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Water sparing versus sharing: Depolarising wetland management with novel environment-agriculture policy

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ABSTRACT

Land sparing centres on agricultural intensification to increase yields and free land for conservation, while land sharing integrates farming and biodiversity but needs larger areas. Although the debate has matured to consider social-ecological systems and potential synergies, water has been almost entirely neglected. We develop a 'water sparing versus sharing' concept, propose new water sharing policies, and assess public values towards them in Australia's Murray–Darling Basin. Here, water sparing dominates and fuels polarised debate, especially around environmental water recovery, where increased conservation—typically in protected areas—occurs while farming becomes more intensive and water-efficient. Conversely, we introduce water sharing, which transcends this binary approach and, under certain conditions, could offer greater environmental, economic and social benefits. We show that water sharing challenges the key premise of land sparing because additional water to integrate biodiversity can increase yields, requiring less land. We illustrate our arguments with three policy options to conserve threatened species dependent on both traditional rice farming and natural wetlands supported by environmental water: (1) amalgamating environmental and irrigation water; (2) using environmental water in artificial refuges; and (3) subsidising water to incentivise multifunctional benefits. Using biodiversity benefits per megalitre, alongside social and economic metrics, scenarios could be prioritised. A survey of Australians ($n = 1478$) showed strong public support for such amendments. A multinomial logit model indicated younger people with higher environmental values and lower incomes were most supportive. Water sharing policy can depolarise management, maximise multifunctional water-use efficiency and offer a political conduit between conflicting interests.

1. Introduction

Water policy is highly contested and complex, with significant impacts on economies, communities, and ecosystems. Disputes over managing this simple yet scarce, vital resource have made it politically charged worldwide, occasionally leading to 'water wars' (Poff et al., 2003; Wolf, 1999). Central to agriculture and conservation, effective water management is increasingly challenged by climate change, population growth, affluence, biodiversity loss, and difficult trade-offs (Bender et al., 2023; Schweizer et al., 2022; Wilson et al., 2022). Freshwater comprises about 2.5% of the world's water but most of it is in ice caps, glaciers and other inaccessible places. Freshwater use is increasing every year and agriculture accounts for about 69% of the global withdrawals from rivers, lakes and other readily exploitable sources, amplifying the urgency to improve water use efficiency (Gleick and Cooley, 2021).

Water policy is particularly critical in Australia's Murray-Darling Basin, which spans 14% of the country's land but produces 40% of its agricultural output, supplying food for approximately 30 million people and generating $35 billion annually, while also causing significant environmental harm (Hundloe et al., 2016; Kingsford and Thomas, 2004; MDBA, 2025; Pittock and Finlayson, 2011). Environmental concerns include land clearing, grazing, fire regimes, invasive species, and pesticide use, but politically, water management has become the dominant issue (Colloff et al., 2015; MDBA, 2010). In 2012, after a century of amendments, the Australian government enacted the $AUD13 billion Murray-Darling Basin Plan to address overallocation to irrigation and restore ecosystems by reclaiming environmental water via entitlement buybacks and water-saving projects (Connell and Grafton, 2011; MDBA, 2010; Ross and Connell, 2016).

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From the start, the Plan was contentious, inadvertently pitting irrigators and conservationists against each other, framing the environment and farming as mutually exclusive (Colloff and Pittock, 2019; Gross and Dumaresq, 2014; Mushtaq et al., 2013). Scientific research around its implementation has also been strongly disputed, given the political sensitivities (Colloff et al., 2021; Stewardson et al., 2021). Proposed water recovery targets ranged from 3000 to 7000 GL, but 2750 GL was ultimately set as the amount in excess of sustainable limits (MDBA, 2010). An additional 450 GL was negotiated by South Australia, bringing the target to 3200 GL (Grafton and Wheeler, 2018). Subsequent amendments under political pressure included a mechanism reducing the target by 605 GL, arguing equivalent environmental outcomes could still be achieved (Bender et al., 2023; Lyons et al., 2023; MDBA, 2025). By July 2025, 2135 GL had been recovered and assigned to government-held environmental accounts, but the 450 GL and 605 GL adjustments have caused complications, such as underestimated project costs (MDBA, 2025). The volume of environmental water needed remains disputed and a Plan review is due in 2026 (Chen et al., 2021; MDBA, 2025; Zuo and Wheeler, 2024).

