will extend the national transmission grid through a 1,100km power network, which will not only create greater energy security, but it will also power the growth of new opportunities for minerals, industrial manufacturing, clean energy large-scale agriculture and greater access to faster broadband at a time when governments around the world are intensely focused on secure mineral supply.

CopperString 2.0 development priorities are:

- Finalise the remaining items under the Implementation Agreement with the Queensland Government, as committed to during the 2020 State election
- Finalise relevant environmental approvals and engagement with traditional owners and landholders
- Finalise negotiations with the Northern Australia Infrastructure Facility on its financing offer for CopperString

[2] Windlab Pty Ltd. windlab.com/our-projects/kennedy-energy-park/

- Finalise the Federal Government-funded study into the potential of CopperString 2.0 to support the development of a "clean industrial ecosystem" across the Townsville to Mount Isa corridor and the North West Minerals Province



HIPCo has approached the CopperString proponents and will undertake further discussions during the preconstruction phases to optimise costs and benefits for the project.

1.4 Hydrogen

The Australian Renewable Energy Agency (ARENA) states that 'when it (hydrogen) is produced using renewable energy or processes, hydrogen becomes a way of storing renewable energy for use at a later time when it is needed',

The Australian Hydrogen Strategy and Low Emissions Technology Statement provide context at introducing more green energy into the grid and lowering carbon emissions. Given hydrogen can be stored as a gas and delivered through existing natural gas pipelines or when converted to a liquid or another suitable material, hydrogen can also be transported on trucks and in ships. This means hydrogen can also be exported overseas, effectively making it a tradable energy commodity.

On face value there may be many primary and secondary benefits to reduce evaporation, make more water available for irrigation, renewable energy production or utilisation and to generate hydrogen from the same set of assets.

The potential advantages of a hydrogen manufacturing facility on site can be summarised as:

- high irradiance levels at Hughenden for relative low-cost solar PV
- water provides cooling effect for higher efficiency and lower cost
- water allows use of bifacial panels for higher efficiency and lower cost
- water production from cutting evaporative water losses leads to lower levels of groundwater use and lower costs across the irrigation project
- hydrogen export facility nearby at Townsville.

The cost of the required assets is likely to be substantial and in excess of the total amount required for the irrigated agriculture assets. Therefore, the investigation will be done in stages to ensure alignment with the Federal and State Government initiatives. If it is feasible, it would be the subject of its own business case and evaluation.

2. Climate

2.1 Resilience and Climate Change

This section provides climate projections for Hughenden and is the output of the Queensland Government's long paddock climate projection model.[3] The data presents information based on SILO[4] historical climate data and Consistent Climate Scenarios (CCS) projections data developed by the Queensland Government.

Annual and monthly climate projections data for 2030, 2050 and 2070 have been generated using 28 AR5 global climate models (GCMs), three model sensitivities to CO_2 rise (low, medium and high warming rates) and four Representative Concentration Pathways (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5) which specify CO_2 levels from 435 to 449 ppm for 2030 and from 478 to 677 ppm for 2070. The baseline climate is the period between 1960 and 2015.

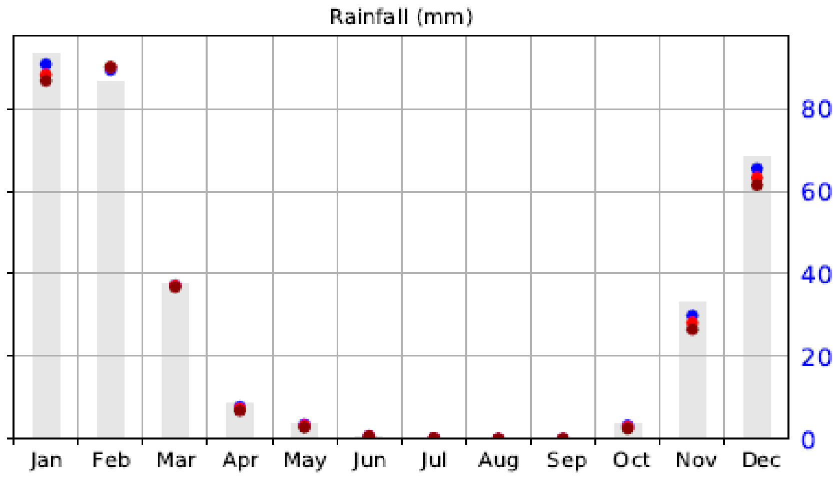
Figure 2.1: Historical and projected climate summary for Hughenden

Historical and projected annual climate summary

Climate Variable (Median Annual)	Historical 1960-2010	Projection 2030	Projection 2050	Projection 2070
Rainfall (mm)	488.7	473.1	453.9	440.6
Evaporation (mm)	2388.1	2530.6	2612.0	2683.4
Mean Temperature (°C)	23.7	24.8	25.5	25.9
Maximum Temperature (°C)	30.8	31.9	32.5	33.0
Minimum Temperature (°C)	16.8	17.8	18.4	18.9
Average Vapour Pressure (kPa)	15.7	16.6	17.1	17.6

The monthly median values for the historical climate (1960 -2015) and climate projections for 2030, 2050 and 2070 are presented in the bar-dot graphs (Figure 2. 2 and Figure 2.3) that indicate the seasonal patterns of historical climate and projected climate under the different global warming rates and scenarios in 2030, 2050 and 2070.

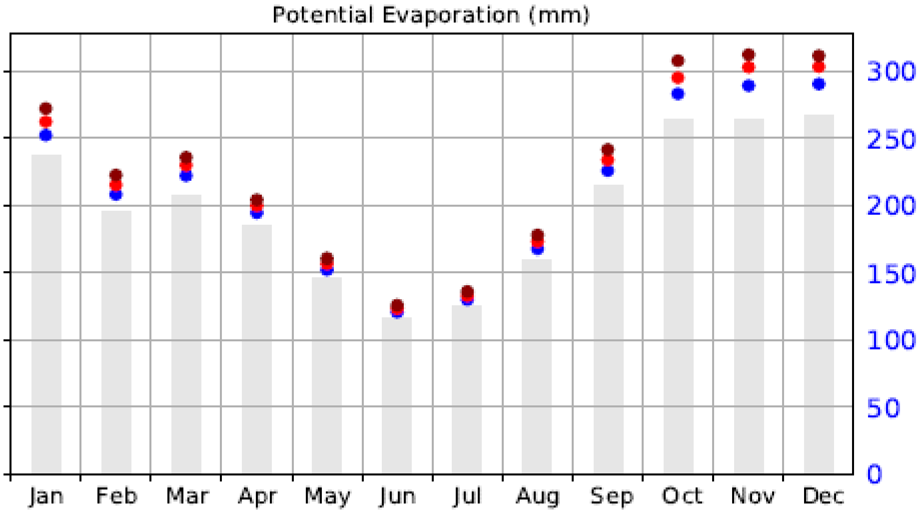
Figure 2. 2: Historical and projected rainfall at Hughenden



[3] Queensland Government. Department of Environment and Science. Long Paddock. www.longpaddock.qld.gov.au/qld-future-climate/dashboard/
[4] Queensland Government. Department of Environment and Science. SILO. www.longpaddock.qld.gov.au/silo/

Historical median 2030 median 2050 median 2070 median

Figure 2.3: Historical and projected evaporation rates at Hughenden



Historical median 2030 median 2050 median 2070 median

The evaporation rates in Figure 2.3 are driven by rainfall and temperature and show the greatest change over the late spring and summer months, particularly in early summer before the onset of the rainy season and increasing cloud cover.

The results for annual projections as shown by the projected annual climate range plots (Figure 2.4 and Figure 2.5) indicate projected rainfall and temperature results under the different global warming rates and scenarios.

