Review of low-cost desalination opportunities for agriculture in Australia

This project emphasises the desalination of brackish and saline groundwater to produce purified water for use in agriculture. The successful deployment of desalination in agriculture relies on a collaborative and holistic approach jointly undertaken by water infrastructure providers and agribusiness.

Desalination is a process that removes dissolved salts from seawater, municipal or industrial wastewater and brackish or saline inland water (including groundwater). The process results in two streams: permeate (purified water), and brine (concentrated salts) which requires disposal.

There are up to 1,000 desalination plants in operation in Australia, ranging in size from small (producing less than 10,000 litres per day – 10 kL/day) to very large (producing more than 250 million litres per day – 250 ML/day). Desalination plants are used by many industries including mining, power, oil and gas, food and beverage, medical and municipal. While only a small number of Australia's desalination plants are used for agriculture, all of these have been established in the last decade.

> Instead of the question 'How cheaply do we need to make desalination for agricultural applications?', we should be asking 'How efficient should the integrated water and food production be for profitable delivery of food?'

Key principles for effective desalination schemes for agriculture

A collaborative and holistic approach ensures the effective deployment of desalination schemes for agriculture. Desalination schemes should be developed as a collective effort of desalination infrastructure providers and agribusinesses that intend to use this alternative water supply, which:

- leads to increases in farming profitability, offsetting the cost of the desalination scheme through increases in agricultural productivity, resulting from water security and improved-quality, 'fit-for-purpose' water
- are sustainable: sustainability of desalination schemes is critical for successful outcomes.

A number of external conditions can influence the effectiveness of desalination schemes including compliance with regulatory policies and/or the consideration of subsidies to offset some of the scheme's costs. Subsidies can catalyse innovation, demonstration, and uptake leading to economically self-sustaining enterprises with a net positive value to the nation and region. Significant desalination schemes for agriculture have been implemented in Israel, northern Mexico, and Spain and provide case studies to examine lessons learned.

Prepared by CSIRO for the National Water Grid Authority

Desalination for agriculture – considerations

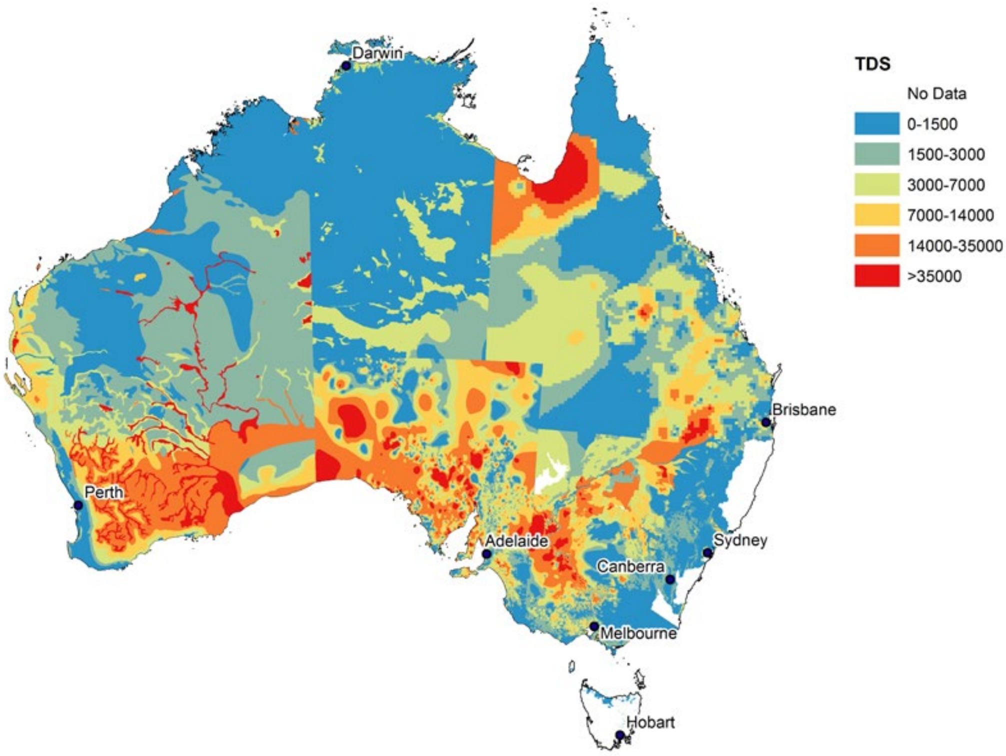
Australia's horticulture industry is a likely target for using desalinated water. Crop irrigation scheduling and seasonality, irrigation efficiency techniques, and even soil type have important implications for the cost effectiveness of desalination schemes. High value crops and protected cropping, including state-of-the-art, high-tech hydroponic greenhouses (like Sundrop Farms near Port Augusta, South Australia) are less sensitive to input water price and so are good candidates for desalinated water use.