The Basin Plan effectively aligns with a 'land sparing' approach—recovering water enables larger areas to be dedicated to conservation, alongside more intensive agricultural production in existing farmland. This contrasts with 'land sharing', where biodiversity is enhanced in farmland, but at the expense of yields and requiring more land (Balmford et al., 2005; Fischer et al., 2008; Green et al., 2005; Kremen, 2015; Phalan et al., 2011). While land sparing often provides maximum biodiversity benefit, evolving evidence shows that land sharing may be more beneficial in some contexts, balancing social, ecological, and economic goals (Baudron et al., 2021; Fischer et al., 2014, 2017; Gardali et al., 2021; Segre et al., 2019). Some mixed-use landscapes provide both high biodiversity and yields, along with social benefits (Gonthier et al., 2014; Kremen and Merenlender, 2018; Torres et al., 2021).

Despite its centrality to conservation and agriculture, water has been almost entirely neglected in the sparing vs. sharing debate (but see Erős et al., 2023). 'Water sparing', as seen in environmental water recovery, has generated significant biodiversity benefits (e.g., Gawne et al., 2020; McGinness et al., 2024), though trade-offs from reducing agricultural water use have been overlooked, and integrated solutions underexplored. Here we introduce 'water sharing' as an alternative model, aiming to manage water for agriculture and biodiversity concurrently, akin to 'wildlife-friendly' farming in land sharing. We contend that policies enabling water sharing could maximise the sum of benefits received by society from each megalitre of water used, avoiding the binary agriculture-environment approach to water resource management that presently dominates. Water sharing could also reduce the divisiveness and polarisation of the debate by fostering better collaboration between farmers and conservationists.

The socio-economic impacts of the Basin Plan have been controversial, influenced by climate change, media framing, and the consistent neglect of First Nations water rights (Moggridge and Thompson, 2021; O'Donnell et al., 2019; Wheeler et al., 2020, 2024). Locating ecological and socio-cultural synergies is key, particularly where relational water values are not well recognised (Jackson and Nias, 2019). While our water sharing concept focuses on agriculture and biodiversity, it also aligns with Indigenous water use, including food, medicine, culturally important species, and other co-benefits (Costanza-van den et al., 2022; Westell et al., 2023). With climate change intensifying water challenges, reframing policy is urgent (Bender et al., 2023; Pittock et al., 2023), and water sharing offers a path to greater integration. However, a lack of evidence limits reforms like those needed in the upcoming Basin Plan review.

Our study had three objectives: 1) to develop a conceptual framework for water sparing and sharing; 2) to offer novel, practical water sharing policy options for the Murray-Darling Basin, drawing on the new framework; and 3) to assess public values regarding water sparing versus sharing using the new policy options. We focused on three globally threatened species – Australasian bittern (*Botaurus poiciloptilus*), Australian painted-snipe (*Rostratula australis*), and southern bell frog (*Litoria raniformis*) – because they use agricultural wetlands in significant numbers, representing water sharing, but also depend on key natural wetlands sustained by environmental water, representing water sparing (Herring and Silcocks, 2014; Herring et al., 2019, 2021a; Ryan et al., 2021; Wassens et al., 2010). Bittern research has spurred trials of 'bittern-friendly' rice farming and showed the feasibility of consumer-funded programs (Herring et al., 2022a, 2022b), exemplifying the concurrent use of water for agriculture and biodiversity conservation, consistent with an application of water sharing. However, novel policy that fosters the expansion of such water use could significantly enhance outcomes for these and other species, and help bridge the environment-agriculture divide that hampers water management.

2. Materials and methods

Our methodology involves three interrelated parts. First, we develop the water sparing versus sharing concept, showing how it differs from the original land sparing versus sharing framework that centres on agricultural intensification to maximise yields that enable more land to be spared, while land sharing integrates farming and biodiversity conservation but requires more land. Second, because water sparing is the dominant strategy in the Murray-Darling Basin, we seek to illustrate water sharing by developing three novel policy options that integrate agriculture and biodiversity conservation, specifically to benefit our three focal threatened species. Third, we assess the public's values of such policies, asking respondents' preferences, agreement levels and feelings towards simple questions and statements, as a way to obtain data rapidly and with minimal cognitive burden compared to complex choice experiments and other more demanding methods.

