Managing irrigation dams for carbon benefits

Emissions from constructed freshwater ponds such as farm dams used for irrigation have now been included the National Greenhouse Gas Emissions Inventory. If managed appropriately, irrigation farm dams can be a part of net zero emissions goals with several opportunities for emission reduction and carbon storage.

Introduction

Irrigation farm dams help support $8.6 billion worth of irrigated production in the Murray-Darling Basin (Australian Bureau of Statistics, 2019). These vital water assets on farms can have wetland-like characteristics that may support carbon storage and potentially offset greenhouse gas (GHG) emissions. Collectively, these artificial waters represent more than 60 km^2 in the irrigation regions of the Riverina, a substantial inland aquatic area that would otherwise not exist. While farm dams are included in national emissions reporting, the carbon footprint of irrigation farm dams remains unknown. With many of Australia's irrigation farming industries committing to net zero emissions, there exists an opportunity to include farm dams in sustainability frameworks.

To better understand the potential of irrigation farm dams as a carbon asset, this study carried out on-ground research investigating the carbon footprint of such dams typically found in large-scale surface irrigation enterprises in the Riverina region of NSW. This fact sheet summarises key preliminary findings from the scoping study and provides suggestions on how to improve the overall carbon footprint of irrigation dams through reducing GHG emissions and boosting natural carbon storage.

Lower emissions than other agricultural waters

When compared with global averages for artificial waterbodies, most Riverina irrigation dams emit far less methane. Depending on the season, the average emission factor (EF) for diffusive methane fluxes from a mix of 38 horticulture and broadacre irrigation dams in the region was found to be four to eight times lower than the global EF (183 kg CH_4/ha/year) for constructed freshwater ponds, as reported by the Intergovernmental Panel on Climate Change (Lovelock *et al.*, 2019). Given Australia recently joined the Global Methane Pledge to reduce methane emissions by 30%, this is promising for irrigators to know that their farm dams are generally minor emitters of methane. It is unclear whether lower emissions could be due to the soil type, regional landscape effects, irrigation management scheduling, rainfall or differences in organic matter input (e.g. animal manure vs plants). It is clear, however, that irrigation dams in the Riverina should not be assumed to emit the same high levels of methane as other artificial fresh waterbodies.

Further, it is well-known that farm waterbodies can be indirect sources of nitrous oxide through fertiliser runoff from fields. This study revealed that although dissolved nitrogen levels were often elevated in irrigation farm dams, this did not result in high nitrous oxide emissions. In fact, at the time of sampling, 73% of the surveyed dams were sinks, playing a role in actively removing this strong greenhouse gas from the atmosphere. Like for methane, this study demonstrates that irrigation dams in the irrigation farming enterprises of the southern Murray-Darling Basin have lower nitrous oxide emissions than those quantified for other agricultural freshwater bodies.

A new area for on-farm emission reduction

Effective farm dam management can be used as a tool to avoid emissions and even support longer-term storage of carbon on farm. This study provides new data that suggests certain irrigation farm dam characteristics can reduce emissions. Although specific management practices are yet to be tested, this observational study provides clues as to management changes that can improve a farm's carbon footprint. Two findings stood out:

1. Waters that were eutrophic had 2-4 times greater CO_2-equivalent emissions than those that were non-eutrophic.
2. Recycle dams had CO_2-equivalent emissions an order of magnitude higher than other dam types (storage, horticultural and turkey nests).

Managing nutrients in recycle dams

On average, recycle dams (dams connected to field channels that recycle irrigation water between fields) had higher nutrient levels, which leads to a more eutrophic state. This means there is more biological activity that can fuel methane production – the main GHG offsetting any observed carbon dioxide and nitrous oxide uptake. Implementing nutrient reduction strategies will help reduce emissions, particularly methane. Managing the amount of nutrients in irrigation water is difficult as this recycled water comes into direct contact with fertilised fields. However, this also means **in-field practices to retain nutrients or reduce fertiliser use** will translate into less nutrients flowing into the dam. This could be a win-win for managing both field and water farm emissions.

Establishing floating aquatic vegetation in recycle dams may also be an effective way to reduce methane production, as vegetation would simultaneously suck up dissolved nutrients and trap methane that would otherwise be released into the atmosphere. The practical feasibility of this may be challenging and requires further research.

