Received: 16 May 2019 | Revised: 25 July 2019 | Accepted: 29 July 2019
DOI: 10.1111/faf.12403

ORIGINAL ARTICLE

FISH and FISHERIES WILEY

A fresh look at inland fisheries and their role in food security and livelihoods

Simon Funge-Smith[1] | Abigail Bennett[2]

[1]Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Rome, Italy

[2]Center for Systems Integration and Sustainability, Michigan State University, East Lansing, MI, USA

Correspondence
Simon Funge-Smith, Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, Rome 00153, Italy.
Email: simon.fungesmith@fao.org

Abstract

The role of inland fisheries in livelihoods, food security and sustainable development is often overshadowed by the higher profile interest in ocean issues. Whilst inland fisheries' catch and contribution to global nutrition, food security and the economy, are less than that of marine fisheries, global-level comparisons of fish production obscure considerable livelihood impacts in certain countries and sub-national areas. To highlight these contributions, this paper synthesizes recent data and innovative approaches for assessing such livelihood contributions and their importance in countries with limited access to ocean resources and aquaculture. Inland fisheries are crucial for many socially, economically and nutritionally vulnerable groups of people around the world, but the challenges in monitoring inland fisheries preclude a complete understanding of the magnitude of their contributions. This situation is rapidly improving with increasing recognition of inland fisheries in development discourses, which has also encouraged research to enhance knowledge on the importance of inland fisheries. We review this work, including collated information published in a recent Food and Agriculture Organization report, to provide an up to date characterization of the state of knowledge on the role of inland fisheries.

KEYWORDS
economic value, global catch, inland fisheries, livelihoods, nutrition

1 | INTRODUCTION

In a number of countries around the world, inland fisheries are important for poverty alleviation, food security, gender empowerment, cultural services, ecosystem function and biodiversity. However, they are underrepresented in national and international policy discussions, despite recent reviews (Lynch et al., 2016, 2017). The low profile of inland water ecosystems (including their fisheries) in the UN Sustainable Development Goals (SDGs) exemplifies their marginalized status in major policy arenas. SDG14 (Life below water) pertains to oceans, seas and marine resources but not freshwater bodies. SDG15 (Life on Land) emphasizes freshwater ecosystems from the perspective of habitat and species protection, rather than sustaining harvests of fish for food or income. Whilst healthy aquatic ecosystems support fish populations, emphasizing conservation over human use may unintentionally marginalize dependent fisheries livelihoods. SDG2 (Zero hunger) specifically mentions fishers and covers agricultural diversity, but emphasizes increased agricultural productivity and incomes, rather than sustaining existing aquatic ecosystems. Although SDG Indicator 6.4.2 (water stress) tracks water withdrawals and even environmental flow requirements, it does not currently account for the temporal qualitative and spatial dimensions of flows, which are crucial to the integrity of inland fisheries.

Some scholarly discourses also underplay the contributions of inland fisheries. Attempts to account for unreported or underreported fisheries production and the contribution of fisheries to food security have tended to focus on marine systems (e.g., Pauly, 2007; Zeller et al., 2016), while research on freshwater systems often emphasizes non-fisheries uses of freshwater. Notably, the prolific scholarship and research funding on the food-energy-water nexus investigates the use of freshwater for land-based food production, yet fails to attend to implications of energy and irrigation on existing inland fisheries that support the food security and livelihoods of some of the most vulnerable regions of the world (Cooke et al., 2016; Juffe-Bignoli et al., 2016; Lynch et al., 2017). This is particularly the case with respect to the massive area of global wetlands that are represented by rice farming systems (although this has been specifically recognized by Resolution X.31 of the Convention on Wetlands, RAMSAR 2008).

Knowledge gaps on inland fisheries perpetuate this lack of recognition of the sector's importance. There is significant uncertainty in many information systems for inland fisheries (e.g., catch data, consumption data), and this constrains analysis and objective decision-making (Bartley, Graaf, Valbo-Jørgensen, & Marmulla, 2015). While no single assessment method or dataset provides a fully accurate characterization of inland fisheries, synthesizing findings from multiple approaches can provide a composite picture. Integrating different assessment methods while also underscoring the potential sources of error and uncertainty associated with each, is invaluable to understanding the real contributions of inland fisheries to sustainable development, biodiversity and ecosystem services, and to informing policies that can support them.

This review synthesizes data and analyses recently published in the United Nations Food and Agriculture Organization (FAO) Fisheries and Aquaculture Circular No. 942, *Review of the State of the World Fishery Resources: Inland Fisheries* (Funge-Smith, 2018; herein referred to as C942). The FAO Fisheries and Aquaculture Department produces C942 periodically, as part of its ongoing effort to improve the global understanding of the role and value of inland fisheries. The 2018 revision of the C942 deepens past analyses, aiming to quantify the contributions of inland fisheries across different social, economic and ecological dimensions, provides baseline values of what might be lost as the result of transformation and degradation of fisheries ecosystems, and discusses innovative assessment approaches. It also extends the work presented in previous versions of C942 to analyse the contributions of inland fisheries to the United Nations Sustainable Development Agenda, especially SDGs 2 (Zero hunger), 3 (Health and wellbeing), 6 (Clean water and sanitation), 7 (Affordable and clean energy) and 15 (Life on land). This paper distils key findings presented in C942, situating them among broader policy and scholarly dialogues on sustainable development.

The paper proceeds as follows: Section 2 draws together several assessment approaches to characterize the state of knowledge on the status and trends of inland fisheries. Section 3 describes inland fisheries' contributions to sustainable development across dimensions of food security, livelihoods, economic value and biodiversity. This section draws attention to how the distribution of benefits from inland fisheries, across different geographic places and scales, is crucial for some of the world's poorest and most vulnerable. In Section 4, the paper concludes with a discussion of the implications for future research and public policy.

1 INTRODUCTION	1
2 THE STATE OF INLAND FISHERIES	2
2.1 Global inland fisheries production	3
2.2 Trends in inland fisheries	4
2.3 National and sub-national variation	4
2.4 Recognizing large-scale and commercially important inland fisheries	5
2.5 Recreational fisheries	6
3 CONTRIBUTION TO SUSTAINABLE DEVELOPMENT: THE SOCIAL AND ECOLOGICAL IMPORTANCE OF INLAND FISHERIES	8
3.1 Food security and nutrition	8
3.2 Contribution of inland fisheries to livelihoods	10
3.2.1 Employment in inland fisheries	10
3.2.2 The role of women in inland fisheries	11
3.2.3 Child labour in inland fisheries	13
3.3 Economic value of inland fisheries	13
3.3.1 Traditional market-based valuation of inland capture fisheries	13
3.3.2 The value of recreational inland fisheries	13
3.3.3 Total inferred value of inland fisheries	14
4. DISCUSSION AND CONCLUSION	14
ACKNOWLEDGEMENTS	15
DATA AVAILABILITY STATEMENT	15
REFERENCES	15

2 | THE STATE OF INLAND FISHERIES

Inland capture fisheries exploit wild fishery resources in inland water environments including rivers, streams, floodplains, wetlands, lakes, inland seas, canals, reservoirs and even rice fields. Only 2.5 per cent of the earth's water is fresh, and of that, only 1.2 per cent is present as liquid, surface water (Shiklomanov, 1993). Yet, global inland capture fisheries contributed a reported 11.9 million metric tonnes of fish in 2017, equivalent to 12.7 per cent of the global fish catch (FAO FishStatJ, 2019). Like marine fisheries, inland fisheries include subsistence fisheries (destined for direct household consumption), commercial fisheries and recreational fisheries. Asia and Africa are the biggest producers of commercial inland fisheries, contributing 67 and 35 per cent, respectively (FAO FishStatJ, 2019). In higher latitudes and developed countries, recreational fisheries tend to predominate.

Inland fisheries face myriad threats besides overfishing, including alternative freshwater uses (e.g., hydropower, irrigation and municipal water supply), tight linkages and high susceptibility to effects of land-based activities such as pollution and runoff (Youn et al., 2014) and some inland fisheries are predicted to be drastically affected by climate change (Harrod, Ramírez, Valbo-Jørgenson, & Funge-Smith,

TABLE 1 Sources of error and underlying causes in reported inland fishery statistics

Sources of error	Effect on reported statistics
Reported statistics might cover only commercial catches Part-time, subsistence or small-scale/artisanal catches may not be covered by sampling programmes/surveys Reported statistics are estimates based on monitoring of a limited set of fisheries. Other fisheries, especially small waterbodies, may be excluded or overlooked	Possible underestimates in inland capture production (unless excluded fisheries are an insignificant part of the fishery or are adjusted at data processing stage). May result in over-reports if a substantial small-scale sector is over-estimated
Inadequate capacity (skills and resources) to undertake surveys	Misreporting (under and over) due to poor survey design, implementation and data anlaysis
Illegal fishing/poaching are not included in reported statistics Retained recreational fish catches are not recorded or reported	Underestimates inland capture and recreational fishery production
Reported production estimates are increased annually to meet projected production targets set in policy documents	Overestimates production. These errors can become considerable if this happens for more than 5 years. FAO approaches countries if production increases appear to be subject to poorly substantiated statistical adjustments
Reported production is based on assumed productivity of water resources, rather than any direct measurements of landings or fishers' catches	Either overestimation or underestimation. Errors arise because of wrong productivity estimate, or wrong water/habitat area estimate
No regular report of inland capture fishery production is provided to FAO, requiring an estimate to be made based on other secondary data sources	Estimation is based on secondary, historic information and previous reports. These may not account for change over time. The result is either overestimation or underestimation if the fishery changes
Countries make periodic, large-scale adjustments to reported inland fishery production, based on updated fishery survey information or other data	May result in improved, more accurate estimates of catch, but can affect historic trend analysis. FAO attempts to reconcile the historic trend in communication with the country
Collapse of a statistical monitoring programme because of economic or institutional changes in a country	Subsequent estimates are based on historical data and the addition or removal of an annual increment. Over time this decreases confidence in the report Reduction in scale of monitoring results in loss of comprehensive coverage. It may result in over- or underestimation

Source: Adapted from Funge-Smith (2018).

2018). Inland fisheries provide a multitude of essential values for sustainable development. However, a confluence of limited priority for information collection coupled to a lack of political salience, has limited their representation in policy and scholarly dialogues on livelihoods and food security.

Improved characterization and accounting of inland fisheries would support efforts to address this problem. The following sections present globally reported statistics and describe attempts to account or correct for possible sources of error, with the goal of arriving at a better understanding of how much inland fish is being caught and how catches are changing over time.

2.1 | Global inland fisheries production

In 2017, FAO reported 11.9 million tonnes of global inland fisheries catch, representing 12.7 per cent of total global capture fisheries. FAO statistics rely primarily on catch data reported by countries, but in cases of non-reporting or lack of response to FAO requests for clarification for anomalous data, these may be supplemented with FAO estimates based on data or evidence from other sources. As FAO is the only UN body that compiles formal national reporting on inland fisheries, FAO statistics are the official and most comprehensive global dataset of inland fisheries catch. Yet, as with all global data collection systems, it is subject to a number of challenges and potential reporting errors due to the way data are collected by countries (Table 1). Although some country statistics may include overreporting, the perception is that official statistics tend to underreport inland fisheries catch, including much subsistence catch and nearly all recreational catch. The historic catch trend is less clear, as catch increases or decreases may reflect changes in the fishery or changes in the quality of reporting systems. Understanding the nature and origin of current or historic reporting errors, is key to addressing them and advancing a more accurate characterization of the current state of inland fisheries.

