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Editorial

Irrigation, fisheries and Sustainable Development Goals: the importance of working collaboratively to end world hunger and malnutrition

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The water–food–energy nexus is central to sustainable development (Poff and Olden 2017). Demand for all three is increasing, driven by a rising global population, rapid urbanisation, changing diets and economic growth. In response, many countries are expanding irrigation infrastructure to produce food and building dams to secure water and generate power. The pace of present-day development is historically unprecedented. The scale of irrigated agriculture is significant, both economically and in terms of food production. Globally, the irrigated area has roughly doubled in the past 50 years (Foley *et al.* 2011). Currently, irrigated agriculture represents 21% of the total cultivated land but contributes 40% of the total food produced worldwide (Caron *et al.* 2018). Therefore, it is important that such development is planned, implemented and managed appropriately.

Typically, food–water–energy services are managed separately, but doing so can have significant unintended environmental consequences. For example, the environmental impacts of dams have been recognised globally as one of the major threats for aquatic biota, particularly riverine species (Poff and Schmidt 2016). Irrigation practitioners are often incentivised to increase land and water productivity for crop production (e.g. rice; McCartney *et al.* 2019). But, in many areas, the effects of irrigation development on fish and aquatic fauna are barely considered (Falkenmark *et al.* 2007; Welcomme *et al.* 2010).

Development of the irrigation sector has already contributed to the decline of many fish populations (Agostinho *et al.* 2016). This has happened even though, for many rivers and basins around the globe, fish remain a primary source of protein, providing food security in the form of protein and essential micronutrients for these areas with growing populations (Sabo *et al.* 2017). As a result, declines of this important food resource can severely affect livelihoods and contribute to malnutrition. Thus, irrigation expansion can create a paradox for countries seeking to generate societal outcomes by harnessing water as a main mechanism to provide food. On the one hand, agricultural production can be enhanced by implementing irrigation development programs; on the other hand, this infrastructure can lead to significant fisheries declines (Baumgartner *et al.* 2019). This situation is creating challenging environmental and social conflicts that have to be addressed for future development and system sustainability.

In an effort to redress the imbalance between development and environmental sustainability, the United Nations developed a series of 17 Sustainable Development Goals (SDGs; https://sustainabledevelopment.un.org/sdgs, accessed 22 July 2019). These goals were intended to provide a blueprint for peace and prosperity, with the ultimate goal of a prosperous future for humans globally (Griggs *et al.* 2013). Many governments continue to view irrigation as critical to meeting the demands of growing populations and a key contributor to achieving SDG 1 (No Poverty) and SDG 2 (Zero Hunger) and other development goals related to hunger and malnutrition (Nilsson *et al.* 2016). However, to truly achieve these goals, future water development activities, such as irrigation expansion, must contribute to both productive agriculture systems and maintaining livelihoods by providing environmental outcomes through improved design and implementation (McCartney *et al.* 2019). Fisheries need to be considered as part of these design activities.

This research front of *Marine and Freshwater Research* explores the complex interactions between irrigation, fisheries and the roles they play in helping address the SDGs. The articles aim to provide a balanced argument by highlighting first the benefits of a productive irrigation sector for securing food and water resources and second the costs these developments are having in terms of lost fisheries production. These contrasting positions are then countered by discussing the significant global

efforts to try to mitigate these effects and ways that several countries are applying policy and on-ground actions to contribute to sustainable development.

The research front includes a selection of articles that will advance knowledge on various aspects of fish and irrigation interactions, and the benefits that addressing these two issues will have in helping achieve the SDGs. Key topics include:

- a global update on the state of irrigation development (McCartney *et al.* 2019)
- the importance of inland fisheries and relevance to the SDGs (Lynch *et al.* 2019)
- the benefits of fisheries in irrigation systems (Dubois *et al.* 2019)
- techniques to mitigate the effects of irrigation development, such as fishways, environmental flows, sustainably managed reservoirs and irrigation screens (Cooper *et al.* 2019; Salalila *et al.* 2019; Stuart *et al.* 2019; Utomo *et al.* 2019)
- irrigation and fisheries development issues in South-East Asia and Africa (Conallin *et al.* 2019; O'Brien *et al.* 2019; Utomo *et al.* 2019).

These topics represent significant issues for fisheries agencies, irrigation developers, regulators and managers, and are relevant to both tropical and temperate systems. Historically, fisheries issues are dealt with by professionals and line agencies mandated to work on fish, whereas irrigation projects are implemented by engineers and water-related line agencies. Rarely is there true and genuine collaboration among these groups (Molden 2007). However, in recent times there has been a growing recognition that irrigation infrastructure projects can have multidisciplinary impacts and outcomes (Lenton 2014). As such, it is becoming increasingly acknowledged that implementation by single-focus line agencies (i.e. irrigation departments alone) is insufficient when projects have multi-objective outcomes.

In recognition of the need to achieve multi-objective outcomes, the editors of the research front are proud to be able to launch this research front at the 3rd World Irrigation Forum (Bali, Indonesia) in collaboration with Charles Sturt University and the Food and Agriculture Organization of the United Nations. This forum is the major global event attended by irrigation practitioners from over 150 countries and, for the first time, organisers have agreed to include a special session on 'environmentally sustainable irrigation'. The aim of launching this research front at the forum is to provide an opportunity for irrigation practitioners and fisheries professionals to engage in an open discussion about issues of mutual concern. These articles will form a solid platform for constructive discussion.

An integrated approach is essential

It is accepted that, globally, fish are the most consumed daily source of protein (Lynch *et al.* 2016). So, there is growing appreciation that fisheries, and the benefits they provide to people, are an essential component of addressing SDGs pertaining to hunger and poverty (Simmance and Funge-Smith 2018). This has been recognised by the Ramsar Convention on Wetlands under Criterion 8, which states that:

> a wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend [Gardner and Davidson 2011].

However, productive fisheries rely on productive aquatic systems, and productive aquatic systems require healthy catchments. So, in order to effectively achieve No Poverty (SDG 1) and Zero Hunger (SDG 2), it is equally important to ensure we adequately manage Life on Land (SDG 15), ensure Clean Water and Sanitation (SDG 6) and have Sustainable Cities and Communities (SDG 11). Recognising that these goals are not mutually exclusive, and contribute equally to functional ecological systems, is the key to balancing development for agriculture while ensuring productive fisheries are maintained.

Conflicts of interest

L. J. Baumgartner and Z. D. Deng are Associate Editors for *Marine and Freshwater Research* and Nathan Ning and John Conallin are guest editors for this research front. Despite this relationship, they did not at any stage have Associate Editor-level access to this manuscript while in peer review, as is the standard practice when handling manuscripts submitted by an editor to this journal. *Marine and Freshwater Research* encourages its editors to publish in the journal and they are kept totally separate from the decision-making processes for their manuscripts. The authors have no further conflicts of interest to declare.

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As handling editors for this research front, we hope you will enjoy reading this compilation of articles and call on those responsible for implementing irrigation upgrade and expansion projects to implement actions that will mitigate the impacts on fish; in doing so, they will support securing two sources of food, protein and micronutrients worldwide. All authors and reviewers are acknowledged for their contributions and attention to tight production deadlines. The handling editors are also grateful to the Australian Water Partnership, which will be funding several participants to present this work at the 3rd World Irrigation Forum, and Charles Sturt University for sponsoring a multi-agency gathering to discuss these issues in December 2018.

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