2.1. Developing the conceptual basis for water sparing versus sharing

We developed a simple conceptual basis for water sparing and water sharing by adapting the theoretical framework of the land sparing versus sharing debate (e.g., Fischer et al., 2008; Green et al., 2005; Kremen, 2015; Phalan et al., 2011) to incorporate paradigms for water resource management, agricultural yield and yield per megalitre, drawing particularly on rice growing in the Murray-Darling Basin. This provided the foundation for the subsequent sections on policy options and public values.

2.2. Policy options for water sharing

From our perspective of threatened species conservation, targeted wetland management and innovative water policy, both as researchers and practitioners, we developed three new policy opportunities to exemplify water sharing. They are based on an understanding of both environmental and irrigation water use in the Murray-Darling Basin (e.g. MDBA, 2025), with clear practical application and particular relevance to three globally threatened wetland species: the Australasian bittern, Australian painted-snipe and southern bell frog. These species were selected because of their high conservation priority within the Murray-Darling Basin and strong association with both natural wetlands maintained by environmental water and agricultural wetlands maintained by irrigation water. Other high conservation priority wetland species in the region, such as trout cod (*Maccullochella macquariensis*) and swamp wallaby grass (*Amphibromus fluitans*), do not regularly occur in agricultural wetlands, whereas the three focal species provide a platform to illustrate potential benefits of the novel water sharing policies. These benefits could extend to biodiversity generally, including species less associated with agricultural wetlands, but we acknowledge the existence of other species that would likely not benefit from water sharing, as is commonly the case in land sharing, where, for example, species dependent on primary forest may only be accommodated in land sparing scenarios.

2.3. Public values for water sparing and sharing

Water managers, government officials, farmers, Indigenous people and other key stakeholders all have values central to developing new water policy, but the general public's values often drive contentious political decisions like water use in the Murray-Darling Basin, so we sought to determine the Australian public's values for water sparing and sharing scenarios. This way, we provide evidence for the key stakeholders about whether or not the social licence exists to explore innovative water policy.

We carried out an online survey from 27 June to 2 July 2019 of adults (18 years and over) living in Australia, using a market research company (Dynata: https://www.dynata.com/), with sampling representative of age, sex and location based on national census data. Approval for this survey was obtained through the Charles Darwin University Human Ethics Committee (H17123). We obtained 1534 completed responses, of which 56 were deemed invalid because they were undertaken in <3 min (intended survey length was 10–12 min), leaving us with a final sample of 1478 valid responses. Using Qualtrics software, the questionnaire incorporated randomization for the order of statements for ranking importance, preference, or indicating agreement, and had mobile-phone-friendly visualization. A pre-test with 19 people to assess functionality, language, and clarity indicated no significant changes were needed.

The questionnaire contained three parts. First, demographic data were collected; age, sex, location, income and education. Second, to ascertain environmental values, we asked six questions from the New Ecological Paradigm (NEP), which assesses respondents' ecological worldview and their views on humanity's apparent dominion over nature (Dunlap et al., 2000), and one question about frequency of environmentally-friendly supermarket purchases. Third, we asked questions that encompassed a range of potential opinions about water use for irrigation and the environment, pertaining to our three policy options, to gauge respondents' values for water sparing and sharing, as expressed through land sparing and sharing. Background information on water resource management in the Murray-Darling Basin was supplied to respondents prior to these questions (the full questionnaire is provided in the Supplementary Material).

2.4. Data analysis

To understand the characteristics of those who preferred water sharing or sparing, we estimated a multinominal logit (MNL) model. The MNL model is based on respondents choosing their preferences from a set of discrete outcomes and estimates the probability of them selecting a particular outcome based on the values of the independent variables. Our dependent variable was drawn from the key question where respondents chose one of four sparing and sharing scenarios, but we combined the two preferences for sparing because of the low number of responses (Fig. S1) and used it as a reference category, resulting in three variable outcomes. The MNL model uses the concept of log-odds to compare the likelihood of each possible outcome relative to a reference category. The coefficients of the included independent variables represent how a one-unit change in such a variable affects the log-odds of selecting a particular outcome compared to the reference (Venables and Ripley, 2002). All statistical analyses were conducted using R version 4.3.1 (R Core Team, 2023). The MNL model was estimated using the *multinom* function from the nnet package (Venables and Ripley, 2002).

First, we checked for highly correlated independent variables using the *corrplot* function (Wei and Simko, 2021) and excluded three variables that were strongly correlated with others (Fig. S2). We then estimated a MNL model including all independent variables deemed important in explaining respondents' preferences, such as demographics and environmental values, including the NEP score. To obtain a parsimonious model, we applied stepwise variable selection based on the Akaike Information Criterion (AIC). Variables were sequentially removed until the model with the lowest AIC was identified, indicating the best balance between model fit and complexity.