Food and Agriculture Organization has been proactive in attempting to find such ways to improve national and global estimates of inland fishery catch. Various FAO studies have attempted to correct for possible underreporting of inland fisheries statistics, or account for the "hidden harvest." Early reviews (Coates, 1995, 2002) hypothesized that reported inland fisheries catch represented as little as half of actual catch levels. Early crude attempts to estimate global inland catch based on assumptions of productivity, estimated catches at between 20 million and 30 million tonnes, more than three times reported catch at the time (FAO, 1999, 2003). A subsequent study that extrapolated from in-depth analysis of six countries suggested that global catch could be 42 per cent greater than reported (World Bank, 2008, 2012). Whilst these analyses all conclude that there is substantial underestimated catch in inland fisheries, none have been able to provide a systematic basis for validating the extent.

Recent innovative assessments show potential to provide the evidence for these findings. One promising approach used household income and expenditure survey (HIES) data on fish consumed in the household to estimate inland fish catch (Bayley, 1981; Fluet-Chouinard, Funge-Smith, & McIntyre, 2018; Hortle, 2007). HIES is fishery-independent, circumventing some of the errors in catch statistics described in Table 1. However, HIES is also subject to sources of error associated with respondent recall, conversion of reported fish consumption to the corresponding live weight of fish caught, as well as attribution to the correct species and source (e.g., inland or marine, aquaculture or capture). In the most comprehensive study to-date, a global estimate for inland fishery catch used HIES data from 42 countries (representing 53 per cent of global catch) to model inland fisheries production and extrapolated those estimates to 38 additional countries with comparable socio-economic characteristics (Fluet-Chouinard et al., 2018). The median year for the HIES data were collected was 2008, and consumption-based estimates were compared with officially reported catch from that year. These 80 countries account for 93.4 per cent of reported global catch.

The results indicated a global catch of 16.6 million tonnes (CI, 2.3–30.9), suggesting that the global-reported inland fish catch may have been underreported by 39 per cent in 2008. Even though improved understanding of inland fisheries in recent years suggests that there may be less underreporting of catch, present-day total inland catch (for the period 2011–2015) is still 47% less than the 2008 consumption-based estimate (Funge-Smith, 2018).

The HIES model, notwithstanding its limitations, corresponds with other analysis (e.g., World Bank, 2008, 2012) indicating that inland fisheries catches are likely underreported in aggregate, although there are some countries (e.g., Egypt, Uganda, Indonesia, Pakistan, Brazil, Kenya and others) whose reported catch is higher than the HIES-modelled catch (Fluet-Chouinard et al., 2018). At least nine countries revealed much higher consumption than reported, suggesting that significantly more “hidden harvest” and even greater contribution of inland fisheries to food security. In these countries, increased efforts should be directed to validate this finding and its implication for inland fisheries' contributions to rural diets.

Another approach to calculating inland fisheries catch entails integrating FAO country statistics with data compiled from published studies of fisheries within river and basins. To address the risk of double-counting, the approach is only used where the FAO report is higher than the aggregate of the country's basin fisheries, the difference being allocated to that part of the country lying outside of the basin. Ainsworth, Funge-Smith, and Cowx (2018) collated inland catch data from published literature on major river basins and large lakes that have significant inland fisheries. As basin level coverage of catches in published literature is incomplete and small basins were not reviewed, FAO country statistics were used to supplement areas where basin data were unavailable. The result was an estimated range of global inland catch between 15.1 and 15.3 million tonnes, 3.6 million to 3.8 million tonnes more than reported to FAO for 2015, but with no median date for the estimate specified. This highlights a weakness of this estimation method in its reliance on published catches from literature that may span decades. Whilst it can give an indication of the sub-national distribution inland fisheries catch over the period, it is unable to provide a precise catch estimate for any particular year.

Although each method has its own sources of error and uncertainty, using a combination of sources of evidence can provide a more complete picture of inland catches. The approaches described provides reasonable evidence that inland fisheries catch was likely underreported between 21 and 51 per cent in 2008, in line with other estimates of the hidden harvest from inland fisheries for the same period (World Bank, 2008, 2012).

2.2 | Trends in inland fisheries

Uncertainty regarding catches hinders the understanding of catch trends in inland fisheries. The trend in global-aggregated catch indicates that inland fisheries catch has risen more or less linearly over the past 20 years (r^2 = .97), increasing by 222,000 tonnes, or 2.3 per cent, per year (1996–2016; FAO FishStatJ, 2018). The global trend is highly driven by a few countries; however, it is important to understand the national level trend to gauge whether inland fisheries are increasing, stable, or perhaps even declining as a result of multiple threats to freshwater ecosystems and competition for freshwater from other sectors (Bartley et al., 2015). Understanding the trend in catch is particularly important in those countries that are most dependent on inland fish. However, it is these dependent countries which are often the least equipped to track the status of their fisheries.

A trend analysis was used to interpret trends in officially reported catch data. Funge-Smith (2018) applied the Mann–Kendall test for trend analysis (90% confidence) to identify countries whose inland fisheries are apparently growing, declining or stable. The analysis was conducted for 110 countries with enough data points available for the period from 2007 to 2016 (FAO, FishStatJ 2018; Table 2).

According to the results, 37 countries (58.7 per cent of global catch) indicate increasing catch trends. Another 28 countries showed a decreasing trend. Although the set of countries with decreasing trends represent only 5.9 per cent of the global inland catch, they do include some of the world's most crucial inland fisheries, including parts of the Mekong and Amazon basins. Finally, 27 countries showed a stable trend in catch. As a cautionary note, Bartley et al. (2015) point out that it is difficult to discern if more recent apparent increases in catch are actual, or the result of improved estimations and reporting, contributing to uncertainty regarding longer-term trends.

2.3 | National and sub-national variation

While assessing global inland fisheries catch is fundamental to understanding their contribution to sustainable development, aggregated data can obscure the magnitude of their importance within

TABLE 2 Production trends and the relative contribution to the global inland fishery catch

Catch trend over decade 2006–2015	Number of countries	Aggregate catch (tonnes)	Percentage of global inland fishery catch	Countries having a significant effect on the group (>1% of total catch of group)
Increasing catch	37	6,830,955	58.7	China (34%), India (21%), Cambodia (7%), Indonesia (6%), Nigeria, Russian Federation, Mexico, Philippines, Kenya, Malawi, Pakistan, Chad, Mozambique, Iran IR, Sri Lanka, Ethiopia, the Congo
Decreasing catch	28	691,672	5.9	Brazil (33%), Thailand (27%), Viet Nam (16%), Turkey, Madagascar, Japan, United States of America, Peru, Poland, Czechia
Stable catch	27	893,401	7.7	Tanzania UR (35%), Congo DR (26%), Mali (11%), Kazakhstan, Niger, Finland, Benin, Venezuela BR, Iraq, Nepal, Argentina, Togo, Romania
No clear trend	17	1,464,573	12.6	Bangladesh (72%), Egypt (16%), Zambia, Canada, Burundi, Germany, Korea RO
Excluded from analysis	43	1,756,309	15.1	Myanmar (50%), Uganda (22%), Ghana (5%), Lao PDR (4%), South Sudan, Senegal, the Sudan, Central African Republic, Guinea, Cameroon, Colombia, Paraguay, Zimbabwe, Mauritania, Turkmenistan, Papua New Guinea, Gabon

Source: Data from FAO FishstatJ, 2018 in Funge-Smith (2018).

regions or countries. Even though inland fisheries contribute <13 per cent of all capture fisheries (FAO FishStatJ, 2019), many rural sub-populations are largely dependent on them for protein and income. Approximately 80 per cent of inland fishery catch originates from just 17 countries, which each produce between 151,000 and 2,300,000 tonnes (FAO FishStatJ, 2019; Table 3).

Even in countries that contribute a low proportion of global catch, per capita provision of fish from inland fisheries may be substantial (Table 4). In the developing world, inland fisheries production is concentrated where there is a confluence of freshwater fishery resources and high population densities to exploit those resources. In parts of South America and Africa, where inland fishery resources are comparatively rich, low rural population density helps explain why total inland fish catches are far lower than in Asia (Funge-Smith, 2018).

Some large countries such as Brazil and India appear to have low or moderate reliance on fish at the national level. However, sub-nationally, some communities may be almost entirely dependent on inland fish, for example in the Brazilian Amazon (Isaac et al., 2015). Consumption-based estimates derived from HIES surveys can also provide insight into sub-national heterogeneity (Figure 1), which is crucial to recognizing the importance of inland fisheries for particular subpopulations, or the relative importance of different inland water bodies, that may be obscured by aggregated national or global-level statistics.

2.4 | Recognizing large-scale and commercially important inland fisheries

While a large majority of inland fisheries are characteristically small-scale, there are examples of large-scale operations and commercially important inland capture fisheries (Funge-Smith & Bennett, 2018). Small-scale operations can be commercially important when high volumes of production aggregated from large numbers of small-scale

TABLE 3 Summary table of global inland fisheries catch (2015)

% of global total inland fisheries	Total inland fishery catch (tonnes; 2015)	Range of national catch (tonnes)	Countries
80	9,190,291	>150,000	China, India, Bangladesh, Myanmar, Cambodia, Indonesia, Uganda, Nigeria, Tanzania UR, Russian Federation, Egypt, Congo DR, Brazil, Philippines, Thailand, Kenya, Mexico
10	1,186,401	50,000–150,000	Viet Nam, Malawi, Pakistan, Chad, Mozambique, Mali, Ghana, Iran IR, Zambia, Cameroon, Sri Lanka, Lao PDR
7	771,666	20,000–49,000	Ethiopia, Kazakhstan, Angola, Peru, the Congo, South Sudan, Niger, Turkey, Venezuela BR, Japan, the Sudan, Senegal, Finland, Rwanda, Central African Republic, Canada, Guinea, Madagascar, Uzbekistan, Iraq, Nepal, Germany, Benin, Burkina Faso, Burundi, Ukraine
1.6	182,773	10,000–20,000	12 countries
1.1	123,482	1,000–10,000	36 countries
0.1	4,887	<1,000	48 countries

Source: Data from FAO FishStatJ 2018 in Funge-Smith (2018).

operators enter a value chain, as in the Lake Victoria Nile perch (*Lates niloticus*, Latidae) fishery. Failing to attend sufficiently to the unique economic, social and governance aspects of these fisheries, risks overlooking key contributions of this part of the sector, as well as attendant problems of access and equity over their management.

Funge-Smith and Bennett (2018) conducted a review of published literature and government data to estimate that large-scale inland fisheries contribute between 1.1 million tonnes and 1.3 million tonnes of inland fish, and commercially important inland fisheries contribute between 700,000 and 900,000 million tonnes (Figure 2). There is substantial overlap between inland capture fisheries that are large-scale and those that could be considered commercially important. Many, but not all, large-scale fisheries are commercially important fisheries and vice versa. For example, eel fisheries (e.g., in the United States of America and European Union) and the Nile perch fishery in Lake Victoria, are highly commercialized but are typically small-scale operations.

Together, large-scale and commercial inland fisheries account for between 11 and 13 per cent of global inland fisheries production. Funge-Smith and Bennett (2018) identified a total of 20 large-scale fisheries and 25 commercial fisheries (many of which were also large-scale). The Lake Victoria sardine (*Rastrineobola argentea*, Cyprinidae) fishery contributed the largest volume, with an annual production of 457,000 tonnes, followed by the multispecies Myanmar *inn* fishery (between 190,000 and 389,000 tonnes) and the Lake Victoria Nile perch fishery (199,000 tonnes).

Recognizing the existence of large-scale and commercial inland fisheries is important in terms of broader understandings of inland fisheries' contributions to sustainable development as well as the development of appropriate fisheries policy. Large-scale fisheries that generate large volumes of catch and commercial fisheries that harvest high-value species have the capacity to generate substantial revenues for fishers, post-harvest sector workers, as well as exporting countries. However, they often have a greater likelihood of detrimental impact on fisheries resources, due to high market demand, efficient harvesting techniques of high fishing effort. At the same time, these fisheries may be amenable to more stringent management measures because of the often-concentrated nature of their operations or integration into more formalized value chains, facilitating monitoring and enforcement.

