A time-series analysis of on-farm storage development in the northern Murray-Darling Basin

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Abstract: In the Murray-Darling Basin (MDB), balancing environmental flows with floodplain harvesting remains challenging due to the lack of detailed quantification of on-farm storage (OFS) development over time. Reliable analysis of OFS growth is essential for regulatory compliance, hydrological modelling, and future policy design. To address this gap, we applied a "first 50% fill" analysis approach to 1,253 storages compiled by the NSW Natural Resources Access Regulator (NRAR) and the Department of Climate Change, Energy, the Environment and Water (DCCEEW) for five northern valleys of the MDB. This study draws on an existing NRAR-DCCEEW database that incorporates prior LiDAR-derived storage volume curves alongside remotely sensed time series observations of OFS water surface areas. Our contribution is the application of the "first 50% fill" approach to this database to identify when storages first became operational and to analyse their development trajectories over 1986-2025. Results show that 1,245 storages reached the 50% threshold with rapid expansion before the 1994 Cap accounting for 62% by count and 64% by volume. After the MDB Cap, growth slowed as policy reforms and infrastructure saturation took effect. These findings highlight the strong influence of regulatory settings on the scale and timing of OFSs development. Comprehensive results including catchment-level analyses, links to agricultural expansion, and comparisons with previous studies of Brown et al. 2022 and Colloff et al. (in review) will be reported in a forthcoming peer-reviewed publication in an identified journal.

Keywords: *On-farm storages, Floodplain harvesting, Murray-Darling Basin*

1. INTRODUCTION

Water policy in the Murray-Darling Basin has shifted from infrastructure-driven irrigation expansion to an integrated water resources management approach by recognising environmental needs as a legitimate water use (COAG 1994). The introduction of the 1994 Cap on Surface Water Diversions is designed to limit extractions to 1993-94 levels and thus limiting further growth in irrigation use (Connell & Grafton 2011). Yet, floodplain harvesting (FPH), enabled by widespread construction of on-farm storages (OFSs), has remained a regulatory challenge due to its scale, variability, and limited historical accounting.

Although OFSs provide irrigators with operational flexibility and drought resilience, they also intercept floodplain flows by altering hydrological regimes and downstream ecosystem function (Kingsford 2000). Recognising this dual role, the NSW Government introduced the Floodplain Harvesting Policy requiring all FPH activities to be licensed and metered in line with Basin Plan sustainable diversion limits (DPIE 2018a (first published 2013)). Reliable quantification of OFS numbers, distribution, and volumetric capacity is therefore critical for hydrological modelling, compliance, and Basin-scale accounting. In response, the NRAR and DCCEEW have developed a comprehensive database of 1,253 active OFSs across the northern MDB, underpinned by LiDAR-derived Storage Volume Curves (SVCs) validated to within ±5% of surveyed volumes (DPIE 2018b) and cloud-free Landsat and Sentinel time series observations of water surface areas (see https://github.com/DCCEEW-RemoteSensing/EOWater) that can be converted to volumetric observations through the SVCs. This study leverages that database from 1986 to 2025 and applies a "first 50% fill" approach to determine the timing of when storages first became operational. This approach provides new insights into how infrastructure growth has interacted with successive policy reforms, offering an evidence base for improved regulation and Basin water accounting.

2. METHODOLOGY AND RESULTS

This study examined the development of on-farm storages (OFSs) across the five northern valleys of the Murray-Darling Basin (MDB): the Border Rivers, Gwydir, Namoi, Macquarie-Castlereagh, and Barwon–Darling. A dataset of 1,253 storages compiled by the NRAR was used as the basis for analysis. To assess storage development through time, we applied a "first 50% fill" approach to the NRAR-DCCEEW database. In this method, the year of first operation is defined as the point when a storage reached at least half of its maximum capacity on area-basis as determined from pre-existing storage volume curves (SVCs). This method provides a consistent proxy for when storages became functional. The analysis was performed at both Northern basin and valley scales to assess spatial differences in growth trajectories. Temporal patterns of storage numbers and cumulative capacity were then compared with major policy milestones, including the 1994 Cap on Surface Water Diversions, to evaluate how water reforms influenced the pace and scale of OFS development.

Results of the study show that out of 1,253 storages, 1,245 reached at least 50% of their capacity during the study period with a cumulative volume of 1,312 GL. At the catchment scale, the Namoi contained the largest number of storages (500), followed by the Gwydir (355), Macquarie-Castlereagh (172), Border Rivers (118), and Barwon Darling (100). Together, the Namoi and Gwydir accounted for more than half of all storages in the northern Basin which shows high irrigation demand and favourable conditions for FPH.

Results show that OFS development in the northern Murray-Darling Basin followed distinct phases strongly aligned with Basin-wide policy reforms (Table 1). Rapid expansion occurred between 1986 and 1990, averaging over 100 storages annually with capacity growth of 110 GL per year. Growth slowed in the 1990s to about 49 storages annually which coincides with the 1994 Cap. There was a decline in number of OFS in the 2000s to around 16 per year. Development nearly plateaued after 2010, averaging fewer than 10 storages annually, and by 2021-2025 only 12 new storages were added. By 2007, 95% of total storage capacity was complete. In 1995, 62% of storages and 64% of capacity were already in place. By 2008, 90% of storages had been built, with only 10% added afterwards. Early growth was faster in the Border Rivers, Barwon-Darling, and Gwydir (~71%) than in the Namoi and Macquarie (~54%).

Table 1 Phases of OFSs development and capacity growth in the northern Murray-Darling Basin from, 1986–2025

Period	Avg. New Storages / Year	Peak Year (Storages)	Avg. Capacity Growth (GL/yr)	Peak Year (Capacity, GL)
1986–1990	104	1986 (185)	110	1987 (199)
1991–2000	49	1995 (72)	56	1995 (75), 1996 (94)
2001–2010	16	2004 (52), 2010 (23)	16	2004 (66)
2011–2020	8	2016 (21), 2020 (22)	3	2016 (19)
2021–2025	3	2021 (12)	1	2021 (4)

3. CONCLUSIONS

The results of this study provide a robust foundation for future policy modelling and regulatory development in the Murray-Darling Basin. Detailed information on storage capacity, location, and numbers offers critical inputs for hydrological modelling, water accounting, compliance monitoring, and the design of sustainable diversion frameworks. These insights are particularly relevant for aligning agricultural water use with Basin Plan objectives and managing trade-offs between consumptive and environmental needs. Our findings are consistent with Brown et al. (2022) who reported 1,833 storages across the Basin. While their study included approximately 1,000 additional small storages not captured in the NRAR-DCCEEW database, both analyses reveal similar development trajectories with rapid growth prior to the 1994 Cap followed by a policy-driven slowdown. A full discussion of spatial patterns, agricultural expansion, and policy implications will be presented in the forthcoming research paper.

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