3. Results

The development of the water sharing versus sparing concept enabled us to determine three new water sharing policy options for the Murray-Darling Basin. These policies are designed to benefit our three focal species by accommodating their ecological needs and addressing conservation issues like habitat suitability, connectivity and breeding success. We then show what the public's values towards such policies are.

3.1. Conceptualising water sharing and water sparing

We define water sparing as water removed or excluded from agriculture and used in natural habitats for biodiversity conservation, akin to land sparing, such as a rainforest reserve, where no agriculture occurs and where nature conservation is the primary purpose. In the Murray-Darling Basin, water sparing specifically relates to the recovery of environmental water – through buybacks and water-use efficiency projects – from irrigated agriculture and subsequently only used for nature conservation. Conversely, water sharing is the explicit, concurrent use of water for biodiversity conservation and agriculture, including the use of environmental water in agricultural habitats. Resembling land sparing, water sparing is characterised by more water for protected areas but it differs in having lower yields per hectare (Fig. 1). This is because of the association of water sparing with more

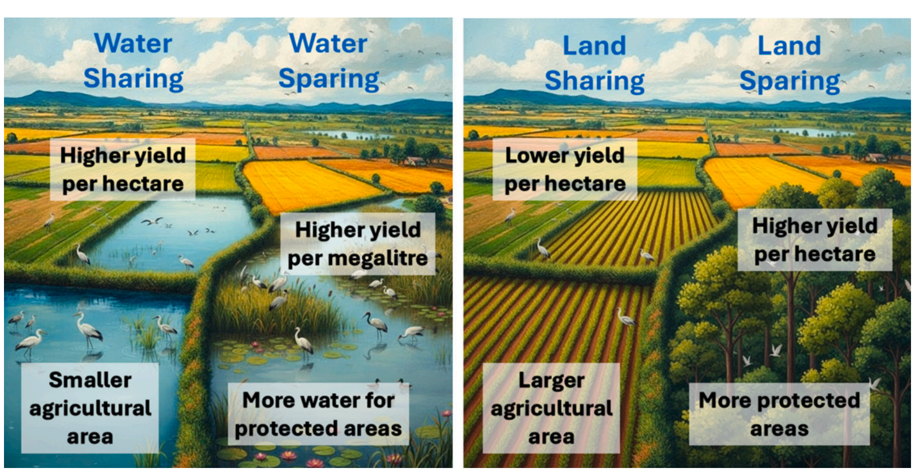

Fig. 1. The concept of water sharing and sparing across four key parameters, showing how it contrasts with the original land sharing and sparing framework.

water-efficient production, and the positive relationship between the volume of water used and yield. For example, rice production in the Murray-Darling Basin that uses water-efficient management like delayed ponding seeks to maximise return on water investment, producing lower yields than traditional management (e.g., 10.1 versus 11.0 t/ha) but higher yields per megalitre (Brinkhoff et al., 2024). Comparable to land sharing, water sharing is characterised by less water for protected areas but it differs in producing higher yields per hectare, thus requiring a smaller agricultural area (Fig. 1).

3.2. Policy options for water sharing

We found that water sharing policy, as we define it, has inadvertently already been implemented in different parts of the world. For example, concurrent water use with agriculture and biodiversity has been applied during conservation incentive programs in rice fields (Herring et al., 2022a; Katayama et al., 2019; Reiter et al., 2018), and through farmers grazing wetland vegetation maintained by environmental water (MDBA, 2025). However, we identified three novel water sharing policy areas that integrate water management in the Murray-Darling Basin, combining agriculture and biodiversity conservation, that could augment potential benefits to our focal threatened species (Fig. 2):

1) Amalgamating environmental and irrigation water;
2) Environmental water use in artificial refuges; and
3) Government subsidies for water sharing.