2.5 | Recreational fisheries

Recreational fishing is defined by FAO as the fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets (FAO, 2012c). Recreational fishing is the predominant inland fishing activity in North and South temperate latitudes; however, some transitional economies such as countries in Latin America are also seeing substantial growth in recreational fishing (Bennett & Thorpe, 2008). Recreational fishing activities range from local people capturing fish on a casual basis for personal consumption, to international tourists targeting highly sought sportfish. Recreational inland fisheries are conducted primarily for leisure or sport, and the fish caught may be released or, if retained, not commercially traded (FAO, 2012c).

There is a lack of recent global data on the extent of recreational fisheries, despite evidence of wide participation and an economic value greater than inland capture fisheries (Thorpe, Zepeda, & Funge-Smith, 2018). Due to limitations in data collection and reporting in most inland recreational fisheries, the retained catches from recreational fishing may be another area where there might be substantially more catch than reported. FAO has requested countries to include all retained catches, regardless of the sector, but recreational fisheries are often poorly estimated and rarely reported (Garibaldi, 2012). This situation is further complicated by the unclear distinction between recreational and subsistence fisheries in some countries and how this may or may not be reported by those countries.

Some studies report decreasing recreational fisheries participation while others show evidence of possible increases (Aprahamian, Hickley, Shields, & Mawle, 2010; Aps, 2003; Hickley & Tompkins, 1998; Le Goffe & Salanié, 2005), with trends varying across geographical contexts. Although there are also indications of the growth

TABLE 4 National inland fishery catch, expressed as kilogrammes per capita of population (2013)

Kg catch per capita of population	Country name
10–35	Cambodia, Myanmar, Uganda
5–10	Chad, the Congo, Malawi, Gabon, Central African Republic, Mali, Tanzania UR, Bangladesh, Lao PDR, Zambia
2–5	Finland, Mauritania, Kenya, Ghana, Cameroon, Congo DPR, Mozambique, South Sudan, Sri Lanka, Thailand, Egypt, Fiji RO, Turkmenistan, Benin, the Niger, Paraguay, Gambia, Senegal, Estonia, Viet Nam, Kazakhstan, Philippines
1–2	Nigeria, Rwanda, Guinea, Papua New Guinea, Russian Federation, China, Indonesia, Iraq, Venezuela BR, Armenia, Montenegro, Equatorial Guinea, Burundi, Namibia, Burkina Faso, Suriname, Brazil, Iran IR, Sweden, Madagascar, Guyana
0.1–1	India, Mexico, Peru, Canada, Nepal, the Sudan, Angola, Zimbabwe, Togo, Pakistan, Bolivia (Plurinat. State), Hungary, Ukraine, Uruguay, Iceland, Albania, Uzbekistan, Serbia, Liberia, Sierra Leone, Poland, Lithuania, Turkey, Morocco, Ethiopia, Colombia, Côte d'Ivoire, Slovakia, Czechia, Falkland Is. (Malvinas), New Zealand, Argentina, El Salvador, Japan, Switzerland, Botswana, Costa Rica, Korea (Dem. People's Rep), Malaysia, Germany, French Polynesia, Panama, Macedonia (Fmr Yug Rp of), Latvia, Guatemala, Cuba, Korea (Republic of), Jamaica, Tajikistan, Syrian Arab Republic, Spain, Romania, Nicaragua, Netherlands

Source: Data from FAO FishStatJ 2018 in Funge-Smith (2018).

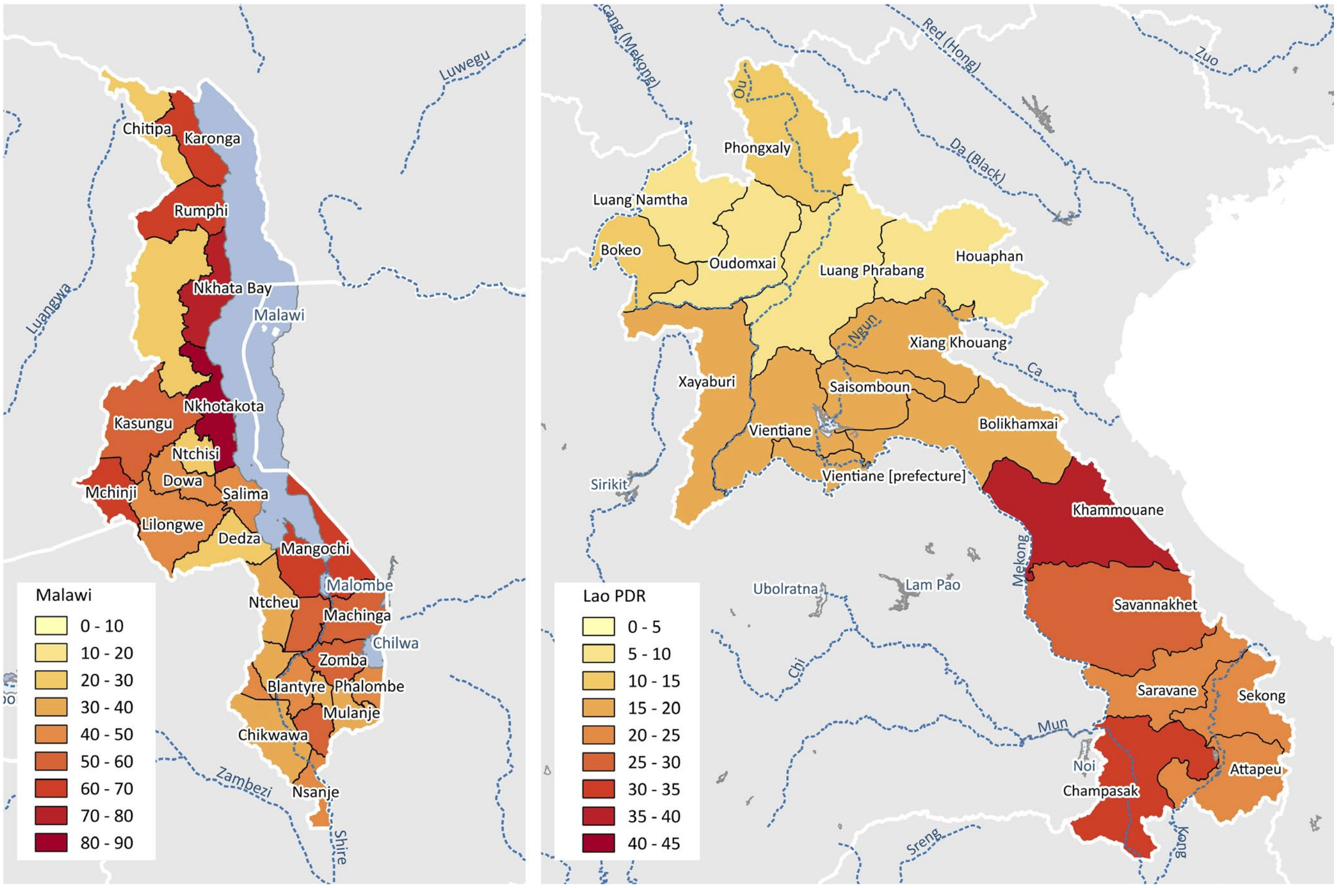

FIGURE 1 Sub-national variation in total fish consumption in two landlocked countries (Kg/capita/year), Malawi (left) and Lao PDR (right). Darker colours represent higher per capita annual fish consumption as estimated from household surveys. Source: Funge-Smith (2018)

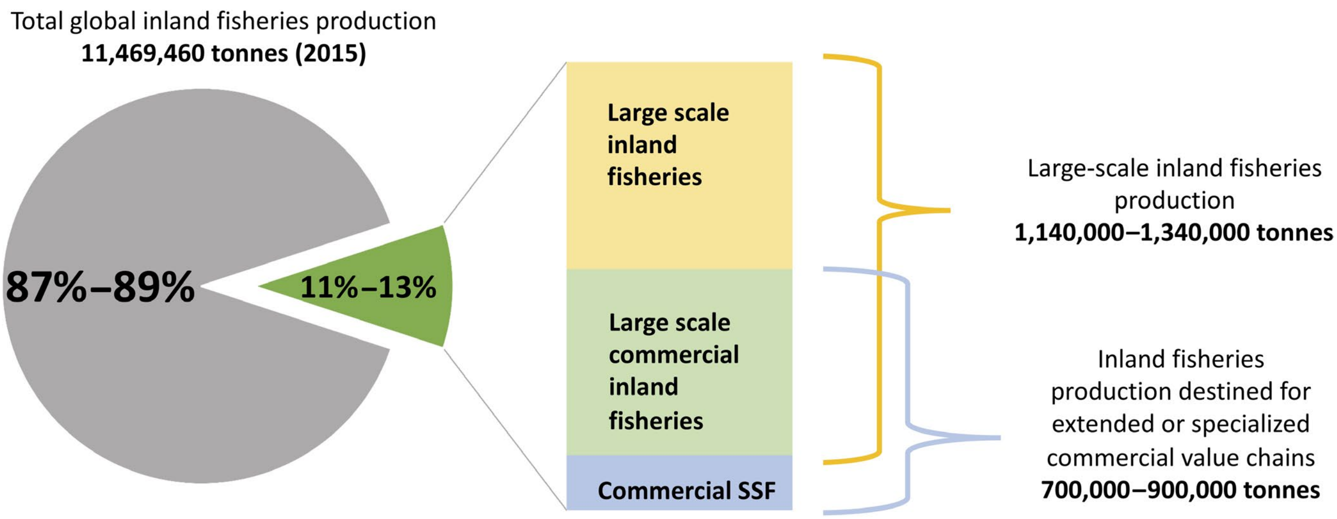

FIGURE 2 Estimated total catch from large-scale and commercially important inland fisheries. Source: Funge-Smith and Bennett (2018)

of recreational fisheries in some regions, for example in recreational fishing parks in Asia, there is a paucity of accompanying data to quantify such trends.

Funge-Smith, Gee, Simmance, and Marttin (2018) collated existing published estimates on the percentage of country populations involved in recreational fishing. These estimates covered 43 countries and indicate a total of more than 174.5 million recreational fishers, or 6.7 per cent of the population in those countries where recreational fishing is common.

Other studies, using extrapolation approaches, have estimated the number of recreational fishers to be even higher, between 220 million (World Bank, 2012) and 700 million (Cooke & Cowx, 2004). Retained recreational catch could represent more than 5 per cent of the current (2016) inland fishery catch (Cooke et al., 2018). This "hidden catch" is likely taking place largely in countries that report relatively small inland fisheries catch, and these recreational fisheries have considerable economic importance, with an annual-estimated non-market use value (NMUV) between USD 64,550 million and USD 78,550 million (Thorpe et al., 2018).

3 | CONTRIBUTION TO SUSTAINABLE DEVELOPMENT: THE SOCIAL AND ECOLOGICAL IMPORTANCE OF INLAND FISHERIES

3.1 | Food security and nutrition

Recent reviews have highlighted the importance of fish for nutrition and food security, both directly through provision of micronutrient-dense, lean protein and indirectly through income generation and opportunities for women's empowerment (Béné et al., 2016; Kawarazuka & Béné, 2010). Much of the recent work on this topic has argued that food security and nutrition policy have underrepresented the role of fish (Thilsted et al., 2016; Toppe, Beveridge, & Graham, 2017), although recent high-level policy documents may foreshadow an expanding space for fish in the discussion (e.g., FAO, 2015; HLPE, 2014). Whilst there has been some focus on the importance of marine fisheries in supplying important micronutrients (Golden et al., 2016), there has been relatively less attention paid to the contribution of inland fisheries in this regard. In LIFDCs and developing countries with rich freshwater resources in Africa, South America and the Asian continent, there are sub-populations which are disproportionately dependent upon inland fisheries (See Table 4). This highlights the need for greater effort to document the contributions of inland fisheries make to nutrition and food security. Inadequate understanding of this dependence will mean that policy decisions about use and development of freshwater resources will fail to anticipate, or compensate, potential nutritional shortfalls.