Figure 2.4: Historical and projected rainfall variability at Hughenden

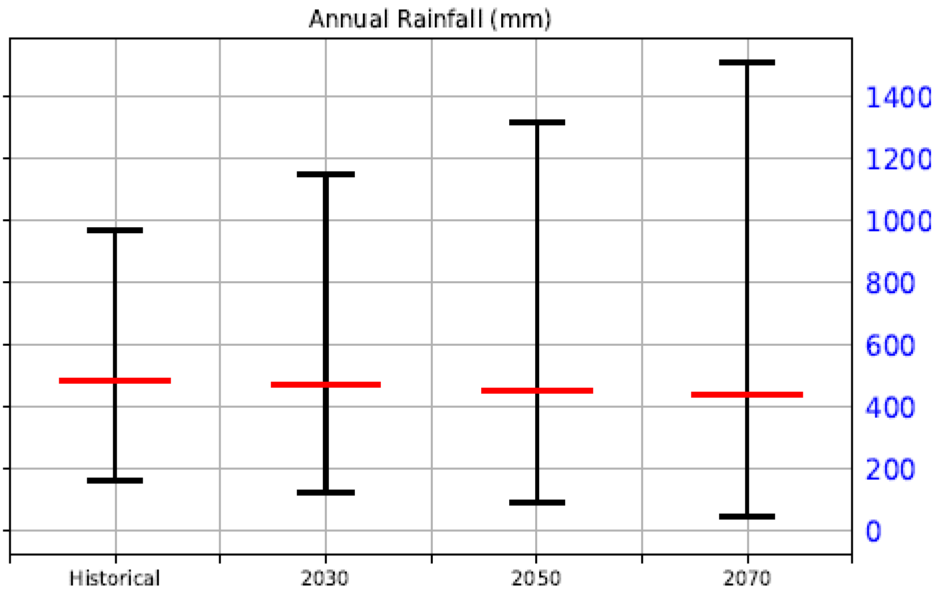


Figure 2.4 highlights increased rainfall variability over the higher CO_2 scenarios modelled. The risk of rainfall being significantly higher than the mean is greater than for lower rainfall. This indicates that most years are projected to have below average rainfall interspersed with years of very high rainfall.

Figure 2.5: Historical and projected maximum temperature variability at Hughenden

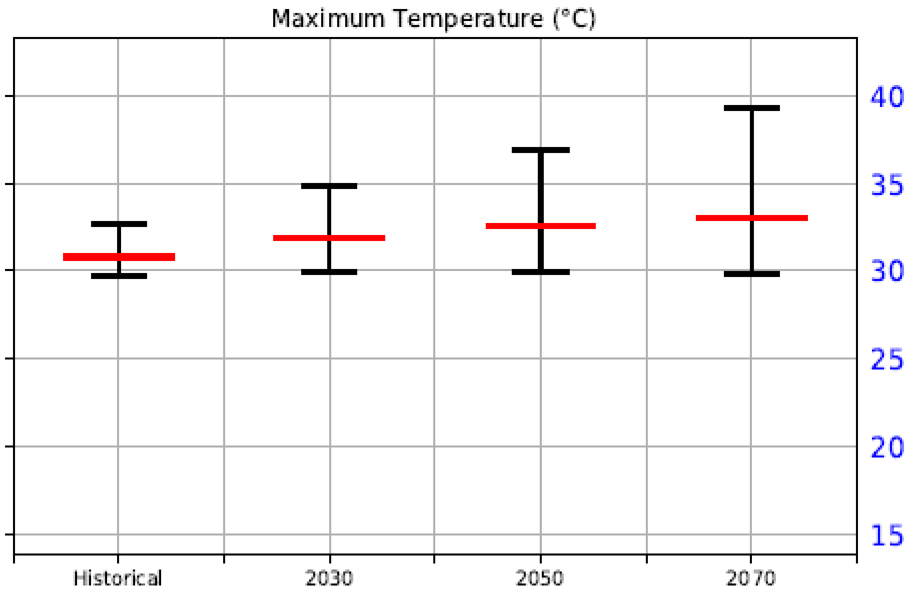


Figure 2.5 illustrates that higher maximum temperature extremes are more likely under each of the scenarios modelled than lower than average maximum temperatures, which is consistent with the overall warming projections at Hughenden.

2.1.1 Risk management

The process of developing the Impact Risk Matrix is a structured way of identifying impacts, risks, and opportunities associated with climate change for a particular industry and location.

The 'risk matrix' is one risk management approach that can help identify the impacts, adaptive responses and risk and vulnerability associated with climate change. Identifying and analysing risks and opportunities, using this risk management approach, can help to plan responses to climate variability and change and can enable organisations to be proactive and more effective in adapting to future uncertainty.

This Impact Risk Matrix at is based on the Australian climate change impacts and risk management guide[5] and can be used to help identify:

- impacts of climate change in the context of the project and the agricultural economy it establishes
- the level of risk or opportunity presented by the climate change impacts
- possible adaptation responses that could be implemented
- how vulnerable the project is to any risk presented by climate change
- how to communicate the key risks and vulnerabilities to others in the community, government and stakeholders
- how to develop an action plan to respond to the risk and vulnerability of climate change.

[5] Australian Government. Department of the Environment and Heritage. Australian climate change impacts and risk management: a guide for business and government. www.environment.gov.au/system/files/resources/21c04298-db93-47a6-a6b0-eaaaae9ef8e4/files/risk-management.pdf

Armed with this assessment and by revisiting it periodically, users will be better prepared to take action and adapt to a more variable climate and climate change impacts.

An Impact Risk Matrix (an example for the grazing industry in Hughenden is given in Table 2.1: Risk matrix for climate change at Hughenden) describes the impacts of climate change variables (y-axis) on elements of a business, region or industry (x-axis). Darker brown colour shading indicates risks of greater magnitude. Blue shading indicates positive risks or outcomes.

Table 2.1: Risk matrix for climate change at Hughenden

Element of the industry	Pasture growth	Surface cover	Plant available water capacity	Wind erosion	Rural human health and well-being	Biodiversity
More days over 35°C	Decrease in pasture growth	Decrease in surface cover	Reduced plant available water capacity due to a reduction in water availability/surface cover	Increased wind erosion due to lower surface cover	Large decreases in rural human health and capacity to cope at current rate of functioning	Changes in plant structure and species composition
More droughts	Severe reduction in pasture growth	Severe reduction in surface cover	Severe reduction in plant available water capacity due to reduction in water availability/surface cover	Increased wind erosion due to lower surface cover	Large decrease in human health, potential for stress related incidence	Major changes in plant and animal species composition
Increased storm intensity – same total rainfall	Decrease in pasture growth	Decrease in surface cover	Decrease in plant available water capacity	Increased wind erosion due to lower surface cover	No change	Changes in insect and plant species composition, siltation of waterholes
Decrease in winter rainfall	Minor decrease in pasture growth	Minor decrease in surface cover	Minor reduction in plant available water capacity due to lower water availability/surface cover	Minor increase in wind erosion due to lower surface cover	Minor decrease in rural human health	Major changes in plant and animal species composition
Decrease in summer rainfall	Severe reduction in pasture growth	Severe reduction in surface cover	Reduced plant available water capacity due to lower water availability/surface cover	Severe increase in wind erosion due to lower surface cover	Large decrease in human health, hardship and welfare, potential for stress related incidence	Changes in plant and animal species composition
More wildfires	Increase in pasture growth	Decrease in surface cover	Decrease in plant available water capacity due to lower surface cover	Increased wind erosion due to lower surface cover	Decrease in human health and welfare related issues	Changes in plant structure and species composition
Higher peak wind speeds	Decrease in pasture growth due to higher evaporation and erosion of topsoil especially in arid and semi-arid regions	Decreased surface cover due to higher evaporation, erosion of topsoil	Decrease in plant available water capacity due to lower surface cover (reduced infiltration into soil)	Increased wind erosion due to higher peak wind speeds	Decrease in human health and increase in welfare related issues	Damage to some tree and animal species
Overall estimate for the risk averse	Reduction in pasture growth	Decrease in surface cover	Decrease in plant available water capacity	Increased wind erosion	Decrease in human health and increase in welfare related issues	General negative long-term effects on ecosystem function

Adapted from Queensland Government. Climate change risk management matrix: a process for assessing impacts, adaptation, risk and vulnerability

2.1.2 Adaptation

Australia is among the most exposed to climatic extremes. Australia's climate will change over the coming decades. Increases in the frequency or intensity of various extreme events in many parts of Australia are likely, including heat waves, droughts, cyclones, floods and bushfires.

