Rapid appraisal of Managed Aquifer Recharge (MAR) opportunities for agriculture

Summary Report for the National Water Grid Authority

Managed aquifer recharge (MAR) is the intentional recharge of water to aquifers for subsequent recovery or environmental benefit. MAR can potentially:

- increase water security in drought more economically than new dams
- augment existing dams with higher efficiency storage (low evaporation)
- facilitate conjunctive use of surface and groundwater resources.

This preliminary study assessed MAR opportunities based on an ongoing demand for water, available water for recharge and suitable aquifer storage in agricultural areas. MAR for agriculture has the potential to increase the availability and security of water supplies, to build the resilience of agricultural enterprises to a changing climate and lead to socio-economic benefits distributed across regional communities. Across the 17 irrigation areas assessed, significant aquifer storage potential was identified in 15 and conservative estimates of storage capacities were in the order of 10 to 280 GL.

New approaches to assessment of MAR potential

Emerging satellite remote sensing data and analytics can complement existing techniques for spatial assessments of MAR potential. Several novel techniques were reviewed and the three areas that showed the most potential for future MAR investigations were:

- defining aquifer suitability for MAR operations by providing volumetric/quantitative insights of the water retention capacity of aquifers on a regional basis
- defining surface water sources by improving understanding of flow dynamics through high-resolution remote sensing data
- defining potential effects of MAR schemes through monitoring of groundwater dependant ecosystem health and aquifer storage-related ground deformation

Principles and information requirements of MAR for agriculture

In Australia, the history of MAR development for agriculture began in the 1960s. There are presently 14 agricultural MAR schemes in Australia, in varying stages of development (11 operational, 2 under development, 1 trial), providing a total capacity of around 70 GL/year. A review of current schemes facilitated the development of several general principles for successful application of MAR for agriculture. These principles from the basis of the rapid assessment method:

- **Presence of high value agriculture**: Of the operational agricultural MAR schemes, 45% have ongoing demand from high-value agriculture (18 GL/year). MAR in agricultural areas that support higher value crops are more likely to be economically viable.
- **Adequate water for recharge**: The availability of water for recharge may be the tightest constraint for a MAR scheme, especially in fully allocated surface water systems. In regulated systems, accommodation for MAR in water management plans is required across hydrologically connected systems that account for surface water and groundwater entitlements and allocations at the appropriate scale. Of the operational agricultural MAR schemes, 64% use surface water (60 GL/year). Approximately 36% of agricultural MAR schemes use alternative water sources such as treated wastewater, urban stormwater, and industrial water (10 GL/year).
- **Suitable aquifer for recharge and storage**: The presence of a suitable aquifer, with an adequate rate of recharge, enough storage capacity to meet demand and the capability of retaining the stored water for recovery and use, is critical for viable MAR schemes. For agricultural MAR schemes, unconfined alluvial aquifers were considered most suitable due to the lower cost of infiltration-based MAR than use of injection wells to recharge confined or semi-confined aquifers. Fifty-five per cent of operating agricultural MAR schemes use infiltration techniques in alluvial aquifers (representing 58 GL/year). The water table needs to be sufficiently deep to accept additional recharge without causing water table mounding issues such as waterlogging at the surface. Low groundwater salinity (e.g. <3000 mg/L) maximises the recoverable volume of low salinity recharged water. Most agricultural MAR schemes target aquifers with low groundwater salinity while the remainder operate successfully in marginally brackish aquifers. Low topographic relief favours infiltration and detention of recharged water so that it is recoverable over long time periods and simplifies installation of recharge structures. It is also important that infiltration MAR schemes are not located near groundwater discharge areas (unless intended for support of groundwater-dependent ecosystems) as retention within the aquifer is likely to be limited.
- **Organisational capability, institutional arrangements, economics, and supportive policy**: MAR scheme proponents require access to capabilities in hydrogeology and water-quality management for the successful design, construction, and operation of MAR schemes. Long-term MAR scheme operation requires ongoing maintenance, particularly to manage clogging. Understanding and assessing the economics of MAR during the development of schemes is critical to ensuring their viability. A supportive policy framework is required to enable effective MAR schemes.