In 2015, inland fisheries provided an amount of animal protein equivalent to the full dietary consumption of at least 158 million people (Funge-Smith, 2018; McIntyre, Liermann, & Revenga, 2016). More than 90 per cent of reported inland fisheries are used for direct, local human consumption (FAO, 2016c; Fluet-Chouinard et al., 2018), thanks to high levels of subsistence production and localized trade. Furthermore, inland fish tend to be more affordable than other animal source foods and are often found in remote areas, providing an important source of nutrition to rural populations whose livelihoods are largely dependent on natural resources (Belton & Thilsted, 2014; Kawarazuka, 2010; Kawarazuka & Béné, 2010). Higher reliance on wild-caught freshwater fish (measured as proportion of animal source protein derived from fish) is associated with lower overall consumption of terrestrial animal-sourced food (McIntyre et al., 2016), an indication that for some populations, freshwater fish is one of the only accessible and affordable animal source foods.

Much of the scholarly and policy dialogue on food and nutrition security focuses on cultivated foods, that is terrestrial crop and livestock agriculture. Yet, wild food sources such as inland fisheries have important unique attributes, especially because they are often open access and relatively available to poor and landless people. Aquatic wild foods are also commonly harvested from rice paddy fields, contributing income and up to half of protein intake from these mixed systems (Balzer et al., 2003; Halwart, 2008; Muthmainnah & Prisantoso, 2016).

Fish constitute much more than simply a source of dietary energy (calories) or even just protein (Allison, 2011; Béné et al., 2015; Bennett et al., 2018; HLPE, 2014; Kawarazuka & Béné, 2011). Fish are high in essential vitamins (A, D, and B) and minerals (calcium, zinc, iron, iodine, phosphorous and selenium), that are important for alleviating micronutrient deficiencies, childhood stunting and health conditions including rickets, cardiovascular disease, high blood pressure, gestational diabetes and preeclampsia, preterm birth and low birth weight, childhood blindness, anaemia and maternal mortality (Bennett et al., 2018). Polyunsaturated fatty acids (PUFAs), including docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are found in high levels in some, but not all, freshwater fish (Youn et al., 2014). PUFAs are crucial for cardiac health (Lim et al., 2012; Mozaffarian & Rimm, 2006; Zhao et al., 2016), promote cognitive development and function (Horrocks & Yeo, 1999; Pottala et al., 2014), and reduce risk of early preterm delivery (Imhoff-Kunsch, Briggs, Goldenberg, & Ramakrishnan, 2012). Finally, the protein in fish is between 5 and 15 per cent more bioavailable than plant-based sources of protein (HLPE, 2014). Given the importance of fish and other animal source food for preventing childhood stunting (a widely-used indicator of malnutrition; Headey, Hirvonen, & Hoddinott, 2018), the accessibility and affordability of inland fish compared with other animal source foods makes it particularly important for fighting hunger and malnutrition among poor populations that are currently dependent on inland capture fisheries.

Human dietary diversity may be greater in wild food systems, due to the broader range of biodiversity that is accessed. For example, Bogard, Farook, et al. (2017) found that wild-caught species in Bangladesh had higher micronutrient density than commonly farmed aquatic species. The same may not be true in other places, depending on specific wild species targeted and farmed species produced, as well as potentially differential access to wild-caught and farmed fish. Nonetheless, this is a potential, partial explanation of a different study finding that micronutrient provision from fish declined over time, even though increased aquaculture production maintained stable levels of per capita fish availability overall (Bogard, Marks, Mamun, & Thilsted, 2017).

TABLE 5 Regional estimates[a] for Inland fisheries employment

Region	Inland fishers	Post-harvest	Percentage of global total inland fishers
Southeast Asia	9,871,379	1,303,853	58.5
South Asia	2,820,694	4,424,796	16.7
Africa	2,739,975	2,122,840	16.2
China	755,622	475,000	4.5
South America	411,877[b]	n.a.	2.4
Central America	107,447[c]	n.a.	0.6
East Asia	84,723	n.a.	0.5
Europe	35,962	n.a.	0.2
Central Asia	24,858	n.a.	0.1
West Asia	9,403	n.a.	0.1
North America	5,000	n.a.	0.0
Oceania	342	n.a.	0.0
Russian Federation	n.a.	n.a.	n.a.
Total	**16,867,282**	**8,326,489**	**100**

Abbreviation: n.a., Not available.
[a]Based on country employment table in Annex 6 in Funge-Smith (2018). The regional estimates are not based on full complement of countries, only for those for which data or an estimate were available.
[b]Estimate in FAO (2016a): 1,087,643 inland fishers.
[c]Estimate in FAO (2016a) (including Mexico): 52,969 inland fishers.
Source: Funge-Smith, Gee, et al. (2018).

An expanding body of literature has demonstrated the nutritional impact of small indigenous species of freshwater fish for vulnerable people. In Africa, between 400,000 and 600,000 small pelagic fish are harvested from large lakes, equivalent to 3.5–5 per cent of total global inland fish catch, contributing substantially to local consumption and regional trade. As catches of larger fish species have declined, small pelagic fish catches have increased substantially, now contributing nearly three quarters of the total catch from African lakes and reservoirs (Kolding, Zwieten, Marttin, Funge-Smith, & Poulain, 2019).

The small fish species Mola (*Amblypharyngodon mola*, Cyprinidae), among others, has been researched extensively for its potential to alleviate vitamin A deficiency (Roos, 2016; Roos, Mazharul Islam, & Thilsted, 2003). Small freshwater fish species are typically consumed whole with the bones and viscera, and their consequent contribution to calcium intake has been shown to reduce the prevalence of rickets (Craviari et al., 2008). Consumption of freshwater fish by lactating women was correlated with an EPA and DHA content of breast milk that even exceeded levels recommended for infant formulas (Longley et al., 2014). Studies in Zambia and Malawi have demonstrated the potential for small freshwater fish to aid in fighting infections and healing chronic wounds in individuals with HIV/AIDS (Banda-Nyirenda, Hüsken, & Kaunda, 2009; Mumba & Jose, 2005).

In light of recent studies suggesting food production systems have already reached planetary boundaries in terms of land use (Acevedo, Harvey, & Palis, 2018) and rising concern regarding the climate impacts of agriculture (Clark & Tilman, 2017; Foley et al., 2005), it is important to consider the relative efficiency of inland fisheries with respect to land, water and energy use compared with other food production systems (Lymer, Teillard, Opio, & Bartley, 2016; Orr, Pittock, Chapagain, & Dumaresq, 2012). Protein produced from inland fisheries does not require irrigation, feeding or clearance of land; indeed, they are dependent upon the maintenance of healthy, freshwater habitats. Most inland fisheries are small-scale in nature, often utilizing non-motorized, non-mechanized vessels or no vessels at all, employ low-tech processing methods and have typically limited post-harvest transportation. The energy use and greenhouse gas (GHG) emissions of inland fish production are minor compared with other agricultural or aquaculture sub-sectors. A complete understanding of the value of inland fisheries food security contributions should thus also entail quantification of the environmental (i.e., land, water, and energy) involved in replacing inland fish with other sources of protein and other micronutrients.

Incorporating such analyses into development decision-making is necessary to drive policy processes to look beyond simplistic economic valuation of lost production, to consider the full economic and environmental costs of replacing lost protein and other micronutrients (Ainsworth et al., 2018). For example, the Diama and Manantali dams were intended to support the development of irrigated agriculture in the Senegal River basin. After the construction of dams, the annual average fish catch of 46,755 tonnes from the Senegal River and estuary was reduced by approximately 90 per cent (GFCC, 1980; Pirot, Meynell, & Elder, 2000). Agricultural production from the irrigated area created by the dams has thus far been unable to compensate for lost fish catch, contributing to malnutrition in the basin (Degeorges & Reilly, 2006). The proposed construction of 11 dams on the Mekong River could result in more than a 40 per cent reduction in fisheries production in Cambodia and Viet Nam (DHI, 2015). Similar reductions

TABLE 6 Ratio of male to female fishers based on country reporting to FAO

Number of male fishers per female fisher	No.	Countries
Unspecified	4	Cambodia, Central African Republic, Taiwan Province of China, Paraguay
<1:1	1	Nepal
1–5	15	Botswana, Chad, Brazil, Bhutan, Republic of Korea, Kazakhstan, Japan, Venezuela (Bolivarian Republic of), India, Guinea, Austria, Mauritius, China, Nigeria, Burkina Faso
5–20	26	Colombia, Nicaragua, Mali, Peru, Hungary, Lesotho, Madagascar, Latvia, Eswatini, Guinea-Bissau, Somalia, Equatorial Guinea, Namibia, Angola, Gabon, South Africa, Cameroon, the Sudan, Ghana, Sierra Leone, Zimbabwe, Liberia, Belize, El Salvador, Democratic Republic of the Congo, Switzerland
20–50	12	Malawi, Ecuador, Sweden, Sri Lanka, Zambia, the Congo, Rwanda, Uganda, Estonia, Ethiopia, Serbia, Bolivia (Plurinational State of)
>50	7	Romania, United Republic of Tanzania, Mozambique, Djibouti, Togo, Uzbekistan, Benin
All male	44	Albania, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Brunei Darussalam, Bulgaria, Burundi, Canada, Croatia, Korea DPR, Dominican Rep., Finland, French Polynesia, Gambia, Guatemala, Guyana, Honduras, Indonesia, Iran IR, Iraq, Italy, Jordan, Kenya, Kyrgyzstan, Lebanon, Lithuania, Mexico, Montenegro, Morocco, Myanmar, New Zealand, Niger, Pakistan, Panama, Philippines, Poland, Senegal, Suriname, Syrian Arab Republic, Tunisia, Turkey

Source: Funge-Smith, Gee, et al. (2018).

in catch (between 30 and 50 per cent) have been seen for key species of carp in the Yangtze River (Xie & Chen, 1999). Accounting for the nutritional and environmental efficiency of food production systems helps evaluate trade-offs more comprehensively, which is crucial given the role freshwater systems play in meeting multiple targets of the sustainable development agenda including poverty reduction, ending hunger and promoting clean energy.

3.2 | Contribution of inland fisheries to livelihoods

Inland fisheries are an important source of livelihoods, especially for rural populations and in developing countries. Ninety-five per cent of the world's inland fisheries catch were from developing countries in 2015 and 43 per cent of global inland fish catch originate from low-income food-deficit countries (Figure 3).

There are multiple reasons why inland fisheries make such substantial livelihood contributions. Most inland fisheries are small-scale, utilizing smaller vessels, minimal mechanization and lower capital input than large-scale fisheries, therefore requiring more labour. This also results in far lower barriers to entry for the poor. The time commitment spent in inland fisheries tends to be variable and seasonal, due to natural and climatic variations in river and floodplain water or even geo-political conflicts that disrupt agricultural production. Inland fisheries are also typically conducted as a complementary activity alongside other livelihoods, for example fishing within rice-field canals. These attributes mean that inland fishing may serves as a safety net for the poor, especially individuals who do not own land (HLPE, 2014; Kawarazuka & Béné, 2011).