Adaptation is the principal way for irrigators to respond to a more variable climate. Adaptation presents new challenges for business and policy decision-makers—it will take time to build the skills and knowledge on how best to adapt and for implementation of decisions to make a difference. Adaptation complements mitigation – which for the project is focused on reducing greenhouse gas emissions at the construction and farm level and sequestering carbon in a carbon forest and in soils.

Successful adaptation to climate variability requires flexible, risk-based approaches that deal with future uncertainty and strategies that can cope with a range of possible local climate outcomes and variations. Appropriate adaption actions in the agricultural sector (as referenced in AgSap 2017) will be incorporated to support successful implementation. This means irrigators will need the capacity, confidence, technologies and tools to make business decisions to address climate change at the producer level.

In a research program funded by the Australian Government's Department of Agriculture and Water Resources[6], researchers have:

- examined systemic and transformative adaptation options
- identified plant and animal traits suitable to changing conditions
- identified and assessed novel technologies and management options
- provided cost-effective tools that enable land managers to adopt practices.

Key findings that are relevant for irrigators in the project are described below.

Agriculture has an important role in assisting Australia to meet its international obligations to mitigate greenhouse gas emissions. Agriculture can also contribute to mitigation through the storage of carbon in trees and agricultural soils, which reduces carbondioxide levels in the atmosphere.

The agricultural sector accounts for approximately 14 per cent of Australia's total greenhouse gas emissions. Agriculture's greenhouse gas emissions comprise methanefrom enteric fermentation in ruminant livestock (around 73 per cent of agricultural emissions), nitrous oxidefrom agricultural soils (around 18 per cent), emissions from livestock manure (around 5per cent) and emissions from field burning of agricultural residues, lime and urea application and rice cultivation (around 3 per cent combined).[7]

Irrigators also need to prepare for the climate changes predicted for coming years. [8]

These risks will grow - there will be more extreme weather, hotter heat waves and morefrequent droughts. The industry will have new opportunities, including for innovation, including business model innovations, new crop types and crop varieties). Farming skill, flexibility andjudgement, together with access to new practices, technologies and professional support,will allow farm businesses to reduce their vulnerability and maintain or improve their long-term productivity and profitability.

Mitigation and adaptation are often related. Many mitigation options result in direct benefits for agricultural businesses -such as improved soils or lower input costs - that strengthen the capability to manage the risks of a more variable climate.

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[6] Australian Government. Department of Agriculture and Water Resources. 2017. *Boosting farm productivity, improving soils and reduced greenhouse gas emissions – Research Findings from the Carbon Futures Programme 2010 to 2016.*

[7] Climate Council. www.climatecouncil.org.au/resources/australia-agriculture-climate-change-emissions-methane/

[8] Ibid.

In Hughenden, irrigators will have many of these mitigation and adaptation opportunities including:

- planting trees to slow evaporative losses from pasture and crops and provide shelter for livestock
- increasing soil carbon levels with the increase in organic matter storing more water in the soil profile
- planting crops such as leucaena and other legumes as a substitute for urea in pasture and hay production
- substituting nitrate for urea in cattle feed
- using solar PV for electricity needs.

2.1.3 Crops in high carbon dioxide conditions

Researchers have studied cereal, pulse (legume) and oilseed crops for resilience to heat and drought stress under elevated carbon dioxide conditions.[9] This has provided real world, validated measurements of crop water and nitrogen use under elevated carbon dioxide conditions.

This work made use of the unique Free Air CO_2 Enrichment (FACE) facilities in Horsham, Victoria, to grow crops under the atmospheric carbon dioxide concentration forecast for by 2050 (40 per cent above 2015 levels). Static heat chambers were imposed over the crops for short (3-day) periods to simulate extreme heat events.

These studies found that growth, yield and resource use (water and nutrients) all changedsignificantly under elevated carbon dioxide. Yields can increase due to a carbon dioxide fertilisation effect, but crop nitrogen demand will also increase, potentially leading to nitrogen limitations (where leaf nitrogen and grain protein levels in cereals are generally reduced).

Water use efficiency is also generally increased under elevated carbon dioxide. Results indicate that the risks from water exhaustion are also greater because of thelarger crop canopy. This complicates the risk/benefit consideration.

2.1.4 Feed supplements

The use of leucaena (a legume fodder crop that grows in tropical and subtropical environments) has been shown to improve productivity and profitability, as well as reduced methane emissions in cattle production systems in northern Australia.[10]

Whole-farm modelling has shown an increase in gross margins by up to 37 per centand methane emission intensity down by up to 17 per cent compared with a base farm without leucaena. This was a result of higher farm production through increased herd sizeand faster liveweight gain.[11]

In Queensland trials near Rockhampton, cattle grazing on both pasture and leucaena had growth rates up to 22 per cent higher than cattle grazing on pasture only. The cattlefeeding on leucaena also produced up to 20 per cent less methane.

Many cattle producers, particularly in northern Australia, feed non-protein nitrogento cattle (in the form of urea) during the dry season to improve animal productivity. Substituting nitrate for urea has been shown to have the added benefit of reducingmethane emissions. An abatement method for the use of nitrates has been approvedunder the Emissions Reduction Fund. This method is best suited to cattle in northernAustralia that typically consume a high fibre low nutrition diet over summer.

Feeding nitrates has the downside that, if too much is consumed too quickly, it is potentially toxic to cattle. A set of best management practice guidelines has been developed and released through Meat and Livestock Australia's website to help producersdecide how to feed nitrates to their herd safely.

[9] Australian Government. Department of Agriculture and Water Resources. 2017. *Boosting farm productivity, improving soils and reduced greenhouse gas emissions – Research Findings from the Carbon Futures Programme 2010 to 2016.*
[10] Meat and Livestock Australia. www.mla.com.au/
[11] Ibid.

2.1.5 Soil carbon management

Increasing soil carbon assists irrigators and farmers mitigate the effects of climate change as higher carbon levels allows soil to hold more water and nutrients. Comparisons between high and low carbon soils shows that the direct farm benefits of high soil carbon on nitrogen mineralisation and associated pasture and crop production are substantial.

Organic amendments increase the stocks of soil carbon and many amendments such as composts and manures are a good source of plant nutrients. Applying these amendments would improve sustainable land use and increased productivity. It is noted that availability of organic amendments is limited, and transport and application costs may be substantial in Hughenden.

Soil amendments such as biochar increase soil organic carbon sequestration significantly, and manures and composts marginally. Consistent yield increases were recorded in field trials from compost and biochar used in combination for sugarcane, banana, maize, papaya and peanut crops in northern Queensland.[12]

In general, land use change from cropping to pasture (especially on marginal lands) improves the long-term productivity of that land. Retention of crop residues and plant matter provides ground cover, which is essential to reduce soil erosion and soil organic carbon loss by water or wind erosion and contributes to sustainable land use.