A key difference between recycle dams and other irrigation dams is they are more hydrologically dynamic, meaning water spends less time in the reservoir. **Creating deeper dams** increases the water residence time, reduces temperature and dilutes inflowing nutrients, which research shows can allow for conditions that minimise methane production and support nitrous oxide uptake.

Further methane reductions could be achieved by **building any new dams in areas with higher soil salinity**. The research team found methane emissions declined as soil electrical conductivity (EC) increased, and this was most pronounced in dams that also had low water nutrient levels. It is expected smaller dams will be more affected by the surrounding soil EC properties, so this potential methane intervention may not be applicable to large turkey nests. This is an interesting new concept that is yet to be explored and needs to consider the impact of higher water EC on salt-sensitive crops.

Carbon storage

Farm dams may support a number of carbon storage avenues depending on farm carbon budgets. These include natural sediment carbon accumulation and carbon stocks in surrounding vegetation. This study investigated the amount of carbon stored in both these areas through sediment cores and drone surveys for biomass mapping, and found:

- Sediment carbon storage in the top 10 cm ranged from 1.5 to 29 t C/ha. This large range likely reflects the different ages of dams (1 to 100 years old) and management differences, such as dredging history and duration of dry periods. The research is not at a stage where estimates can be made about how much carbon an irrigation dam may accumulate over 10 or 20 years, but some dams have shown promising capacity for carbon storage.
- **Dams should be kept flooded**. Where water goes, carbon flows. So, any carbon that makes its way into the bottom sediment will likely remain there, as overlying water creates low-oxygen conditions that slow remineralisation. For example, horticultural dams had the lowest carbon footprint, with higher sediment carbon storage and minimal emissions. One reason for this could be that horticultural dam water levels tend to be more evenly maintained and oscillate less over the irrigation season than broadacre systems.
- Vegetation around the dam offers the benefit of longer-term storage of carbon in the biomass of this uncropped farm area. The density of carbon stored in grasses, shrubs and trees ranged from 14.7 to 38 t C/ha in a select few dams (n=3) that had buffer vegetation, although the carbon density likely varies more across other sites. Therefore, **establishing a thriving bush area** around each farm dam on a property would boost on-farm carbon storage.
- A healthy vegetation area around a farm dam also has other co-benefits. For example, shade provided by large trees will minimise dam sunlight exposure, preventing warmer temperatures that favour eutrophication. Aquatic vegetation can filter agricultural runoff and increase sedimentation. Vegetation in and around the dam can also provide a natural habitat for wildlife, increasing the biodiversity value of irrigation farms. Establishing the stability of surrounding vegetation on dam walls and surrounds to avoid dam choking and restricting access are areas that would need to be developed to ensure best practice.

Creating sustainable irrigation networks in Australia can have wide-ranging benefits for both agriculture and the environment. The Emissions Reduction Fund can reward landholders for either reducing emissions or supporting natural carbon storage. Irrigation farm dams present opportunities for both emissions reduction and carbon storage, yet are not yet included as an eligible activity. The next steps are to directly test promising avenues identified in this study for emissions reduction and carbon storage, and develop the methodology for carbon markets.

References

Australian Bureau of Statistics. (2019). *Gross Value of Irrigated Agricultural Production, 2017-18 financial year*. Australian Bureau of Statistics, Canberra, Australia. https://www.abs.gov.au/statistics/industry/agriculture/gross-value-irrigated-agricultural-production/latest-release

Lovelock, C. E. et al. (2019). Wetlands. In: Calvo Buendia, E. *et al* (eds), *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 4 – Agriculture, Forestry and Other Land Use*. Intergovernmental Panel on Climate Change, Geneva, Switzerland. https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch07_Wetlands.pdf

Project team

Dr Jackie Webb, Assoc. Prof. Wendy Quayle and Dr Carlos Ballester
Centre for Regional and Rural Futures
Deakin University
Hanwood NSW 2680
j.webb@deakin.edu.au

Creating sustainable irrigation networks in Australia can have wide-ranging benefits for both agriculture and the environment. Irrigation farm dams present opportunities for both emissions reduction and carbon storage, yet are not yet included as an eligible activity as part of the Emissions Reduction Fund (ERF).

This project *Quantifying the greenhouse gas emission and carbon co-benefits of on-farm irrigation dams* has been funded as part of the AgriFutures Australia Carbon Program, designed to help understand the risks and opportunities associated with carbon projects, and to explore new market pathways for producers to collaborate. $2 million has been invested across 15 individual projects to deliver high-impact and practical benefits, targeting six transformative areas.