The very characteristics that make inland fisheries crucial to the livelihoods of rural and poor people around the world also complicate quantitative assessment of their contributions, undermining recognition in high-level policy discussions. The highly dispersed and informal nature of small-scale fisheries impacts the accuracy of employment data. The variability and part-time nature of inland fishing leads to underrepresentation in national statistics that typically only report fishing employment when it is conducted on a full-time basis or as a primary source of income.

3.2.1 | Employment in inland fisheries

Analysis in Funge-Smith, Gee, et al. (2018) attempted to derive a more complete account of employment in inland fisheries. There are widespread gaps in national statistics that often fail to recognize inland fishing as a primary or secondary livelihood. Employment data reported to FAO are combined with estimates from two other comprehensive case studies in Table 5 (DeGraaf & Garibaldi, 2014; World Bank, 2012). According to these data, inland fisheries employ nearly 17 million fishers and more than 8 million post-harvest workers, with greater than 50 per cent of all employment in Southeast Asia. World Bank (2012) estimated inland fisheries post-harvest sector employment to be around 39 million, representing about six per cent of the global agricultural workforce and nearly fivefold the number presented in Table 5.

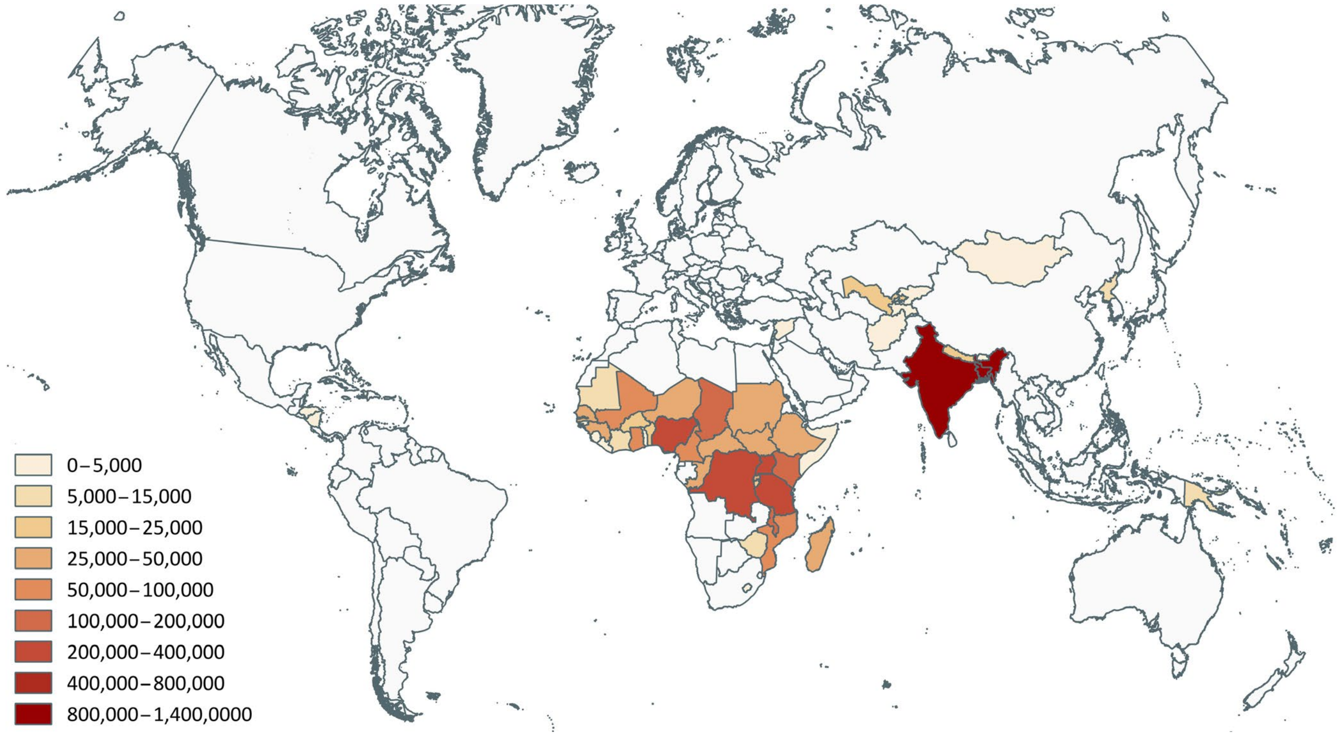

FIGURE 3 Tonnes of inland fish production in LIFDCs. Source: Funge-Smith (2018)

These figures do not include employment in the recreational and allied services sectors.

As inland fishing is predominantly a part-time occupation, these numbers need to be interpreted with significant caution to avoid giving the impression that employment figures are full-time equivalents. Post-harvest employment is also difficult to estimate in the sub-sector, as it is not highly aggregated, organized or industrialized and may not be well-reflected in national statistical systems. In some situations, post-harvest processing and marketing activities are also not exclusively linked to inland fisheries, but may also involve aquaculture products or those from marine fisheries.

There is clear evidence that inland fisheries make significant contributions to livelihoods of the poor, yet the extent of these contributions is poorly assessed and accurate monitoring challenges the statistical system tasked with compiling employment data. Improved data on employment assist in properly valuing inland fisheries within the sustainable development agenda. Such information would cover part time and seasonal fishing work by family members, as well as post-harvest sector employment and the participation of women and children.

3.2.2 | The role of women in inland fisheries

Women play a substantial yet often invisible role in inland fisheries. For a variety of reasons, data on fishery employment are often biased towards harvest rather than post-harvest sectors and also overlooks the role of women. Employment data are often not gender disaggregated. These limitations are likely to lead to a general underrepresentation of the role of women in inland fisheries (Kleiber, Harris, & Vincent, 2015; Siason et al., 2002). Yet, estimates suggest that more than half of the people employed in global inland capture fisheries are likely to be women, a proportion that is higher than in marine fisheries (Bartley et al., 2015; HLPE, 2014; World Bank, 2012).

Based on reported data, women represent 20 per cent of all people employed in the primary sector of inland fisheries for 2014 (Funge-Smith, Gee, et al., 2018) in line with the figure of 26 per cent for women in inland fisheries in Africa (DeGraaf & Garibaldi, 2014). Overall, 61 countries that provided gender-disaggregated data to FAO reported women fishing. These countries had one female fisher for every three male fishers, a ratio driven largely by countries that report large inland fisheries employment of both men and women, including Nigeria, Nepal, Mali, India, China, Chad and Brazil. Expanding the set of countries to all those that report gender-disaggregated data (i.e., including countries that report only male fishers) brings the ratio down to one female fisher per 7.3 male fishers, driven largely by Myanmar's reporting of 15 million exclusively male fishers (Table 6).

Women play an important role in fish trade and processing. DeGraaf and Garibaldi (2014) reported women comprising 69 per cent of the inland fishery processing sector in African countries they investigated. In the lower Mekong basin, women are the main traders in the estimated 5,000–6,000 fish markets. Whilst women are also active as fishers, they tend to be more heavily involved in the post-harvest sector.

Despite their broad participation in inland fisheries, women still face significant barriers. Cultural norms around gender can reduce women's access to resources and bargaining power and increase their vulnerability to different kinds of shocks and variability (Abbott,

TABLE 7 Towards an estimation of the value of the world's inland capture fisheries, bony fish only (2015 catch data in FAO FishStatJ 2018)

Region	Country	Quantity (tonnes)	Average price (USD/kg)	MUV (USD million)
Africa	**Total Africa**	**2,752,129**	**2.1**	**5,780**
Americas	USA	9,250	5.4	50
	Canada	17,807	5.4	96
	Mexico	118,648	2.1	253
	Central America & the Caribbean	10,390	2.1	22
	Brazil	227,865	3.6	828
	Argentina, Chile, Paraguay, Uruguay	34,842	3.6	127
	Peru	31,599	2.2	70
	Bolivia (Plurinational State of), Colombia, Ecuador, Guyana, Suriname, Venezuela (Bolivarian Republic of)	66,414	2.2	147
	Total Americas	**516,816**	**3.1**	**1,591**
Asia	China	1,647,299	1.6	2,688
	Myanmar	836,586	3.2	2,646
	Bangladesh	830,316	2.6	2,122
	Cambodia	482,450	1.6	769
	Viet Nam	161,937	1.9	312
	Pakistan	124,462	2.5	313
	India	1,209,010	3.7	4,416
	Thailand	205,343	2.4	487
	Indonesia	380,789	3.4	1,276
	Philippines	118,487	2.7	314
	Sri Lanka	67,694	1.3	88
	Lao PDR	47,218	3.7	175
	(Rest of Asia [a])	221,997	**2.6**	**567**
	Total Asia	**6,333,587**	**2.6**	**16,172**
Europe	Germany	16,264	0.9	14
	Finland	20,544	2.8	57
	Poland	18,368	2.7	49
	Russian Federation	140,237	1.2	169
	(Rest of Europe [b])	51,120	2.2	112
	Total Europe	**246,534**	**1.6**	**403**
Oceania	Papua NG	10,814	2.3	25
	(Other developing states)	94	2.3	<1
	Australia	1,099	10.7	12
	(New Zealand)	325	10.7	4
	Total Oceania	**12,332**	**3.3**	**40**
Global	**Total World**	**9,861,399**	-	**23,985**

Source: Thorpe, Zepeda and Funge-Smith (2018).

Note: [a]Rest of Asia: Afghanistan, Armenia, Azerbaijan, Bahrain, Bhutan, Brunei Darussalam, Cyprus, Democratic Peoples Republic of Korea, Georgia, Indonesia, Iraq, Iran IR, Israel, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lebanon, Malaysia, Maldives, Mongolia, Nepal, Oman, Palestine, Qatar, Palestine, Republic of Korea, Saudi Arabia, Singapore, Syrian Arab Republic, Tajikistan, Timor-Leste, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, Yemen.

[b]Rest of Europe: Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Denmark , Estonia, France, Greece, Iceland, Ireland, Italy, Hungary, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Former Yugoslav Republic of Moldova, Republic of Montenegro, Netherlands, Norway, Portugal, Romania, San Marino, Serbia, Serbia and Montenegro [now separate states], Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom.

Campbell, Hay, Næsje, & Purvis, 2007; Deb, Haque, & Thompson, 2015; Geheb et al., 2008; HLPE, 2014; Rajaratnam, Cole, Longley, Kruijssen, & Sarapura, 2014). There are instances of transactional sex between male fishers and female fish traders to secure fish for sale (Béné & Merten, 2008), and this has been linked to health and safety risks. Women may also be more vulnerable to food and income shortfalls due to a relative lack of alternative employment opportunities and intra-household power dynamics (Porter, 2012; Quisumbing, Brown, Feldstein, Haddad, & Peña, 1996; Skinner, 2011; Weeratunge, Snyder, & Sze, 2010).

3.2.3 | Child labour in inland fisheries

The International Labour Organization (ILO) defines child labour as occurring when children are too young for the work they do, work interferes with their schooling, or work risks harming the health, safety or morals of children under 18. Child labour is often overlooked in assessments of rural employment, and the informal and remote nature of inland fisheries frequently compounds the challenge of identifying the extent to which children engage in inland fisheries. Children do engage in inland fisheries, their activity ranging from foraging and informal fishing through to full-time occupation as child labour.

Children may be required to carry out dangerous activities as part of inland fishing activities. There are a limited number of identified situations where this has become a regular practice, with children being traded for their labour (Afenyadu, 2010; ICF Macro Inc., 2011; ILO-IPEC, 2013; Nyasa Times, 2013; Walakira, 2010).