Vegetation management for soil organic carbon provides benefits through landscape remediation. These include:

- riparian plantings to improve water quality
- plantings in (potentially) saline or waterlogged paddocks
- reforestation on degraded lands
- native tree plantings to reduce salinity downslopes
- plantings to decrease soil loss via erosion and improve soil physical and chemical properties.

Projects focused on reforestation, environmental plantings and grazing lands have also facilitated superior new soil sampling designs. By improving their understanding of the sampling intensities required, researchers minimised uncertainty in soil carbon estimates.

2.1.6 Adaptive value chains

Climate variability has significant impacts on the market availability of food and commodities. This affects the viability and resilience of farms and their networks, as well as businesses along the supply chain that produce, handle, process and market agri-food products. An adapted value chain is one where participating businesses- from farmers to retailers- are able to harness joint strategies to sustain competitive advantage in a changing climate.

Studies have identified that:

- consumers do not understand the impacts of climate variability on their day-to-day lives enough to value adaptation in food, so few marketing opportunities are currently possible
- whole-of-chain adaptation is possible and beneficial (as a risk mitigation strategy rather than a marketing opportunity)
- a non-adapted value chain can only continue to exist up to a certain point until climate and weather risk and threats, both direct and indirect, become insurmountable.[13]

These studies have developed a process to enable businesses to gauge the merits of an adaptation action against multiple, and potentially competing, priorities.

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[12] Ibid.
[13] Australian Government. Department of Agriculture and Water Resources. 2017. *Boosting farm productivity, improving soils and reduced greenhouse gas emissions – Research Findings from the Carbon Futures Programme 2010 to 2016.*

3. Water management planning

3.1 Sustainability indicators

Sustainability indicators have been used traditionally by ecologists to assess ecosystem health.[14] More recently, indicators have been broadened to gauge aspects of societies, economies, institutions, cultures and the living environment as a whole. It is this broader role of indicators that is applicable in the assessment of the sustainability of the project. The sustainability indicators should be used as part of establishing a water management plan for the project where exceedance of an indicator triggers remedial action.

Traditional biophysical sustainability indicators are provided in Table 3.1: Sustainability indicators. These indicators are useful in assessing sustainability at the farm level.

These sustainability indicators can be used to assess aspects of the biophysical sustainability of irrigation ecosystems at the field, farm, district, scheme and catchment scales. [15]

Table 3.1: Sustainability indicators

Categories	Indicators	
Healthy Soil	nutrient balance soil salinity soil sodicity pH exchangeable aluminium content soil loss soil compaction soil organic matter soil fertility artificial N requirements artificial P requirements total phosphorus trace elements % bare soil soil water holding capacity dispersive nature physical barriers to root development number of earthworms per soil unit	soil consistence soil texture soil colour water intake rate soil strength slaking and dispersion cotton strip assay total nitrogen sodium bicarbonate ($NaHCO_3$ P) exchangeable K and Na effective root depth potential for leaching of acid sulphates, salt and nutrients depth to water table % clay depth of topsoil nutrient availability microbiological diversity
Physical Water Resources	access to surface water and groundwater availability of surface water and groundwater seasonality of surface water and groundwater water supply system reliability water supply system reversibility	source water salinity, sodicity and pH salt, nutrient and pesticide concentrations water supply system vulnerability equity in water sharing water use efficiency demand as % of available aquifer and surface water volumes

[14] Bell, S., and Morse, S. (1999). *Sustainability Indicators – Measuring the immeasurable*. Earthscan Publications Limited, London.
[15] Kellett, B. M., Bristow, K. and Charlesworth, P. B. *(2005). CSIRO Land and Water Technical Report No. 01/05*

Categories	Indicators	
	maximum water abstraction rate depth to water table	spatial distribution of surface waters and groundwater
Farming and Irrigation Methods	1) matching crop requirements with water allocation 2) daily, schedule and annual water application rates 3) extent and duration of ponding 4) surface water runoff volume 5) % of crop land with reduced tillage and stubble retention 6) weather forecasting used to plan chemical applications 7) pesticide applications in grams of active ingredients according to toxicity 8) method of tillage 9) management of chemical residues 10) nutrient balance 11) implementation of best management practices 12) overall consumed ratio (water)	13) crop rotation frequency 14) fallow frequency 15) % of farm area under fallow 16) % of farm area with low input crops (green manure, legumes) 17) water stored in root zone as % of irrigation water supplied 18) agrichemicals and fertilisers used per quantity of crop produced 19) % of irrigation water supplied by tail water 20) sprinkler, low level sprinkler, micro, drip, subsoil, high rate sprays or flood irrigation 21) frequency of fertiliser application 22) application of soil conservation measures 23) chemical residue levels in produce 24) net volume of water extraction 25) frequency of pest control 26) field application ratio (water)
Site Design	27) site risk of run-off 28) average width of buffer zones between farmland and sensitive rivers, streams, lakes and or wetlands	29) extent of surface drainage 30) length of farmland edge bordering with native vegetation 31) plan approval
Water Service Provision	32) supply reliability 33) cost per ML 34) agreed service level 35) conveyance ratio 36) dependability of irrigation duration 37) effectiveness of infrastructure 38) relative change of water level	39) water supply system reversibility 40) water supply system vulnerability 41) water delivery performance 42) distribution ratio 43) dependability of irrigation interval 44) discharge ratio
Landscape Integrity	45) length of farmland bordering with native vegetation 46) rates or load of sediment, nutrients, salt and pesticides passing to surface waters 47) concentration of sediment, nutrients, salt and pesticides in surface waters 48) depth to water table 49) net salt accumulation or leaching	64) extent of bare soils 65) extent of remnant vegetation 66) rates or loads of nutrients, salt and pesticides leaching to groundwater 67) concentration of nutrients, salt and pesticides in groundwater 68) extent of cultivated area 69) extent of forested area 70) area of weeds 71) extent of salt pans

Categories	Indicators	
	50) distance between farmland and sensitive rivers, streams, lakes and wetlands 51) gully erosion index 52) number of new reports of new pests and weeds 53) level of farmland encroachment into floodplain 54) habitat and food source value of site for native fauna 55) ration of land use capacity to current land use 56) dust storm frequency 57) algal bloom frequency 58) frequency of river discontinuity 59) vegetated stream length number of access ways through riparian vegetation for stock 60) stream sinuosity 61) % habitat loss per year 62) % catchment cleared, native vegetation 63) % waterways fenced	72) extent of sodic soils 73) extent of saline soils 74) extent of crop dieback 75) crop diversity 76) extent of buffer strips for wildlife and corridors 77) soil loss per year 78) land slope 79) distance between farmland and national parks 80) in-stream invertebrates, fish, frogs, water birds population sizes and diversity 81) population sizes of feral animals 82) presence of native fauna of high conservation value 83) enterprise diversity 84) change in area of productive agricultural land 85) fish kill frequency 86) number of river structures 87) ecological survey ratings
Climate	88) frequency of cyclones and storms with potentially damaging winds 89) seasonality of rainfall	90) flooding frequency 91) median annual rainfall

3.2 Managed Aquifer Recharge

As part of the DBC HIPCo has undertaken a number of investigations into the sustainable use of groundwater and possible managed aquifer recharge application. These studies were of a limited nature given the funding and time available and therefore did not find or recommend any use of the local aquifers.