3.2.1. Amalgamating environmental and agricultural water

Amalgamation in agricultural wetlands like channels and storage dams could elevate the overall biodiversity benefits of irrigation and environmental water, and offer socio-economic advantages (Fig. 2). Australasian bitterns and rice farming illustrate how water sharing via amalgamation could offset the negative effects of water-use efficiency measures that undermine the habitat values of rice fields by reducing opportunities for successful breeding. Traditional water management with a sufficient ponding period for bitterns uses around 13.5 megalitres/ha, while fields using new water-saving agronomy, which have become the rice industry standard over the past decade, use about 12.25 megalitres/ha, which constitutes a substantial cost-saving to farmers (Herring et al., 2021b). Potentially, environmental water could be used to facilitate bittern conservation by making up the difference, incentivising traditional growers to maintain their water management, or supplementing water in the modern crops. In this way, environmental water redirected into this water sharing scenario could potentially achieve a 13.5 megalitre/ha benefit – successful bittern breeding – at only 1.25 megalitre/ha, and rice farmers could benefit financially from the consumer premiums of 'bittern-friendly' rice products.

3.2.2. Environmental water use in artificial refuges

The targeted use of environmental water in strategically located, specially designed wetland refuges could augment agricultural habitat values for our three focal species and, potentially, provide better overall biodiversity benefits per megalitre than if it were used conventionally. In the case of bitterns, bell frogs and rice farming, wetland refuges could help mitigate the impacts of increasing water-use efficiency on successful breeding opportunities, and provide populations with habitat after the rice season ends and throughout the non-breeding season, avoiding potentially hazardous dispersal. In other cases, environmental water could be used in channels and storage dams, where the water is about to be used or the supply terminated, but which support key species, like Australian painted-snipe, or provide important connectivity functions, such as those for frogs and fish. In areas where water-use efficiency measures have replaced open channels with pipelines, or dams with troughs, environmental water could be used to maintain sites with high biodiversity values where wildlife has come to depend on them.

3.2.3. Subsidised water for integrated use

In natural habitats, government support for conservation is routinely determined by biodiversity values, and a similar approach could be taken in novel, agricultural environments. In the Murray-Darling Basin,

Fig. 2. Three novel water sharing policy options that integrate agriculture and biodiversity conservation in the Murray-Darling Basin, potentially maximising benefits for the southern bell frog (a), Australian painted-snipe (b), Australasian bittern (c) and other species: a) Amalgamating environmental water and irrigation water in storage/recycle dams, rice fields and other agricultural wetlands, such as facilitating connectivity in channels for frogs and fish to reach winter or drought refuges; b) Environmental water use in dedicated artificial refuges to augment agricultural habitat values, such as enabling completion of reproductive cycles, providing non-breeding season habitat or mitigating negative impacts of farm management like draining for irrigation use; c) Subsidised water for integrated use, where government intervention supports irrigators for growing a certain crop in a particular way that provides significant biodiversity outcomes, such as successful breeding in rice fields.

state and federal governments could subsidise the specific irrigation industries, crops and growing methods that incorporate the most biodiversity conservation. In the case of wetland biodiversity, traditional rice farming would be such a candidate for this market intervention, supporting significant populations of threatened waterbirds and frogs, as well as important populations of more common species (Fig. 2).

Irrigation water assigned for integrated use, where there are clear environmental benefits, could be treated separately and favoured during the seasonal process of allocation to permanent entitlements. Similarly, environmental water assigned for integrated use, where there are clear social and economic benefits, could be favoured. Subsidising costs on the temporary water market could also provide a mechanism for government to encourage water sharing initiatives, incentivising multifunctional benefits per megalitre used, while other options for facilitating integrated water use are through ethical water investment funds and non-entitlement water.

3.3. *Public values of water sharing*

Our sample of the Australian public ($n = 1478$) was gender balanced, with an average age of 46.4 (SD: 17.1), and most respondents had apprenticeship/TAFE qualifications (29%) or a university degree (26% undergraduate and 12% postgraduate degrees). More than half of respondents (58%) had an income of up to $50,000 (Table S1).

A strong majority – over 85% – of the Australian public felt positive about the recovery of environmental water in the Murray-Darling Basin, though most of these people had minor issues with the reforms. A similar majority – over 83% – also felt positive about adjusting the allowable use of environmental water so that artificial wetlands like rice fields can be incorporated (Fig. S3). However, 67% also agreed that environmental water is in short supply and should only be used in natural ecosystems (Fig. S4). Still, 83% also agreed that some environmental water should be used to supplement irrigation water in rice crops to help bitterns breed successfully (Fig. S4). The Australian public was also largely supportive of the idea of government intervention to support one crop type over another based on the wildlife it supports (20% yes, definitely; 54% yes, probably; 22% no, probably not; 4% no, definitely not).