Rapid assessment of MAR opportunities to support agriculture

Irrigation areas were selected to obtain a broad geographic spread across Australia based on where high demand and competition for water exists, production of high-value agricultural commodities, potential to transition to higher value crops, and avoiding areas known to have groundwater salinity issues. Across the 17 irrigation areas selected and assessed for MAR potential, significant aquifer storage potential was identified in 15 and conservative estimates of storage capacities were in the order of 10 to 280 GL. Six agricultural areas had storage opportunities greater than 50 GL, these were: Gingin, WA (140 GL); Lachlan, NSW (280 GL); Macquarie, NSW (130 GL); Bundaberg, Qld (60 GL); South East, SA (50 GL); and Namoi, NSW (110 GL) (Figure 1).

Of the six areas with greatest aquifer storage ≥50 GL, three (Lachlan, Macquarie, Namoi) show favourable to highly favourable conditions. Two areas (Gingin and South East) have possible constraints on the availability of water for recharge. Bundaberg also shows highly favourable conditions although the water allocation price range was not available at this location. Irrigation areas with potential aquifer storage volumes in the 10-20 GL range, do not appear to be highly limited in availability of water for recharge.

Benalla and Loddon-Kerang had conditions that were favourable while the lack of upstream storage at Carnarvon potentially means less time available for capture and recharge to occur. Cressy-Longford, St George and Winnaleah are currently less dependent on groundwater entitlements and contain lower irrigation bore densities. However, MAR in these areas could provide additional reliable sources of water to enable development of higher-value perennial cropping and horticulture.