However, a consortium of councils located across North Queensland is seeking the development of groundwater research to assist in the identification of water banking opportunities to support regional development. The region of interest covers from Hughenden to Julia Creek, extending over 300 km along the Flinders River and covering an area of approximately 1.4 Million ha. Recent research by CSIRO identified the potential of the Flinders catchment to support irrigated agriculture thanks to the soils' suitability [Petheram et al., 2013]. Water availability however was recognised as a constraint due to high capital costs for surface water storage infrastructure. A report for the North Queensland Water Infrastructure Authority (NQWIA), which covered an area equivalent to only 0.3% of the region of interest, concluded limited opportunities for managed aquifer recharge (MAR) (groundwater storage) were observed around Glendalough Station [Laattoe et al., 2020]. Recent data on aquifer thickness however suggest that other areas not investigated so far around Hughenden, Richmond and downstream of the Woolgar River, show potential for groundwater storage through MAR implementation. CSIRO has recently worked on a rapid assessment of MAR feasibility at national scale for the National Water Grid Authority (NWGA). Detailed studies as the one proposed here help refine these large-scale assessments and provide more certainty to stakeholders in terms of enhanced water security at local and sub-regional scales. In this context, CSIRO is partnering with Geoscience Australia (GA) to identify opportunities for groundwater banking by employing the most advanced technological solutions supporting hydrogeological characterisation and MAR assessment.

HIPCo is supporting council to undertake this study adopting a staged approach based on the risk-assessment framework described in the Australian Guidelines for MAR Assessment, consisting of the following stages: Stage 1 Subsurface and groundwater systems characterisation and MAR/groundwater desalination feasibility assessment Stage 2 Detailed hydrogeological and MAR investigations and pre-commissioning risk assessment Stage 3: Water banking implementation through MAR.

Each stage is a gate point where knowledge about MAR feasibility is assessed and investment decisions are evaluated to progress into subsequent stages of the project. If this work shows that MARi feasible it could assist in the Sustainability Implementation Plan.

3.3 Managing Salinity and Rising Groundwater

Salinity and water quality are complex issues. Economically sound decisions about project priorities and policy mechanisms require considerable technical information, such as information about the likely level of impact of salinity in the absence of enhanced management, the timing of salinity onset, the likely reductions in salinity impacts through various forms of action, and lags in those reductions following management changes.

Given the reality of a fixed budget in most on-farm environmental and engineering programs, irrigators and landholders often face a trade-off between investing in works that will have an immediate effect – such as cleaning out a silt filled dam or irrigation channel -- and investing in actions that may have a bigger effect in the longer term such as planting trees for a salinity problem that could be decades distant.

Adoption and success more likely require a mandatory and coordinated approach such as a universal project-wide initiative, for example a levy to fund collective benefit projects including tree planting and engineering works. Under this type of initiative trees would be planted in likely impact areas as part of the project's development and protected over the long term by covenants. Tree plantings need not detract from farm productivity but rather enhance it with plantings in areas such as along fence-lines, roads and laneways, around dams, channels and water storages and other easements not required for cropping.

3.3.1 Extent of the problem

Salinity is the presence of salts such as sodium chloride, magnesium and calcium sulphates, and bicarbonates, in soil and water. Salinity is a major threat in many parts of Australia including irrigation projects in Queensland.

Its harmful effects include lost agricultural production, stream salinity and damage to infrastructure, urban households and environmental costs. Saline soils occur naturally in parts of coastal, south-west and northern Queensland.[16] However, salinity is also induced by unsuitable land management practices.

A 2001 survey in Queensland estimated 48,000 hectares were seriously affected by induced salinity (Figure 3.1). The most affected areas in Queensland are coastal or sub coastal—generally associated with basalt or granite geology, and where the average annual rainfall is 400–1200 millimetres.[17] Hughenden's geology and climate fit each of the risk categorisations although with irrigation the rainfall risk metric is purely academic.

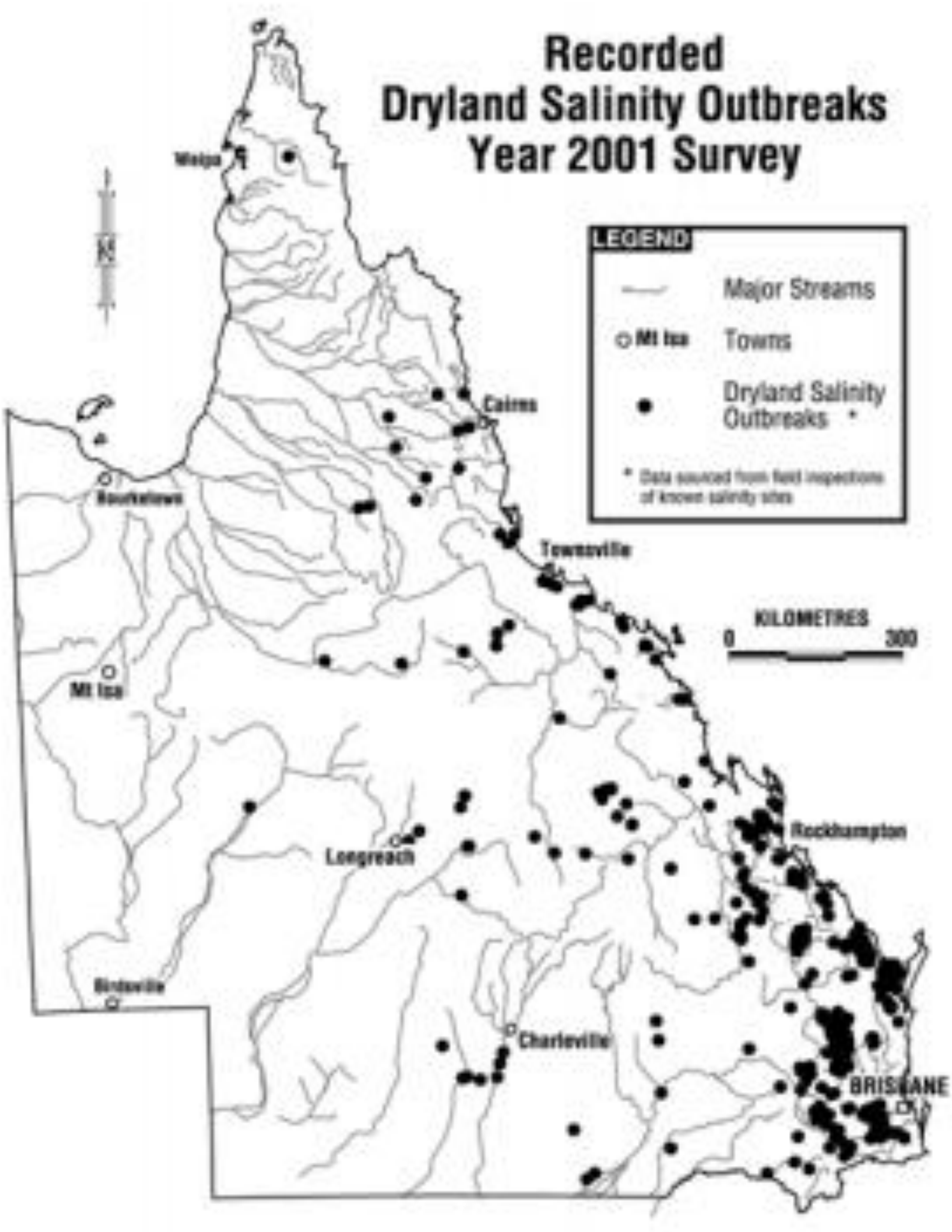
An assessment undertaken for the National Land and Water Resources Audit found 3.1 million hectares in Queensland could be affected by salinity by 2050. Under the National Action Plan for Salinity and Water Quality a salinity hazard mapping program has completed hazard maps for priority catchments:

- Burdekin River catchment and adjoining coastal plains
- Burnett Mary and western catchments of south east Queensland

[16] Queensland Government. 2010. *Science Notes - Land Series L51*. www.qld.gov.au/environment/land/soil/salinity
[17] Ibid.