3.3 | Economic value of inland fisheries

3.3.1 | Traditional market-based valuation of inland capture fisheries

The systematic economic valuation of global inland fishery production has been constrained by the diversity of methodological approaches used by national reporting systems, research and case studies. It is very difficult to identify and estimate the volume of inland fish caught for home consumption, bypassing markets. It is also a challenge to estimate shadow/surrogate prices of fish entering local market chains that are not monitored or reported. FAO reported that the 2008 inland fishery catch was 10.2 million tonnes and worth an estimated USD 5,500 million (FAO, 2012b), implying that average global ex-vessel price per kilogram of inland fish was $0.50. As part of its statistical collection, FAO provides annual global estimates of the ex-vessel monetary value of capture fisheries by groups of species, but these are not disaggregated by country or between inland and marine capture fisheries (FAO, 2012b).

In the case of specific studies, some examine market price, while others use the first-sale value (FSV) preventing aggregation of the data. Much of the available disaggregated data relates to the value of international fish trade and thus largely excludes the products of inland capture fisheries (it also does not provide value by whole weight equivalents). For inland fisheries, there are additional complications of deciding whether to include the value of diadromous species or input costs of stocked fisheries.

Analysis presented in Thorpe et al. (2018) provides the first-detailed, global-level estimate of the economic value of inland fisheries. Valuing inland fisheries is significantly challenged by lack of documented first-sale price data as substantial amounts of inland fish are landed and consumed directly or only sold locally. This analysis used FAO inland fishery catch data (2015) and assigned values using fish prices (typically first-sale or first-market values) drawn from an extensive literature review (Thorpe et al., 2018). The authors recognized the limitations of this first study, and that the values might be overestimated. Market Use Value (MUV) refers to the capture and sale of fish and fish products through local, national and international markets, whether for food or ornamental purposes. The values used in this study were first-sale or first-marketed values. The total MUV of inland capture fisheries (bony fish only) was estimated at USD 23,985 million (Table 7). The inclusion of diadromous and brackishwater species harvested in inland areas increased the value to about USD 26,019 million, with about two thirds from Asia and 22 per cent from Africa. The addition of USD 12,426 million estimated for the value of inland hidden harvest to catch data reported to FAO increased the estimate of economic value to USD 38,445 million. The total global value is increased further if the MUV of molluscs and crustaceans is added to the bony fish species, reaching a final maximum estimate of USD 43,445 million. For context, the estimated ex-vessel price of global capture fisheries was USD 131,000 million in 2016, of which only 9,870 million was clearly attributed to freshwater species (FAO, 2018), although this would be higher if anadromous species, freshwater molluscs and crustaceans were included. The large difference in value for global inland fisheries arises from the low first-sale values for inland fish used by FAO in the global estimation and the use of higher market values for inland fish in the 2018 study. An improved assessment of inland fish prices would increase confidence in this higher valuation.

The average annual global value of marine capture fisheries between 1980s and 2005 has been estimated at USD 100,000 million

TABLE 8 Estimated NMUV of the world's inland recreational fisheries (2015)

Region	Subregions	NMUV (USD million)
North America	Canada	9,670
	United States of America	35,400
South America	South America	1,310–2,700
Asia	China	1,340–3,620
Europe	Russian Federation	3,320–8,640
Europe	Rest of	13,040–17,810
Oceania	Australia	260
	New Zealand	210–610
Total world		**64,550–78,740**

Source: Thorpe, Zepeda and Funge-Smith (2018).

(Swartz, Sumaila, & Watson, 2013), with another estimate of between USD 80,000 and 245,000 million for 2010 (Tai, Cashion, Lam, Swartz, & Sumaila, 2017). The valuation of inland fisheries suggests that the reported landings from inland capture fisheries are approximately 22–26 per cent of the first-sale value of marine capture fisheries. This is probably realistic, considering that inland capture fisheries represent around 21 per cent of total captured food fish and minimal amounts are directed for reduction or use in animal feeds.

3.3.2 | The value of recreational inland fisheries

Drawing on a second review of published literature, the total NMUV of recreational inland fisheries in 2015 was estimated between USD 64,550 million and USD 78,740 million (Thorpe et al., 2018). For this valuation, the NMUV values obtained from a range of country studies, relates to the principal direct purchases and expenditures that arise from engaging in recreational fishing. These range from the cost of licences and bait, the manufacture and sales of fishing tackle and equipment, design and building of recreational fishing boats and the provision of boat charters. This is a lower value than travel cost method for valuation, which also includes indirect expenses such as travel, accommodation and food.

This NMUV for recreational inland fisheries is substantially higher than inland capture fisheries (Table 8), but is to be expected as the NMUV is not a measure of the value of the fish caught, it is the expenditures made in the pursuit of recreation. These types of expenditure are also not included in economic valuation of food fisheries, which are typically based on the first-sale value of the fish landed.

Nearly three quarters of this value is attributed to Canada and the United States. This estimate is in need of a comprehensive update, as most of the available estimates used were historic (Funge-Smith, Beard, Cooke, & Cowx, 2018). There was also a lack of data from African and Asian regions (which have burgeoning recreational fishing sectors) and no estimate of recreational fisheries value in the Russian Federation, where an estimated 17.5 per cent of the population engage in recreational fisheries (Funge-Smith, Beard, et al., 2018). As with the valuation of inland capture fisheries, case studies on recreational fisheries' economic value make a variety of methodological choices, introducing sources of uncertainty into global aggregated estimates.

3.3.3 | Total inferred value of inland fisheries

The MUV of capture fisheries and NMUV of recreational fisheries use different valuation methodologies. There is also a reasonably clear distinction between developing countries providing the majority of fish caught for food and the concentration of recreational fishing value in developed countries (albeit still often providing employment for the poor). This justifies adding the two values as a proxy for the total global value of the inland fisheries in their different development contexts. In combination, the use values of inland capture and recreational fisheries are estimated between USD 108,000 million and USD 122,000 million for the year 2015. After discounting the costs of capture (the value-added ratio), the gross value added is still estimated between USD 90,000 million and USD 100,000 million. This provides a clear indication that far from being of minor value relative to marine fisheries, global inland fisheries are indeed economically significant.

4 | DISCUSSION AND CONCLUSION

The most recent analyses reviewed in this paper underscore the importance of inland fisheries for livelihoods and food security, synthesizing global data from FAO, combining it with other sources, and adding nuance on their status, trends and contributions. The updated analyses presented above indicate that the importance of inland fisheries across multiple dimensions is higher than commonly perceived.

While global statistics indicated a total inland fishery catch of 11.5 million tonnes in 2016, models and estimates suggest that this figure was already exceeded by 2008. The economic value of reported global inland catch (in terms of first-sale value) is estimated at USD 24,000 million, approximately 24 per cent of estimated first-sale value for marine fisheries (Swartz et al., 2013), suggesting that the first landing prices of inland fish are higher than the average for marine fish.

Traditional economic analysis belies the multifaceted food security and livelihood contributions that even low-value or subsistence inland fisheries make for many vulnerable populations around the world. Ninety-five per cent of the world's inland fisheries catch originates from developing countries and 43 per cent comes from LIFDCs. The lower level of animal protein in the diets of inland fish-dependent populations means that each tonne of inland fish provides dietary protein for more people than an equivalent amount of marine or farmed fish.

Although national reports of fisheries employment are likely incomplete, they indicate fisheries employ nearly 17 million fishers and more than 8 million post-harvest workers, more than half of which are likely to be women.

The same factors which make inland fisheries difficult to track (their rural, highly dispersed, informal nature), also underlie their crucial contributions to the rural poor and food insecure. Discussions of this importance must be articulated within the context of broader imperatives of sustainable development that balances freshwater biodiversity and ecosystem services with the multiple pressures these systems face.

Freshwater species and habitats are some of the most threatened in the world (Grill et al., 2019; IUCN, 2010; Jelks et al., 2008; Ricciardi & Rasmussen, 1999; Vörösmarty et al., 2010; WWF, 2016), with an estimated one fifth of the described freshwater fish species are extinct, threatened or endangered (MEA, 2005; Darwall et al., 2009; Moyle & Leidy, 1992). In this context, it is crucial to acknowledge that sustainable inland fisheries often have compatible objectives with those for the conservation of aquatic biodiversity. Habitat loss and degradation, changing water flow and loss of connectivity, water pollution, invasive species and disease pose threats not only to inland fisheries, but also to freshwater ecosystems that support them (FAO, 2016b). Freshwater ecosystems also provide regulating services (e.g., water treatment and flood control) and support biodiversity. Many of these mutual concerns of ecological conservation and sustainable development are consistent with healthy inland fisheries and the habitats they depend upon. Indeed, inland fisheries can often serve as indicators of ecosystem health (FAO, 2016b; Lynch et al., 2016).

Reflecting our improving awareness of the importance of inland fisheries, there are increasing calls for improved representation of inland fisheries in policy processes. One aspect is the use of integrated or landscape approaches for the appropriate management of the variety of social and ecological interlinkages between inland fisheries and associated systems, such as agriculture, transportation and hydropower development (FAO, 1997). Within such approaches, the concept of intersectorality is increasingly acknowledged as a keystone for inland fisheries policy, which can help to illuminate or avoid unintended consequences of single-sector interventions and permit action against common concerns (e.g., water quality; Song et al., 2018; Thorpe, Reid, Anrooy, Brugere, & Becker, 2006). The use of an ecosystem approach to fisheries management can provide a planning framework to address these inter-connections (Beard et al., 2011).

Perhaps the most salient type of interlinkage exists between inland fisheries and competing uses for freshwater resources. Each year, 1,500 km^3 of freshwater is extracted for agricultural irrigation, ranging from a low of 4.1 per cent of water in Sweden to nearly all (98.6 per cent) in Afghanistan (FAO, 2012a). Dams and reservoirs, a key source of irrigation water and global energy generation, significantly alter inland fisheries and habitat. More than half of the largest river systems in the world have dams above 15m, which together retain more than 15 per cent of global river runoff (Nilsson, Reidy, Dynesius, & Revenga, 2005) and only 37 per cent of rivers longer than 1,000 km remain free-flowing over their entire length (Grill et al., 2019).

While the complete elimination of threats to inland fisheries, for example from hydropower or agricultural water development, is not politically feasible and in some cases may not even be desirable, there is evidence of successful compromise and synergy. For example, fish passages can significantly reduce negative ecological impacts from the construction of instream barriers such as dams (Baumgartner, Boys, Barlow, & Roy, 2017; Baumgartner et al., 2014) and other measures can prevent damage or injury from flood sheer or pressure changes from small-scale hydropower dams (Thorncraft et al., 2013). Innovative design and operation of irrigation systems can provide improved habitat and connectivity for inland fisheries, thereby synergistically enhancing food production, livelihoods and sustainable development (Gregory, Funge-Smith, & Baumgartner, 2018).

A number of additional concrete actions can secure and enhance the contributions of inland fisheries to livelihoods and food security. For example, value chain interventions to reduce post-harvest losses could substantially improve the food security contributions of inland fisheries (Cheke & Ward, 1998; Kolding et al., 2019). Due to their remoteness, small-scale nature, and frequent association with underdeveloped infrastructure, inland fisheries suffer disproportionately from post-harvest losses, which range from 13 to 45 per cent and average 27 per cent of catch (Diei-Ouadi, 2018). Often, simple interventions could have substantial effect. For example, improved solar dryers and drying racks, alongside better storage facilities, could reduce post-harvest losses in the Lake Victoria sardine value chain, where physical losses are particularly high during the rainy season when moisture spoils drying fish.

The development of policy approaches to support sustainable inland fisheries will depend on research that continues to grapple with knowledge gaps and advance assessment methods. The utilization of complementary assessment approaches will contribute to more robust knowledge on the status and trends of inland fisheries. Methods that aid in quantifying the financial, food security and ecological impacts of inland fisheries decline can help to enhance the visibility of the sector in broader development policy dialogues and promote discussion of appropriate prevention, mitigation or compensation approaches.