As a surrogate for water sparing in the survey, land sparing in combination with a smaller area of land sharing (36%) and land sparing on its own (7%) for irrigated agriculture in the Murray-Darling Basin combined for a total of 43% of respondents preferring sparing as the dominant strategy (this was the reference category for the MNL). Land sharing, as a surrogate for water sharing, and a smaller area of land sparing was preferred by 32%, while land sharing on its own was preferred by 25% (Fig. S1).

The final MNL model after stepwise elimination of variables had a AIC of 2903 (Table 1). The Nagelkerke R^2, a Pseudo-R^2 measure, was 0.22, indicating a satisfactory level of explanatory power for a MNL model (Louviere et al., 2000). It showed that younger respondents preferred land sharing over land sparing, indicated by the positive coefficients for those scenarios relative to the combined land sparing reference category, which has the two options that favour sparing (Table 1). The combined reference category was preferred by respondents with low NEP scores, indicated by the significant and positive coefficients for the NEP scores in the two other categories. Respondents with low income were more likely to prefer land sharing, while opinions about environmental water use, irrigated agriculture and the economy also had significant impacts on the preference for land sharing, with more positive views on agriculture associated with a land sharing preference. The preferences for land sparing were more homogenous with differences not well explained by the opinions of respondents. Other variables, such as sex, education and where someone lived (e.g., rural, small city, large town), were not significant.

Table 1
Significant variables in the multinominal logit model for respondents' preference for land sharing, as a surrogate for water sharing, in the Murray-Darling Basin. The categories are compared to the reference category, where land sparing is preferred. Standard errors are provided in brackets. Significance codes: *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$.

Independent variables	Category	
	Land sharing and a smaller area of land sparing	Land sharing
	Coefficients (SE)	
Respondent age	0.012*** (0.004)	0.021*** (0.004)
NEP score (between −11 and 12)	0.092*** (0.015)	0.134*** (0.018)
Respondent income (coded from 1 to 7)	0.013 (0.042)	−0.115** (0.052)
Agreement to 'Agriculture that involves irrigation should be phased out in the MDB'	−0.015 (0.089)	−0.551*** (0.105)
Agreement to 'Agriculture that involves irrigation in the MDB plays a key role in feeding and clothing our nation's population'	−0.036 (0.101)	0.841*** (0.115)
Environmental water is in short supply and should only ever be used in natural ecosystems such as rivers and swamps.	−0.013 (0.093)	−0.213* (0.109)
Agreement to 'Environmental water use should be expanded to include human-made ecosystems such as rice crops'	0.160 (0.097)	0.263* (0.109)
Agreement to 'Do you think state and federal governments should intervene and provide support for one crop type over another based on the wildlife it supports'	−0.154* (0.090)	−0.252** (0.107)
Constant	−0.950** (0.415)	−1.717*** (0.487)
AIC	2902.56	
Log-likelihood	−1433.30	
Nagelkerke R^2	0.22	

4. Discussion

4.1. *Conceptualising water sharing and water sparing*

Water management, while essential to agriculture and biodiversity conservation, has been neglected in the land sparing versus sharing framework. Our new water sparing versus sharing concept highlights water sparing as the dominant approach in the Murray-Darling Basin, with water sharing scenarios being underexplored, despite their clear potential benefits to biodiversity. Some environmental water delivery already provides a grazing benefit to farmers, serendipitously epitomising the existence of water sharing and showing how win-win situations can emerge. For example, the Australian painted-snipe appears to benefit from cattle grazing in the Macquarie Marshes, a key delivery site for environmental water, because it maintains a vegetation structure that supports more open feeding areas required for the species (*Tracking Australian Painted-snipe*, 2025).