- Fitzroy Basin
- Murray-Darling Basin.

Figure 3.1: Location of salinity outbreaks in Queensland (Source: Queensland Government)



The risk of salinity in Queensland may be lower than that for southern states as the summer dominant rainfall ensures higher rates of water-use through evaporation and transpiration, rather than as deep drainage (water seeping through the soil profile into groundwater flows).

The irrigation practices planned for the project will negate much of this benefit as irrigation practices significantly increase the likelihood of irrigation water seeping through the soil profile to the groundwater. Critically for the project, localised areas of salinity due to rising water-tables have occurred under irrigation around Emerald, Bundaberg, Mareeba, Ayr, Proserpine and Theodore.

Poor quality irrigation water has led to some salinity problems in the Lockyer valley and the Darling Downs. In recent years there has been an increase in the irrigation of soils derived from geologically old marine basins that are naturally high in salts.

3.3.2 Factors contributing to salinity

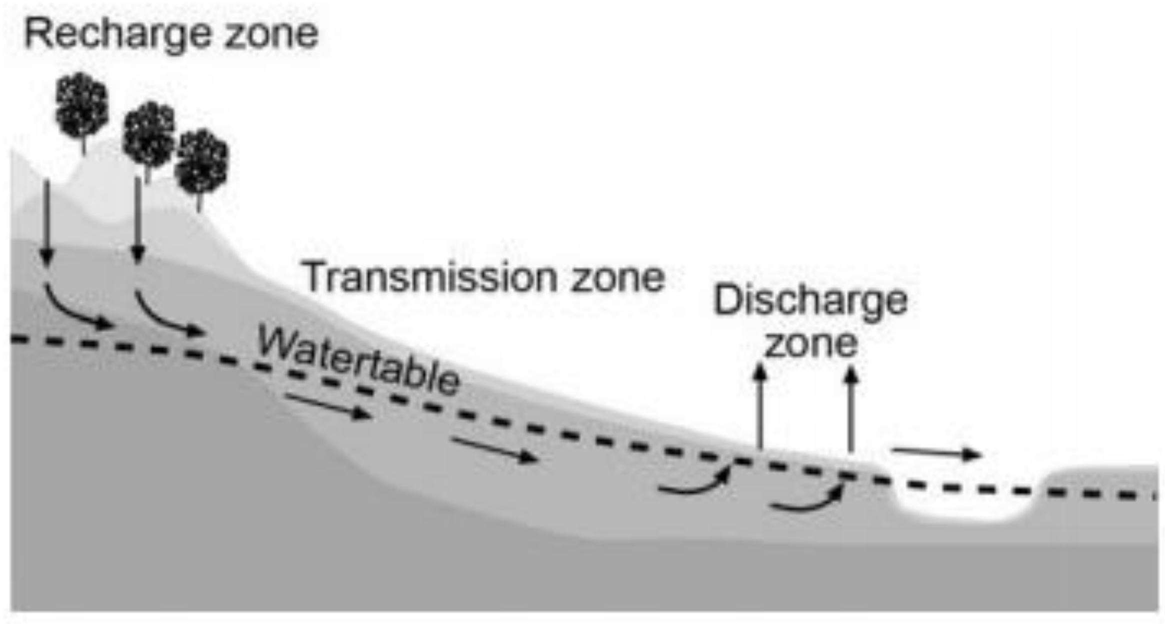
The likelihood of salinity problems developing can be affected by soil types, rainfall, topography and location within a catchment. Figure 3.2 shows the three zones of groundwater movement in a catchment. The upper catchment is the intake or recharge zone—rainwater either runs off or soaks into the soil.

Water that is not used by plants in the intake zone enters the groundwater system and passes through the transmission zone in the mid slope area. Where the water-table is high, groundwater may seep onto the soil surface at discharge areas. Salts occurring naturally in soils and groundwater may also move towards the soil surface by capillary action. Surface evaporation and use of water by plants concentrates these salts in the root zone.

In uncleared catchments, deep rooted trees use much of the rainfall, and the water-table lies well below the surface. In Hughenden, the proposed irrigation area is naturally sparsely populated with trees, however their function is partially replaced by deep-rooted native grasses including Mitchell Grass (*Astrebla sp.*).

When shallow rooted crops and pastures replace Mitchell Grass and trees, deep drainage increases, and the water-table may rise. A high salt level in soil adversely affects plant growth, and in some cases the structure of the soil. Salts may enter streams via spring flow or when run-off removes salts previously deposited on the surface by evaporation.

Figure 3.2: Recharge, transmission and discharge zones



Source: Queensland Government

Tree and native grass clearing can result in a rise in groundwater levels with salts being concentrated at the soil surface by evaporation. Irrigation can lead to salinity if water with high salt levels is used or if the excessive use of water, (particularly from surface waters) results in a rise in the water-table. The inappropriate siting of off-stream water storages including farm dams and their leaking may also contribute to salinity.[18]

[18] Ibid.

3.3.3 Salinity indicators

Salinity may become apparent over a long period of time or may occur as an outbreak after extended periods of rainfall. It is important to monitor the changes in land salinity qualitative indicators to assess the resource condition, including:

- rising groundwater levels in bores
- ground surface becoming permanently or seasonally damp, waterlogged or remaining damp after extended rain (or after an irrigation event)
- intermittent streams flowing for longer periods or in periods when they shouldn't
- dieback of vegetation in low-lying areas, or plants failing to germinate or grow
- areas of bare soil or an increase in salt tolerant plants growing on the area
- deterioration in surface and groundwater quality.

3.3.4 Risk assessment triggers

Sinclair Knight Mertz (2004)[19] developed irrigation development guidelines for the Murray-Darling Basin Commission. These guidelines were designed to make proponents and authorities aware of the information to be provided in a development application and help them to understand the evaluation process.

These guidelines are grouped by issues and biophysical attributes and constitute a risk assessment framework (Table 3.2). This framework uses sustainability indicators and threshold values to assess the suitability of potential irrigation development sites. If the assessment concludes the site is suitable for irrigation development, a site management plan and site use licence are prepared.

For the project, the risk assessment outcomes should be incorporated into the Post DBC environmental impact assessment where risks triggering the need for remedial action can be captured and implemented to ensure the project remains sustainable over the longer term. Some options for remedial actions are described later in this chapter.

Table 3.2: Risk assessment triggers for irrigation projects

System attribute or issue	Minor risk	Major risk	Not permissible
Salinity and sodicity	92) low existing water table >4m 93) deep root zone >80cm 94) low salinity groundwater <300mg/L TDS 95) low natural salt in soil <0.5dS/m ECe	96) high water table >2m 97) shallow root zone <50cm 98) high salinity groundwater >5000mg/L TDS 99) high salinity irrigation water >1500mg/L TDS 100) high natural salt in soil >2dS/m ECe	101) >4.5dS/m ECe
Surface water	102) low levels of salinity, nutrients or other toxicants in water 103) Irrigation by low level sprinkler, micro	105) high levels of salinity, nutrients or other toxicants in water	108)

[19] Sinclair Knight Mertz. (2004). *Land Use Suitability and Capability for Irrigation Development – draft irrigation development guidelines and evaluation criteria.*

System attribute or issue	Minor risk	Major risk	Not permissible
	irrigation, drip or sub soil irrigation 104) No receiving waters or drainage lines are within close proximity	106) high rate sprays/guns, flood irrigation or long laterals 107) a major sensitive river, lake or wetland is adjacent	
Groundwater	109) low existing water table >4m 110) low annual irrigation rate <3ML/ha 111) low depth of applied water <30mm/application 112) sprinkler or micro irrigation 113) heavy impervious soils	114) high existing water table <2m 115) high annual irrigation rate >6ML/ha 116) high depth of applied water >50mm/application 117) high rate sprays or flood irrigation 118) permeable porous soils (sands, gravels) or fractured rocky soil (granite)	119) Rapidly rising water table <2m

3.3.5 Prevention and control

Managing salinity requires a combination of options, which aim to achieve a balance between the volume of water entering the groundwater system (recharge) and the volume of water leaving the groundwater system (discharge). Different management options exist for the three zones of water movement shown in Figure 3.2.