Benefits

- Water security: The major benefit of desalination technologies to agriculture is water security. While extremely site specific, desalination technologies can support agricultural resilience to drought and climate variability, de-risking agricultural businesses.
- Water quality improvement: Where water in the upper range of a crop's salt tolerance is used for irrigation, reduction in water salinity (via desalination) improves crop productivity. For example, a 25% reduction in water salinity leads to a 100% increase in grape vine crop productivity (NSW DPI).
- Water conditioning: Permeate can be further conditioned by adding fertilisers and/or minerals ('fertigation') directly to the irrigation stream, customised to individual crops.
- Water use efficiency: The expanding use of desalinated water for agriculture is closely correlated with developing water-saving irrigation techniques and high-value crops.
- Increasing agricultural productivity: Desalination and permeate post-treatment allows delivery of 'fit-for-purpose' water, which supports advanced agricultural productivity. This would lead to an increase in farming profitability, helping to offset the cost of desalinated water.

Challenges

- Seasonality of water demands: The wide variability of irrigation water demand (daily, monthly and annually) can lead to a high cost of desalination if it is used as an 'emergency supply'. Desalination plants operate at the lowest unit water cost when water is produced at a constant rate (100% capacity, i.e. 'base load'). This issue can be resolved by deploying desalination in conjunction with water storage. MAR (managed aquifer recharge or water storage in an aquifer) may be cost-effective where suitable aquifers are available.
- Current water price: Within Australia, the unit water cost (from sources other than desalination) is highest in South Australia ($0.383/kL to $2.307/kL) and lowest in Queensland ($0.133/kL to $0.405/kL). The unit cost of desalinated water is commonly greater than $1/kL (could be much higher) and is highly dependent upon factors such as feedwater quality and salinity, and brine disposal options.
- Perception: In addition to cost, lack of expertise and low implementation confidence can be factors limiting the wider use of desalinated water in Australian agriculture.



National groundwater salinity map

Source - Australian Hydrological Geofabric, WA Department of Primary Industries and Regional Development, SA Department for Water, Land and Biodiversity Conservation, QLD Department of Natural Resources and Mines, Vic Department of Environment, Land, Water and Planning

Cost-effective desalination

Desalination costs consist of capital investment and total annual operation and maintenance (O&M) costs per unit of permeate capacity ($/kL). These costs are greatly influenced by several conditions, which are highly variable depending on the location of the desalination plant (also illustrated in Box 1):

- Feedwater quality: Lower feedwater salinity (<3,000 mg/L) leads to lower O&M annual costs and allows for higher recovery rates, lower brine volumes and lower costs for brine disposal.
- Opportunities for brine disposal: Inland brine disposal costs comprise 40% to 80% of total desalination scheme costs and can be a major limitation for higher salinity feedwater. In coastal regions, brine discharge to the ocean can significantly reduce brine disposal costs.
- Operation and maintenance costs: For brackish water desalination, in addition to capital costs, the O&M costs range from $0.32/kL to over $1/kL (with energy costs contributing up to 50% of this).
- Energy source: Although Australia has abundant solar and wind resources, renewable energy only directly powers small-scale desalination units at present. Declining renewable energy costs make a behind-the-meter renewable energy farm co-located with a desalination plant an attractive option. Based on site-specific analysis, and taking into account energy price fluctuation, the most economic option (with respect to energy costs) is for a desalination plant to operate as a deferrable load with at least one week of water storage.
- Other costs: Cost is also influenced by feedwater intake and transmission structures, including pipelines and borefields for groundwater abstraction, distance from desalination plant to end user(s), and any requirement for a treated water storage facility.