In the era of modernization and economic optimization of capture fisheries, they have been primarily viewed as natural resources for generating revenue, with the secondary function of support for food security and livelihoods. This view may be appropriate to industrial-scale marine fisheries, but the order of importance is reversed when considering inland fisheries. Inland fisheries catch and its global contribution to nutrition and the economy are less than that of marine fisheries; consequently the role of inland fisheries in livelihoods, food security and sustainable development is often overshadowed by the higher global profile of marine fisheries. However, this global perspective undervalues the considerable impact and importance of inland fisheries in certain countries and in some sub-national areas. The invisibility and vulnerability of inland fisheries have perpetuated the notion that inland fisheries do not substantially feed people and are rather unimportant economically and socially. The synthesized evidence in this paper clearly shows the need to revise this general perception.

A primary challenge to raising the profile of inland fisheries entails highlighting more the crucial food and nutrition and livelihood contributions of this sub-sector to the world's poor. This was clearly recognized in the Rome Declaration: Ten steps to responsible inland fisheries (FAO/MSU, 2016), which emerged from a global conference on inland fisheries (Taylor, Bartley, Goddard, Leonard, & Welcomme, 2016). The data and analysis brought together in Funge-Smith (2018) and reviewed in this paper, are intended to challenge preconceptions and contribute to the global effort to improve knowledge, assessment and valuation approaches that can support policy development to effectively include inland fisheries. This extends to the SDGs where it is incumbent upon the inland fishery sector to demonstrate its role and contribution to sustainable development.

ACKNOWLEDGEMENTS

The authors would like to thank our colleagues Manuel Barange, Stefania Vannuccini, Adrienne Eggers, Jennifer Gee and two anonymous reviewers who kindly reviewed this manuscript and made valuable comments and suggestions for improvement.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analysed in this study.

ORCID

Simon Funge-Smith https://orcid.org/0000-0001-9974-5333
Abigail Bennett https://orcid.org/0000-0001-9356-8014

REFERENCES

Abbott, J. G., Campbell, L. M., Hay, C. J., Næsje, T. F., & Purvis, J. (2007). Market-resource links and fish vendor livelihoods in the upper Zambezi river floodplains. *Human Ecology*, *35*, 559–574. https://doi.org/10.1007/s10745-006-9102-5

Acevedo, M. F., Harvey, D. R., & Palis, F. G. (2018). Food security and the environment: Interdisciplinary research to increase productivity while exercising environmental conservation. *Global Food Security*, *16*, 127–132. https://doi.org/10.1016/j.gfs.2018.01.001

Afenyadu, D. (2010). *Child labour in fisheries and aquaculture – A Ghanaian perspective*. Background paper prepared for the Workshop on Child Labour in Fisheries and Aquaculture in cooperation with the ILO, Rome, 14–16 April 2010. Rome: Food and Agriculture Organization of the United Nations.

Ainsworth, R. A., Funge-Smith, S. J., & Cowx, I. G. (2018). Chapter 10.3: Assessing Inland fisheries at basin level. In S. J. Funge-Smith (Ed.), *Review of the state of world fishery resources: Inland fisheries*. FAO Fisheries and Aquaculture Circular No. C942 Rev. 3. (pp. 317–334). Rome, Italy: Food and Agriculture Organization of the United Nations.

Allison, E. H. (2011). *Aquaculture, fisheries, poverty and food security*. Working Paper 2011–65. Penang, Malaysia: The WorldFish Center.

Aprahamian, M., Hickley, P., Shields, B., & Mawle, G. (2010). Examining changes in participation in recreational fisheries in England and Wales. *Fisheries Management and Ecology*, *17*, 93–105. https://doi.org/10.1111/j.1365-2400.2009.00667.x

Aps, R. (2003). *Freshwater fisheries in central and eastern Europe. Major underlining causes of biodiversity decrease in Selected CEE countries: Overview report*. Warsaw, Poland: IUCN Office for Central Europe.

Balzer, P., Balzer, T., Pon, S., Halwart, M., Bartley, D., & Guttman, H. (2003). *Traditional use and availability of aquatic biodiversity in rice-based ecosystems*. Rome, Italy: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/y4768e/y4768e03.htm

Banda-Nyirenda, D., Hüsken, S. M. C., & Kaunda, W. (2009). *Impact of nutrition and fish supplementation on the response to anti retroviral therapy, Zambia. A literature review*. Regional Programme Fisheries and HIV/AIDS in Africa: Investing in Sustainable Solutions. Project Report 1985. Penang, Malaysia: The WorldFish Center.

Bartley, D., De Graaf, G., Valbo-Jørgensen, J., & Marmulla, G. (2015). Inland capture fisheries: Status and data issues. *Fisheries Management and Ecology*, *22*, 71–77. https://doi.org/10.1111/fme.12104

Baumgartner, L. J., Boys, C. A., Barlow, C., & Roy, M. (2017). Lower Mekong Fish Passage Conference: Applying innovation to secure fisheries productivity. *Ecological Management & Restoration*, *18*, E8–E12. https://doi.org/10.1111/emr.12272

Baumgartner, L. J., Daniel Deng, Z., Thorncraft, G., Boys, C. A., Brown, R. S., Singhanouvong, D., & Phonekhampeng, O. (2014). Perspective: Towards environmentally acceptable criteria for downstream fish passage through mini hydro and irrigation infrastructure in the Lower Mekong River Basin. *Journal of Renewable and Sustainable Energy*, *6*, 012301. https://doi.org/10.1063/1.4867101

Bayley, P. B. (1981). Fish yield from the Amazon in Brazil: Comparison with African river yields and management possibilities. *Transactions of the American Fisheries Society*, *110*, 351–359. https://doi.org/10.1577/1548-8659(1981)110<351:FYFTAI>2.0.CO;2

Beard, T. D. Jr, Arlinghaus, R., Cooke, S. J., McIntyre, P. B., De Silva, S., Bartley, D., & Cowx, I. G. (2011). Ecosystem approach to inland fisheries: Research needs and implementation strategies. *Biology Letters*, *7*, 481–483. https://doi.org/10.1098/rsbl.2011.0046

Belton, B., & Thilsted, S. H. (2014). Fisheries in transition: Food and nutrition security implications for the global South. *Global Food Security*, *3*(1), 59–66. https://doi.org/10.1016/j.gfs.2013.10.001

Béné, C., Arthur, R., Norbury, H., Allison, E. H., Beveridge, M., Bush, S., … Williams, M. (2016). Contribution of fisheries and aquaculture to food security and poverty reduction: Assessing the current evidence. *World Development*, *79*, 177–196. https://doi.org/10.1016/j.worlddev.2015.11.007

Béné, C., Barange, M., Subasinghe, R., Pinstrup-Andersen, P., Merino, G., Hemre, G.-I., & Williams, M. (2015). Feeding 9 billion by 2050–Putting fish back on the menu. *Food Security*, *7*, 261–274. https://doi.org/10.1007/s12571-015-0427-z

Béné, C., & Merten, S. (2008). Women and fish-for-sex: Transactional sex, HIV/AIDS and gender in African fisheries. *World Development*, *36*(5), 875–899. https://doi.org/10.1016/j.worlddev.2007.05.010

Bennett, A., Patil, P., Kleisner, K., Rader, D., Virdin, J., & Basurto, X. (2018). *Contribution of fisheries to food and nutrition security: Current knowledge, policy, and research*. NI Report 18–02. Durham, NC: Duke University.

Bennett, E., & Thorpe, A. (2008). Review of river fisheries valuation in Central and South America. In A. Neiland & C. Béné (Eds.), *Tropical river fisheries valuation: Background papers to a global synthesis* (pp. 1-46). Penang, Malaysia: The WorldFish Center.

Bogard, J. R., Farook, S., Marks, G. C., Waid, J., Belton, B., Ali, M., … Thilsted, S. H. (2017). Higher fish but lower micronutrient intakes: Temporal changes in fish consumption from capture fisheries and aquaculture in Bangladesh. *PLoS ONE*, *12*, e0175098. https://doi.org/10.1371/journal.pone.0175098

Bogard, J. R., Marks, G. C., Mamun, A., & Thilsted, S. H. (2017). Non-farmed fish contribute to greater micronutrient intakes than farmed fish: Results from an intra-household survey in rural Bangladesh. *Public Health Nutrition*, *20*, 702–711. https://doi.org/10.1017/S1368980016002615

Cheke, R. A., & Ward, A. (1998). A model for evaluating interventions designed to reduce post-harvest fish losses. *Fisheries Research*, *35*, 219–227. https://doi.org/10.1016/S0165-7836(98)00074-5

Clark, M., & Tilman, D. (2017). Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. *Environmental Research Letters*, *12*, 064016. https://doi.org/10.1088/1748-9326/aa6cd5

Coates, D. (1995). *Inland capture fisheries and enhancement: Status, constraints and prospects for food security*. In FAO (1995). Report of the International Conference on the Sustainable Contribution of Fisheries to Food Security: Kyoto, Japan, 4–9 December 1995. Rome: Food and Agriculture Organization of the United Nations.

Coates, D. (2002). *Inland capture fishery statistics of Southeast Asia: Current status and information needs*. RAP publication number

2002/11. Bangkok, Thailand: Food and Agriculture Organization of the United Nations.

Cooke, S. J., Allison, E. H., Beard, T. D., Arlinghaus, R., Arthington, A. H., Bartley, D. M., … Welcomme, R. L. (2016). On the sustainability of inland fisheries: Finding a future for the forgotten. *Ambio*, *45*, 753–764. https://doi.org/10.1007/s13280-016-0787-4

Cooke, S. J., & Cowx, I. G. (2004). The role of recreational fishing in global fish crises. *AIBS Bulletin*, *54*, 857–859. https://doi.org/10.1641/0006-3568(2004)054[0857:TRORFI]2.0.CO;2

Cooke, S. J., Twardek, W. M., Lennox, R. J., Zolderdo, A. J., Bower, S. D., Gutowsky, L. F. G., … Beard, D. (2018). The nexus of fun and nutrition: Recreational fishing is also about food. *Fish and Fisheries*, *19*, 201–224. https://doi.org/10.1111/faf.12246

Craviari, T., Pettifor, J. M., Thacher, T. D., Meisner, C., Arnaud, J., Fischer, P. R. & Rickets Convergence Group (2008). Rickets: An overview and future directions, with special reference to Bangladesh: A summary of the Rickets Convergence Group Meeting, Dhaka, 26–27 January 2006. *Journal of Health, Population, and Nutrition*, *26*, 112.

Darwall, W., Smith, K., Allen, D., Seddon, M., Reid, G. M., Clausnitzer, V., & Kalkman, V. J. (2009). Freshwater biodiversity: A hidden resource under threat. In J-C., Vié, C., Hilton-Taylor & S.N., Stuart (Eds.), *Wildlife in a changing world–An Analysis of the 2008 IUCN red list of threatened species* (pp. 43–54). Gland, Switzerland: IUCN.

Deb, A. K., Haque, C. E., & Thompson, S. (2015). 'Man can't give birth, woman can't fish': Gender dynamics in the small-scale fisheries of Bangladesh. *Gender, Place & Culture*, *22*, 305–324. https://doi.org/10.1080/0966369X.2013.855626

Degeorges, P. A., & Reilly, B. K. (2006). Dams and large scale irrigation on the Senegal River: Impacts on man and the environment. *International Journal of Environmental Studies*, *63*, 633–644. https://doi.org/10.1080/00207230600963296

DeGraaf, G., & Garibaldi, L. (2014). *The value of African fisheries*. FAO Fisheries and Aquaculture Circular. No. 1093. Rome: Food and Agriculture Organization of the United Nations.

DHI (2015). *Study of the impacts of mainstream hydropower on the Mekong River*. Ministry of Natural Resources and Environment, Government of Vietnam.