Lowering the water-table can be achieved by:

- planting, regenerating and maintaining native vegetation and good ground cover in recharge, transmission and discharge zones. In an irrigation area such as for this project, native trees should be planted on all available non-cropping land such as along roadsides, easements, fence lines and farm laneways particularly in lower lying areas
- increasing groundwater use in recharge areas by pumping water from bores and using drainage to redirect water to other storages
- undertaking engineering works, including drainage, siphons, relief wells, and pumps in discharge areas—water of suitable quality can be used to irrigate adjacent areas
- installing sub surface drainage
- maximising cropping opportunities and avoid fallowing land.

3.3.6 Co-benefits of Tree Planting

Planting trees to mitigate any future salinity issues in the project area will also produce a range of co-benefits:

- sequester the GHG emissions from the construction of the project and its ongoing operation
- provide shelter belts for livestock including shade for cattle and improved productivity
- rehabilitation of degraded land and windbreaks for crops to reduce evaporative losses
- buffer zones for watercourses and wildlife corridors
- augment biodiversity and vegetation offsets for land clearing elsewhere on the project site

- reduction of sediment export into dams and storages
- improvement in ecological value and ecological connectivity
- greater amenity value.

The project can also use the trees to augment any carbon forest that is not a component of the project area and used to achieve carbon neutral status where the amount of GHG emissions calculated through the inventory is offset or sequestered through the carbon forestry project.

Seedlings may also be required for a vegetation offset if this is a requirement of the project approval process. Typically, vegetation offsets required as part of a development approval need to secure ecosystems similar to those being destroyed as part of the development. Offsets are therefore disturbed vegetation communities – as undisturbed communities are already protected by legislation – with the proponent required to undertake works to restore the community over time to something approaching a pre-clearing standard. Augmenting offset areas with seedlings can accelerate this process and reduce costs for the proponent.

A vegetation offset project can also be used to increase ecological and biodiversity benefit by siting adjacent to an existing conservation area or national park or protecting an ecosystem that is not adequately represented in the protected area estate. These options should be explored with the Queensland Parks and Wildlife Service if and when the opportunity emerges.

Any vegetation offset requirement could also be used as a carbon offset project. Where the rate of sequestration is greater than the project greenhouse gas emissions, the excess can be sold in the market.

The species planted should be a mix of locally indigenous species as defined by the relevant Regional Ecosystems for the Mitchell Grass Downs Bioregion[20] that are currently found in the Hughenden district. Using local species ensures the trees are adapted to the soils and climate and that the forest is resilient, quick growing, sequesters the maximum amount of carbon possible at the site, and provides habitat for local species.

3.3.6.1 Shade and shelter belts

Planting and establishment of shelterbelts may provide a multitude of productivity and biodiversity benefits for farming industries. The value of shelterbelts in raising agricultural productivity has been demonstrated in many countries suggesting potential improvements in crop yields (25 per cent) and pasture yields (20 to 30 per cent).[21]

Shelterbelts with strategic placement and well-defined objectives have numerous potential benefits to farm productivity such as:

- protect crops and pastures from drying winds and water loss
- provision of shade to protect stock from the effects of heat stress
- provide habitat for wildlife and natural biological control agents to help in pest management
- help prevent salinity and soil erosion
- boundary shelter and windbreaks can reduce bio-security hazards to stock from neighbouring land (eg. prevent nose-to-nose contact, weed movement control)
- provide ethnobotany benefit for Indigenous people
- protect and enhance living and working areas and property amenity
- increase medium to long-term land values.

[20] Queensland Government. Regional Ecosystems Descriptions Mitchell Grass Downs Bioregion. https://apps.des.qld.gov.au/regional-ecosystems/list/?bioregion=4
[21] Tisdell CA. *Conserving and Planting Trees on Farms; Lessons from Australian Cases. Volume 53; Review of Marketing and Agricultural Economics*

Well-designed, established and maintained shelterbelts, support ecologically sustainable agriculture, which benefit from increased productivity, sustainability, biodiversity, and property and landscape values.

Sustainable whole-farm planning incorporating shelterbelts and biodiversity values can also potentially increase the 'environmental credentials' of a farm, supporting best practice and increased market share.

Shelterbelts are not a short-term panacea but a mid to long term proposition that requires a flexible approach and site specific solutions. More than this they contribute to equity for future generations, position project-related irrigators for a 'low-carbon' future, and adaptation to a changing climate as the trees planted for the carbon forest can also satisfy the salinity mitigation and shelter belt needs for the irrigation areas. Trees can also help moderate local climate conditions including reducing heat loading though transpiration action.

Costs associated with tree planting generally include costs of tree production (nursery establishment, seed collection, potting media), establishment (irrigation, fencing, site preparation) and maintenance, costs of lost agricultural production on the planted area, and cost of time spent away from other farming activities.

Where trees are planted (or maintained) primarily to prevent or combat land degradation, including carbon sequestration forests, control salinity, stabilise erosion gullies, and establish wind breaks to prevent soil erosion and evaporative water loss from crops and pastures, the costs usually offer tax advantages.

3.3.6.2 Nursery establishment

Seedlings can be produced from an on-site nursery or purchased from a contract grower. Both options provide benefits, but an on-site nursery provides greater flexibility and reduces the risk of seedling losses post planting as seedlings can be planted during or immediately preceding rain events. Contract growers will deliver seedlings according to a production timeline and at a time that may be unsuitable for planting. This may mean that a nursery is required regardless in order to safeguard the seedlings delivered from a contract grower until favourable planting weather conditions emerge.

An on-site nursery can also provide seedlings for the biodiversity or vegetation offset planting as it is certain that any areas approved for biodiversity offsets will required substantial improvements to the existing vegetation including replanting of seedlings. A nursery also provides options for a commercial business providing seedlings for clients including other farmers, local governments, resource managers such as mines, infrastructure and landscape and amenity providers.

A nursery design including a hardening-off area suitable for the area to be planted and the required production schedule will be undertaken in a subsequent project should a decision to proceed with tree planting be made. Seeds required for nursery establishment should be collected locally wherever possible as this ensures use of local genotypes that are best adapted to local conditions. Alternatively, seed can be purchased from reputable suppliers such as Queensland Native Seeds[22] that will collect seed from local trees where required. The nursery could be established as part of the implementation phase.

3.3.6.3 Tree planting and establishment

The trees should be planted on less productive soils or those not required for agriculture and adjacent to the irrigated cropping areas and in areas where shade and shelter for crops and livestock can best be attained. Access to irrigation tail water would assist with forest establishment but would not be required on a permanent basis unless as a solution to ongoing tail water disposal.

A revegetation plan will be developed, during the implementation phase, in order to provide detail on:

- species to be planted including stratification, mix ratio and spacing rates

[22] Queensland Native Seeds. www.qldnativeseeds.com.au

- seed collection, storage and germination
- nursery production including set up and costs versus contract supply
- nursery design and build including Hiko trays, types of seed raising and potting mix, irrigation, fertiliser, germination procedures for each species, disease and pest control and management
- site preparation including rip lines and weed management pre and post planting
- planting techniques, equipment and work force requirements
- initial silvicultural requirements to minimise seedling losses.