The inclusion of water in the land sparing versus sharing framework can contradict the fundamental element that agricultural intensification allows for more land to be spared by increasing yields per hectare in existing farmland. Indeed, the neglect of water in the debate may have inflated some values of sparing over sharing. The intensification associated with water use in sparing scenarios increases yield per megalitre but reduces yield per hectare, representing a net loss of agricultural production per unit area. Theoretically, more biodiversity occurs in the farmland of water sharing, given the more traditional, less intensive approach, while in water sparing scenarios more biodiversity occurs in protected areas because of the additional water and exclusion of agriculture. Water sparing, like environmental water recovery, can increase the incentives for agricultural water-use efficiency, where biodiversity values can be undermined (Giuliano and Bogliani, 2019; Huntsinger et al., 2017; Kidera et al., 2018; Van Schmidt et al., 2021), and the opportunities to address ecological trade-offs can diminish rapidly (Herring et al., 2021b; Law et al., 2021). The spared water and any subsequent biodiversity benefits may be at least partially negated elsewhere by the additional land and water requirements to compensate for lost food production. Another implication of the water sparing approach is that novel habitats and agricultural land tend to be excluded from conservation even though they sometimes support biodiversity values that are at least comparable to their natural counterparts (Herring et al., 2019; Quine and Humphrey, 2010; Van Schmidt et al., 2021; Sousa et al., 2019). Australia's water management, through markets and environmental water recovery, is among the most sophisticated in the world, driven largely by being the driest inhabited continent (MDBA, 2025). As water policy development becomes more important in other countries, water sharing could help reconcile the competing demands from agriculture and biodiversity conservation.

4.2. Policy options for water sharing

4.2.1. Amalgamation

The careful amalgamation of private agricultural water with public environmental water could, under specific circumstances, produce better environmental, social and economic outcomes. Failing to fully realise this potential could see lost opportunities to improve water resource management. Under existing policy, amalgamation is not explicitly permitted, largely because environmental water is assigned to restoring and maintaining natural systems (MDBA, 2010, 2025), whereas most irrigation water is used in artificial systems. The objectives for individual environmental watering events vary greatly, from broad notions of improving ecosystem function and health, through to increasing vegetation recruitment, connectivity for native fish, facilitating reproduction of a threatened frog, or ensuring a waterbird breeding colony is successful (e.g., McGinness et al., 2024; MDBA, 2025; Ryan et al., 2021). Conversely, the economic return per megalitre increasingly drives agricultural water use by irrigators. Merging of some agricultural and environmental water to increase dual benefits per megalitre could represent true water-use efficiency and value for money. Given the increasing scarcity of water, it's reasonable to ask why enabling conditions like this, which leverage the large volume of water still managed by irrigators, are not implemented to benefit biodiversity.

The amalgamation of agricultural water in natural wetlands with environmental water could be more difficult, with, for example, issues associated with water polluted by synthetic pesticides and fertilisers, or facilitating pathways for invasive species to spread. Still, there are cases where this could occur under careful management, such as an irrigator supplementing environmental water in a natural wetland to extend its grazing benefits.

4.2.2. Artificial refuges

For any environmental water use in artificial wetland systems, the subsequent decrease in natural systems, where it would have been used otherwise, would require careful consideration to avoid any net loss of environmental benefit. In some cases, this could be relatively straightforward. For example, a large flow of 1.5 GL through a high priority wetland complex, a scale at which flows regularly occur (MDBA, 2025), could potentially be reduced to 1.45 GL, with little or no predicted impact on the outcomes from specific objectives, such as the completed reproductive cycles of target species, but while delivering significant relative benefits to the same species. Additional social and economic advantages may also exist with the integrated use. In other cases, comparisons with conventional environmental water use, and identifying net benefits, would be more complex. For example, with bitterns and rice farming, any potential net species-specific gains, which could incorporate a whole assemblage associated with rice, may need to be evaluated against gradients of ecosystem health and recovery, and against different species assemblages, such as in the Murray Mouth, the rivers themselves or black box floodplain woodlands (e.g., Doody et al., 2021).

In Italy and Japan, incentives have been provided to create water retention structures (excavated ditches) around rice fields to reduce the negative effects of drying periods on aquatic organisms, offering a refuge from which recolonization of the rice field can occur, with larger, deeper structures being the most successful (Giuliano and Bogliani, 2019; Miyu et al., 2020). Refuges could incorporate innovative, wildlife-friendly agricultural production, such as yabby (a crustacean), waterfowl and fish farming, garden mulch production, or offer tourism opportunities, each providing employment opportunities. There are already situations where environmental water has commercial benefits, such as the grazing value gains in natural wetlands, or, as at Banrock Station, a popular winery and tourist destination, where their wetland helps attract visitors (Tourenq et al., 2018).

4.2.3. Subsidies

Driven by economic return per megalitre, many rice growers have recently transitioned to cotton and corn, or incorporated them in their cropping programs. Almonds have also become lucrative, inflating water prices on the temporary market, where costs approach $1000 per megalitre during droughts (Douglas et al., 2016; Hughes et al., 2023). Unlike rice, these alternatives do not involve the creation of a sustained wetland environment that supports aquatic biodiversity. However, they have other biodiversity values that would need to be considered (e.g., threatened parrots using almond plantations: Luck et al., 2013).