BOX 1. APPROXIMATE CAPITAL COST OF 1 GL/YR DESALINATION OF LOW-SALINITY BRACKISH GROUNDWATER (<3,000 MG/L TDS)	
Minimum of $3M if:	high recovery rate brine discharge to ocean, salinity drain, or existing evaporation site thick and transmissive aquifers aquifer available as a storage facility for treated water
More than $20M if:	low recovery rate evaporation pond with liner system required low yield or very deep aquifers large treated water storage facility required
OPPORTUNITIES TO REDUCE DESALINATION SCHEME WATER COST	
Blending	increasing water production by up to 200% through blending desalinated water (permeate) with ambient feedwater
Existing inland disposal options	existing evaporation ponds (e.g., for salt interception schemes); salt lakes; unused mines (pits)
Beneficial brine use	recovering constituents from feedwater (e.g., Mn, Li, gypsum); aquaculture; energy from solar ponds
Energy production	selling surplus renewable energy generated to the grid

1.5 MLD Santos Leewood Desalination Plant near Narrabri, NSW with concentrate evaporation ponds in the background

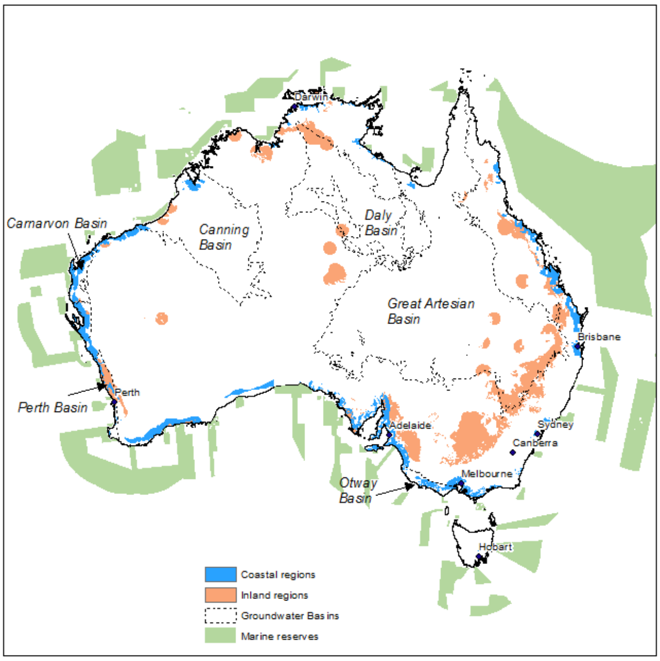
Suitable areas for desalination

The use of desalination technologies for water supply in agriculture is synergistic with secure markets, increased agricultural productivity and the profitability required to offset desalination costs. Therefore, in Australia, the best opportunities to use desalination technologies are in areas where there is irrigation of high-value crops, particularly protected cropping (e.g., greenhouses), where groundwater is of moderate salinity, hosted by a highly transmissive, thick aquifer and where the agricultural areas are close to the ocean. The regions where such conditions are likely to be met are illustrated in the accompanying map.

Future research

Further research is required to realise the opportunities for development and implementation of desalination schemes for irrigated agriculture in Australia. Key components include:

- Engagement with agribusiness to build expertise and increase implementation confidence with a focus on agricultural productivity growth
- An assessment of brackish groundwater resources, which are currently not well characterised, for effective long-term sustainable desalination schemes
- Assessment of advanced options for inland brine management (e.g., minimisation of brine volume, value-added options for brine) and increased integration of renewable energy opportunities
- Investigation of value-adding opportunities to existing infrastructure (e.g., Murray–Darling Basin salt interception schemes)
- Evaluation of the role of subsidies as a catalyst for innovation, demonstration and uptake.



A suitability map indicating where brackish (or saline) groundwater could potentially be used as a feedwater for cost-effective desalination (Marine Parks regulation may constrain ocean brine disposal)

Note: This map identifies regions where desalination may be effectively implemented for agricultural purposes; however, the map is not at the scale that would support individual project proposals.

High value irrigated crop

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