There is an opportunity to provide training to local people in seed collection, cataloguing and storage, nursery construction and operation, seedling management, site preparation, planting and establishment, and initial management. Alternatively, seedling production and planting can be sub-contracted, but this comes with a range of additional risks.

4. Social

Irrigation can transform small towns and communities as well as land and landscapes.[23] Irrigation projects can transmute a society as definitely and profoundly as it transforms a landscape.[24] Irrigation systems are often mistakenly simply viewed as hydrological systems, as engineering systems or as farming systems.[25] But they should equally be viewed as systems of social organisation closely linked to the biophysical environment and the engineering structures that make them.

Irrigation development in Hughenden will be a complex undertaking involving changes to the landscape and physical structures – including a diversion structure on the Flinders River, new farming systems and every aspect of social life of the town. Developing new irrigation systems - particularly ones in remote Australia such as HIP - must take into account the implications of change in environmental, engineering and farming systems will have on the region's social construct. This is critical to sustainability of the project and the community.

While the bulk of the detailed business case for this project is understandably focused on the economic and social values of the project as revealed through market prices – the margin from the use of an extra ML of irrigation water – not all benefits can be calculated through market transactions. For example, the value of maintaining the condition and extent of riparian ecosystems along the Flinders River and the social impacts a degradation of the ecosystem may cause.

There are several methodologies for assessing the values placed on sustainable or non-consumptive water use by the community in an otherwise productive irrigation setting.[26] These methodologies include averted cost approaches for the relationships between catchment condition, pollutant loading and erosion to valuing ecosystem functions to measure the change to ecosystem assets such as native vegetation loss or reduced river flow.[27]

Certain economic values can be placed on the potential for the project to support fishing, tourism and recreational users as well as non-economic values such as ecological values, ecosystem services, biodiversity - although this can also be economic in certain circumstances – and cultural and Indigenous values.

4.1 Social impacts

When irrigation and the project is discussed among stakeholders and primary producers in Hughenden, land use change and its implications is not something that is commonly understood or embraced by all. Some envisage a more intensive version of the existing cattle production systems albeit with less vulnerability to the vagaries of drought. This means using the water to produce fodder crops and not for new higher value horticulture. For others, irrigation is viewed as insurance against a changing climate rather than a production management tool and an opportunity to switch into a much more valuable production system, such as orchards and horticulture.

For some long-term landholders in Hughenden, adoption of irrigation will likely mean a substantial change in daily work patterns. Irrigated agriculture is much more hands-on, labour intensive, capital intensive with almost constant monitoring of the crop and soil required, which is in stark contrast to traditional livestock grazing particularly on the rangelands of north Queensland.

Social change at Hughenden will not become endemic until these traditional stakeholders see and embrace the full benefits of sophisticated irrigation technology and fully exploit the new economy provided by irrigation water. Social change will likely emerge as farmers see that new practices offered by irrigation also mean changes in patterns of work, changes in machinery and equipment used, changes in cropping and the

[23] McCrostie,, Little, Heather and Taylor. 2001. Social and economic impacts associated with irrigated land use change Proceedings of Seventh Annual Conference of the New Zealand Agricultural Resource Economics Society (Inc.) Blenheim, July, *AERU Discussion paper No. 148*, Lincoln University, Canterbury.
[24] Coward, El W. 1980. Irrigation development: institutional and organisational issues, pp 15-27 in E. Walter Coward, Jr (ed), *Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences*, Cornell University.
[25] ibid
[26] Freeman, A. M. 2014. *The Measurement of Environmental and Resource Values: Theory and Methods*.
[27] Ibid.

infrastructure needed to support it that in turn leads to change across the entire community. Some will be unable to adapt and change and will leave the district to be replaced by younger more enthusiastic farmers.

Cattle grazing in north Queensland and intensive irrigation production are not always compatible with the latter requiring a different mind-set particularly in the relatively large scale of capitalisation required to manage the change. It is likely that not all existing graziers contemplating the transition will be able to manage the changes required. Some graziers are likely to adopt a cautious approach and develop their new irrigation blocks over time, investing as they learn and managing the capitalisation required over a number of years.

This may mean that not all of their water allocation is used in early years, but a more gradual approach will likely help the town and community more readily adjust. Change will also be measured by an exodus of people that are unable to adjust and an influx of newcomers that are animated by the changes offered in the new economy of Hughenden. These population changes are associated with all rural towns in Australia that have moved from a traditional livestock grazing economy to one more based around intensive agriculture industries.

Another likely social impact is that irrigation will make Hughenden's population more affluent, younger and probably better educated and this will increase demand for new services and products but equally it may likely cause the demise of some existing community services. Social divisions may also emerge between the newcomers and long-term residents, particularly those that are tied to traditional grazing industries and are unable to embrace the changes.

Despite these challenges, the irrigation development at Hughenden will produce economic benefits that will be life-changing for all residents and that will prove overwhelmingly positive over time. Other towns in Queensland have undergone similar transformations in previous eras. Emerald and Mareeba were tiny decrepit towns much like today's version of Hughenden, limited to servicing their local grazing communities before being transformed by new irrigation schemes into modern, affluent regional centres with much larger, diversified and wealthier economies. Hughenden's potential is clear.

4.2 Tourism and recreation at the water storage

The water storage and weir will provide an attractive destination for tourists seeking a camping, fishing and passive water sports recreation. Studies undertaken at similar sites elsewhere using the travel cost method indicate significant economic values for the Hughenden economy can be obtained of up to $10 to $30 per person per visit.[28]

The site could also attract additional visitors for reasons such as camping, bushwalking, nature appreciation, bird watching and rock climbing.

4.3 Educational and aesthetic values

The water storage site and catchment area provides spectacular scenery that could be exploited to attract community groups, school groups, non-government organisations, and government agencies among others to provide and facilitate educational and learning and developmental opportunities.

The natural beauty of the area could also be used to attract investment for rural residential and rural living or lifestyle blocks and sub-division. Introduction of any or all of these measures requires careful planning as one has the potential to spoil the attractiveness of the other if over development and over allocation is permitted.

4.4 Indigenous values

The HIPCo Board has advised they are working on initiatives with the Yirendali People, the traditional owners, to embed socioeconomic benefit into the project. The Yirendali People are also working with Flinders Shire Council

[28] Gillespie, R. 1997. *Economic Value and Regional Economic Impact of Minnamurra Rainforest Centre. NSW National Parks and Wildlife Service.* James, D. et al. 1993. *Environmental Economics: Gerringong Gerroa Case Study*.

on a Reconciliation Plan and the intent is to align all these pieces of work. These initiatives go beyond Cultural Heritage compliance and are part of the sustainable future of the regions and this project.

Access to water can potentially have a number of elements for Indigenous people involving economic development, employment and participation in the local economy within the context of traditional rights, environmental custodianship and the maintenance of cultural connections.[29] Water and water dependent ecosystems including the Flinders River itself and its immediate riparian zones contribute to the cultural and economic values of local Indigenous people although these relationships are complex and often poorly understood.

The separation of land and water rights raises a number of equity issues that likely impact the ability of local Indigenous people to maintain their cultural values and connectivity to the land and each other. The dam and weir provide a new opportunity to rebuild some of these values and connectivity by engaging with local Indigenous leaders and providing water access arrangements.

[29] Collings, N. 2011. *Indigenous Water Planning and Management Issues*. First Peoples Water Engagement Council, report prepared for the National Water Commission 2011 Biennial Assessment.