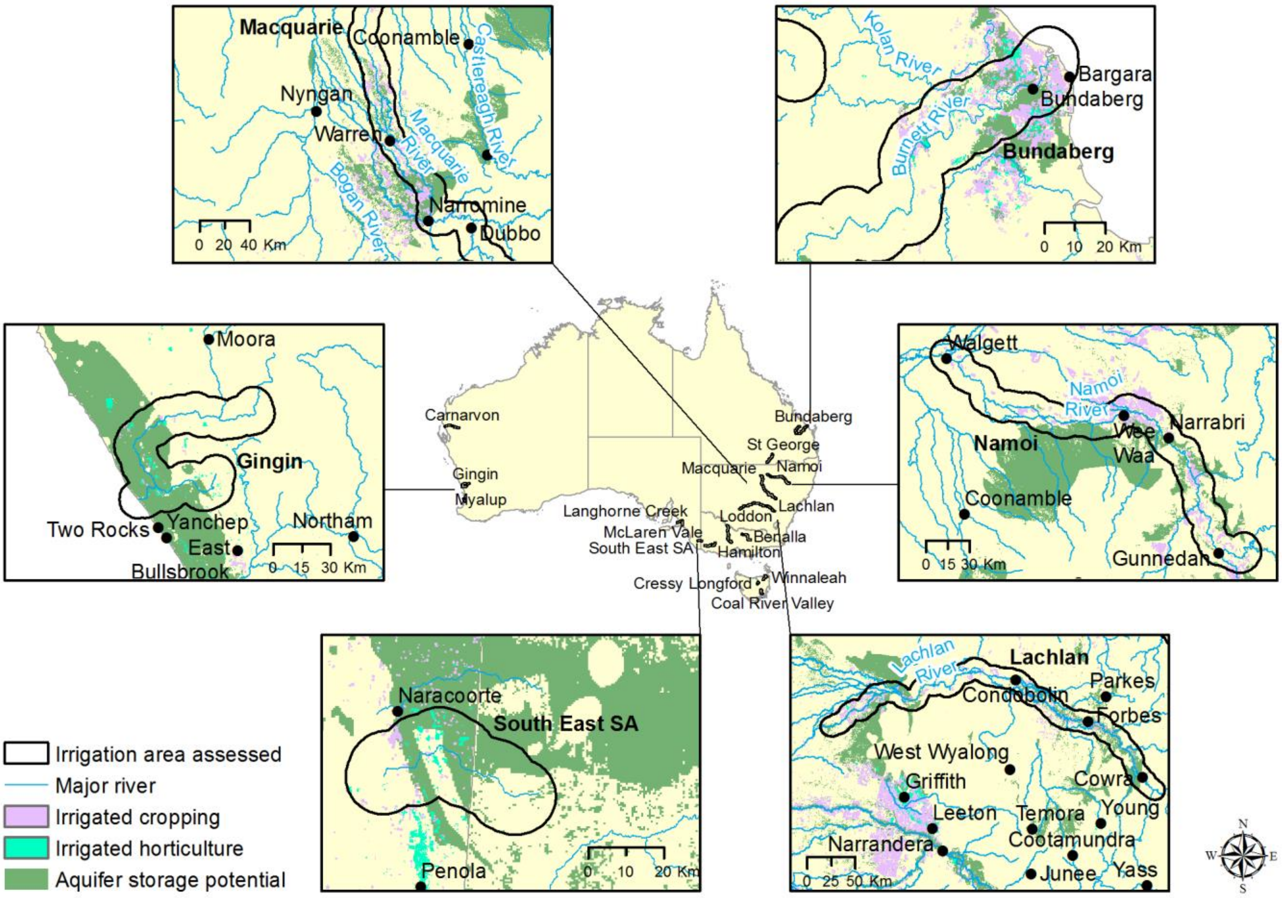

Figure 1 Irrigation areas assessed with ≥50 GL potential aquifer storage

Across the irrigation areas, flows from the rivers are substantial, despite the very varied precipitation (290–1278 mm/year) and potential evaporation (1241–2101 mm/year). The rapid MAR assessment used lower quartile annual flows as an indicator of surface water availability. The presence of upstream dam storage capacity was also considered favourable for MAR. Of the six areas with potential storage ≥50 GL, Bundaberg, Lachlan, Macquarie, and Namoi annual flows were >200 GL. Flows were an order of magnitude lower in the South East (20 GL) and Gingin (60 GL, possibly with the addition of 7 GL/year treated wastewater).

This does not account for requirements of water policy, entitlements and allocations, and access rights. In many catchments surface water is already fully allocated and existing upstream dam storage may be more important for determining MAR opportunities. There was significant dam storage (>750 GL) at Bundaberg, Lachlan, Macquarie, and Namoi, but none at Gingin or the South East.

Understanding the scale of ongoing water demand is equally important. Of the areas with potential aquifer storage areas greater than 50 GL, substantial river flow and dam storage, Bundaberg, Lachlan, Macquarie, and Namoi had total annual water entitlements greater than 500 GL with irrigation demand. By comparison, other irrigation areas like Benalla, Carnarvon, and Langhorne Creek had entitlements and demand in the order of tens of GL/year. MAR may be of specific use to manage groundwater levels in highly allocated groundwater systems. Of the areas with greater than 50 GL storage, groundwater entitlements and approximated irrigation demand were highest for the Lachlan irrigation area, which also had the highest irrigation bore density (95/100 km^2). The Bundaberg, Macquarie and Namoi areas also had substantial groundwater use.

The type of existing agriculture has important implications for MAR development. Irrigation areas with significant storage potential and low levels of horticulture (e.g. Namoi, Macquarie) could benefit from additional water through either supporting existing farming practices, or through enabling transition to high-value horticulture that relies on the availability of high-security water. Areas with high levels of existing horticulture (e.g. Gingin, Bundaberg) could benefit through the provision of additional water to protect investments during periods of low water availability, or to boost production. The ability to expand or transition to high-value horticulture depends on several factors including (but not limited) to land and soil suitability, hydro-climatic factors, and market potential (logistics and competition).

Future research

Further research is required to realise the opportunities for large-scale agricultural MAR schemes in the irrigation areas identified in this assessment. Key components include:

- Detailed desktop studies focussing site identification, project design, human and environmental risk assessment, economic feasibility analysis, and impact assessment for use in community and regulator consultation and within an investment prospectus.
- Site-specific field and laboratory investigations to address knowledge gaps, verify infiltration rate potential and clogging, water quality monitoring, human health, and environmental risk management.
- Assessing the potential for agricultural development, expansion, and transition to higher value farming systems such as horticulture, precise characterisation of water demand patterns and consideration of socio-economic implications of changes to agricultural practices.
- Building and operating pioneering demonstration agricultural MAR schemes to confirm viability of full-scale implementation and ongoing operational management.
- Determining governance arrangements for MAR schemes including identifying owners, investors, operators, and users, identifying mechanisms for long-term economic sustainability of operations, and working with regulators to align policy and regulatory frameworks.

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