Although government subsidies and incentives for agriculture, like tariffs and quotas, often distort markets, generating inefficiency and creating environmental damage, repurposing the support could see substantial gains in sustainability and human health (FAO, UNDP and UNEP, 2021). Globally, Australian farmers are among the least subsidised, particularly for fostering sustainability beyond economics, with the sugar industry the sole example of targeted environmental support (Greenville, 2020). In other countries, like the United Kingdom and United States of America, where agricultural subsidies are common, agri-environment schemes, including those that ultimately demonstrate water sharing policy, regularly integrate farming and biodiversity conservation, but polarisation still dominates in an era of agricultural intensification to maximise yields and profit (Greenville, 2020; Kremen and Merenlender, 2018; Reiter et al., 2018).

4.3. Public values

The Australian public were largely supportive of water sharing and our three proposed policy options, including government intervention to support one crop type over another based on the wildlife it supports. However, some contradiction in their values occurred, with 83% supporting the use of environmental water in artificial wetlands like rice fields but two thirds also agreeing that environmental water is in short supply and should only be used in natural ecosystems. This is likely a result of agreeableness (Graziano and Eisenberg, 1997) and perhaps a limited understanding of the issues at hand and the difficulty of knowing what might be the best use of water. Future research could explore these nuances and incorporate the trade-off we identified with lower yield per hectare of water sparing scenarios. Still, the results show that when presented with water management scenarios that integrate agriculture and biodiversity conservation the Australian public is at least willing to consider innovative policies, which is useful information for government agencies like the Commonwealth Environmental Water Office and other key water resource stakeholders. In particular, they should be aware that younger people with higher environmental values and lower incomes were more likely to support land and water sharing scenarios.

5. Conclusion

We identified water as being neglected in the land sparing versus sharing framework. That enduring debate has provided a stimulating challenge for conservation biologists and natural resource managers when considering land use change, protected area management, sustainable agriculture and the prioritisation of conservation efforts, from individual farms to vast landscapes. We proposed a water sparing versus sharing concept, adapting the original debate and emphasising that the premise of agricultural intensification facilitating more land to be spared can be undermined by the inclusion of water. Using the Murray-Darling Basin as a case study, where water sparing and the separation of agriculture and biodiversity conservation dominates, we illustrated three novel water sharing policy options, including amalgamation, artificial refuges and subsidies, where three high priority threatened species could benefit. We also show that water sharing – the explicit, concurrent use of water for agriculture and biodiversity conservation – has inadvertently already been implemented in other ways, notably by grazing wetlands maintained by environmental water and through incentive programs for rice growers to alter water management to meet biodiversity objectives like successful bittern breeding.

A survey of the Australian public showed strong support for land and water sharing initiatives, demonstrating a social licence for policy makers, conservation practitioners and agricultural stakeholders. While water policy amendments can be complex and difficult to understand, the public support for integrating irrigated agriculture and biodiversity conservation was clear. Assessment of the biodiversity conservation trade-offs and synergies that have been at the centre of land sparing and sharing debate could be applied to water resource management in future research, alongside standardised social and economic metrics to determine the highest projected overall benefits of different water use options. For water sharing policies, such as those we developed, future research could also measure the biodiversity benefits per megalitre of different scenarios to help enable prioritisation. Water sharing and the integrated policy we develop reinforces humans as part of socio-ecological systems. This contrasts with water sparing and protected areas – including environmental water recovery – that can inadvertently subjugate the environment to a foreign place from which people feel separated. Water sharing policy has the potential to act as a leverage point for systemic change, where rural landscapes become hubs for the coexistence of sustainable agriculture and biodiversity stewardship – socially just agroecosystems – supporting vibrant local economies.

CRediT authorship contribution statement

Matthew W. Herring: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Stephen T. Garnett:** Writing – review & editing, Supervision, Funding acquisition. **Kerstin K. Zander:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Formal analysis.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work Matthew W. Herring used DeepAI in order to help generate the background images for Fig. 1, and Chat GPT to reduce text length for the Abstract and Introduction, and after using these tools the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr Matthew Herring reports financial support was provided by Charles Darwin University. Dr Matthew Herring reports a relationship with Bitterns in Rice Project that includes: consulting or advisory. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2026.111701.

Data availability

Data will be made available on request.

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