Diei-Ouadi, Y. (2018). Chapter 4.5: Post-harvest losses in inland fisheries. In S. J. Funge-Smith (Ed.), *Review of the state of world fishery resources: Inland fisheries*. FAO Fisheries and Aquaculture Circular No. C942 Rev. 3. (pp. 206–215). Rome, Italy: The Food and Agriculture Organization of the United Nations.

FAO (1997). *Inland fisheries*. FAO Technical Guidelines for Responsible Fisheries. No. 6. Rome: Food and Agriculture Organization of the United Nations.

FAO (1999). *Review of the state of world fishery resources: Inland fisheries*. Rome, Italy: Food and Agriculture Organization of the United Nations.

FAO (2003). *Review of the state of world fishery resources: Inland fisheries*. Rome, Italy: Food and Agriculture Organization of the United Nations.

FAO (2012a). *FAO-AQUASTAT Country data 2012–2017*. Retrieved from http://www.fao.org/nr/water/aquastat/data/query/

FAO (2012b) *Recreational fisheries*. FAO Technical Guidelines for Responsible Fisheries. No. 13. Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/i2708e/i2708e00.pdf

FAO (2012c). *The state of world fisheries and aquaculture*. Rome, Italy: The Food and Agriculture Organization of the United Nations.

FAO (2015). *Voluntary guidelines for security sustainable small-scale fisheries in the context of food security and poverty eradication*. Rome, Italy: The Food and Agriculture Organization of the United Nations.

FAO (2016a). *Panorama de la Pesca Continental y la Acuicultura en America Latina y el Caribe. Documento informativo para la Comisión de Pesca Continental y Acuicultura para América Latina y El Caribe (COPESCAALC)*. Decimo cuarta reunión, Lima, Perú. COPESCAALC-XIV-3. 11 pp. (Also available at http://www.fao.org/3/a-bc474s.pdf).

FAO (2016b). *State of the world's aquatic genetic resources for food and agriculture*. Rome, Italy: Food and Agriculture Organization of the United Nations.

FAO (2016c). *The state of world fisheries and aquaculture: Contributing to food security and nutrition for all*. Rome, Italy: The Food and Agriculture Organization of the United Nations.

FAO (2018). *The state of world fisheries and aquaculture: Meeting the sustainable development goals*. Rome, Italy: The Food and Agriculture Organization of the United Nations.

FAO FishStatJ (2018). FAO FishStatJ database: 2018 dataset. http://www.fao.org/fishery/statistics/software/fishstatj/en Accessed November 2018.

FAO FishStatJ (2019). FAO FishStatJ database: 2019 dataset. http://www.fao.org/fishery/statistics/software/fishstatj/en. Accessed July 2019.

FAO/MSU (2016). *The Rome declaration: Ten steps to responsible inland fisheries*. Rome, Italy and East Lansing, MI: FAO and Michigan State University.

Fluet-Chouinard, E., Funge-Smith, S., & McIntyre, P. B. (2018). Global hidden harvest of freshwater fish revealed by household surveys. *Proceedings of the National Academy of Sciences of the United States of America*, *115*, 7623–7628. https://doi.org/10.1073/pnas.1721097115

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., … Gibbs, H. K. (2005). Global consequences of land use. *Science*, *309*(5734), 570–574. https://doi.org/10.1126/science.1111772

Funge-Smith, S. J. (2018). *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries and Aquaculture Circular No. C942 Rev. 3. Rome: The Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/ca0388en/CA0388EN.pdf

Funge-Smith, S. J., Beard, T. D., Cooke, S. J., & Cowx, I. G. (2018). Chapter 8: Recreational fisheries in inland waters. In S. J. Funge-Smith (Ed.), *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries and Aquaculture Circular No. C942 Rev. 3 .(pp. 274–285). Rome, Italy: The Food and Agriculture Organization of the United Nations.

Funge-Smith, S. J., & Bennett, A. (2018). Chapter 2.1: Estimating the contribution of large-scale and commercial inland fisheries. In S. J. Funge-Smith (Ed.), *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries and Aquaculture Circular No. C942 Rev. 3. (pp. 8–20). Rome, Italy: The Food and Agriculture Organization of the United Nations.

Funge-Smith, S. J., Gee, J., Simmance, F., & Marttin, F. (2018). Chapter 6: Contribution of inland fisheries to employment. In S. J. Funge-Smith (Ed.), *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries and Aquaculture Circular No. C942 Rev. 3. (pp. 256–263). Rome, Italy: The Food and Agriculture Organization of the United Nations.

Garibaldi, L. (2012). The FAO global capture production database: A six-decade effort to catch the trend. *Marine Policy*, *36*, 760–768. https://doi.org/10.1016/j.marpol.2011.10.024

Geheb, K., Kalloch, S., Medard, M., Nyapendi, A.-T., Lwenya, C., & Kyangwa, M. (2008). Nile perch and the hungry of Lake Victoria: Gender, status and food in an East African fishery. *Food Policy*, *33*, 85–98. https://doi.org/10.1016/j.foodpol.2007.06.001

GFCC (1980). *Assessment and plan of action. Assessment of environmental effects of proposed developments in the Senegal river basin*. Prepared for the Organisation pour la Mise en Valeur du Fleuve Senegal (OMVS) by Gannett Fleming Corddry and Carpenter Inc., Harrisburg, PA, USA, in association with ORGATEC Societe Africaine d'Etudes Techniques, Dakar, Senegal.

Golden, C., Allison, E. H., Cheung, W. W., Dey, M. M., Halpern, B. S., McCauley, D. J., … Myers, S. S. (2016). Fall in fish catch threatens human health. *Nature*, *534*(7607), 317–320.

Gregory, R., Funge-Smith, S. J., & Baumgartner, L. (2018). *An ecosystem approach to promote the integration and coexistence of fisheries within irrigation systems*. FAO Fisheries and Aquaculture Circular No.1169. Rome: The Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/CA2675EN/ca2675en.pdf

Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., … Zarfl, C. (2019). Mapping the world's free-flowing rivers. *Nature*, *569*, 215–221. https://doi.org/10.1038/s41586-019-1111-9

Halwart, M. (2008). Biodiversity, nutrition and livelihoods in aquatic rice-based ecosystems. *Biodiversity*, *9*, 36–40. https://doi.org/10.1080/14888386.2008.9712879

Harrod, C., Ramírez, A., Valbo-Jørgenson, J., & Funge-Smith, S. (2018). Chapter 19: Current anthropogenic stress and projected effect of climate change on global inland fisheries. In M., Barange, T., Bahri, M.C.M., Beveridge, K.L., Cochrane, S., Funge-Smith & F., Poulain (Eds.), *Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options* (pp. 393-448). FAO Fisheries and Aquaculture Technical Paper No. 627.Rome, Italy: The Food and Agriculture Organization of the United Nations.

Headey, D., Hirvonen, K., & Hoddinott, J. (2018). Animal sourced foods and child stunting. *American Journal of Agricultural Economics*, *100*, 1302–1319. https://doi.org/10.1093/ajae/aay053

Hickley, P., & Tompkins, H. (1998). *Recreational fisheries: Social, economic, and management aspects*. Oxford, UK: Fishing News Books.

HLPE (2014). *Sustainable fisheries and aquaculture for food security and nutrition*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome: The Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/a-i3844e.pdf

Horrocks, L. A., & Yeo, Y. K. (1999). Health benefits of docosahexaenoic acid (DHA). *Pharmacological Research*, *40*, 211–225. https://doi.org/10.1006/phrs.1999.0495

Hortle, K. G. (2007). *Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin*. MRC technical paper, Vol. *16*, 1–88. Vientiane, Lao PDR: Mekong River Commission.

ICF Macro Inc. (2011). *Child labor in the fishing industry in Uganda*. Washington, DC: U.S. Department of Labor, Office of Child Labor, Forced Labor, and Human Trafficking.

ILO-IPEC (2013). *Analytical study on child labour in Lake Volta fishing in Ghana*. International Labour Office, International Programme on the Elimination of Child Labour (IPEC). Geneva: International Labour Organization.

Imhoff-Kunsch, B., Briggs, V., Goldenberg, T., & Ramakrishnan, U. (2012). Effect of n-3 long-chain polyunsaturated fatty acid intake during pregnancy on maternal, infant, and child health outcomes: A systematic review. *Paediatric and Perinatal Epidemiology*, *26*, 91–107. https://doi.org/10.1111/j.1365-3016.2012.01292.x

Isaac, V. J., Almeida, M. C., Giarrizzo, T., Deus, C. P., Vale, R., Klein, G., & Begossi, A. (2015). Food consumption as an indicator of the conservation of natural resources in riverine communities of the Brazilian Amazon. *Anais da Academia Brasileira de Ciências*, *87*, 2229–2242. https://doi.org/10.1590/0001-3765201520140250

IUCN (2010). *IUCN Red list of threatened species*. Retrieved from http://www.iucnredlist.org/

Jelks, H. L., Walsh, S. J., Burkhead, N. M., Contreras-Balderas, S., Diaz-Pardo, E., Hendrickson, D. A., … Warren, M. L. (2008). Conservation status of imperiled North American freshwater and diadromous fishes. *Fisheries*, *33*, 372–407. https://doi.org/10.1577/1548-8446-33.8.372

Juffe-Bignoli, D., Harrison, I., Butchart, S. H. M., Flitcroft, R., Hermoso, V., Jonas, H., … van Soesbergen, A. (2016). Achieving Aichi Biodiversity Target 11 to improve the performance of protected areas and conserve freshwater biodiversity. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *26*, 133–151. https://doi.org/10.1002/aqc.2638

Kawarazuka, N., (2010). *The contribution of fish intake, aquaculture, and small-scale fisheries to improving nutrition: a literature review*. The WorldFish Center Working Papers No. 2106. Penang, Malaysia: WorldFish. 44 pp. (Also available at http://aquaticcommons.org/3469/1/WF_2590.pdf).

Kawarazuka, N., & Béné, C. (2010). Linking small-scale fisheries and aquaculture to household nutritional security: An overview. *Food Security*, *2*, 343–357. https://doi.org/10.1007/s12571-010-0079-y

Kawarazuka, N., & Béné, C. (2011). The potential role of small fish species in improving micronutrient deficiencies in developing countries: Building evidence. *Public Health Nutrition*, *14*, 1927–1938. https://doi.org/10.1017/S1368980011000814

Kleiber, D., Harris, L. M., & Vincent, A. C. (2015). Gender and small-scale fisheries: A case for counting women and beyond. *Fish and Fisheries*, *16*, 547–562. https://doi.org/10.1111/faf.12075

Kolding, J., van Zwieten, P., Marttin, F., Funge-Smith, S., & Poulain, F. (2019). *Freshwater small pelagic fish and fisheries in the major African lakes and reservoirs in relation to food security and nutrition*. FAO Fisheries and Aquaculture Technical Paper No. 642. Rome: Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/3/ca0843en/ca0843en.pdf

Le Goffe, P., & Salanié, J. (2005). Economic failures in French recreational fishing management. *Journal of Environmental Planning and Management*, *48*, 651–664. https://doi.org/10.1080/09640560500181896

Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., … Ezzati, M. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*, *380*(9859), 2224–2260. https://doi.org/10.1016/S0140-6736(12)61766-8

Longley, C., Haraksingh Thilsted, S., Beveridge, M., Cole, S., Banda Nyirenda, D., Heck, S., & Hother, A.-L. (2014). *The role of fish in the first 1,000 days in Zambia*. Brighton, UK: Institute of Development Studies. Retrieved from https://opendocs.ids.ac.uk/opendocs/handle/123456789/4384

Lymer, D., Teillard, F., Opio, C., & Bartley, D. (2016). Freshwater fisheries harvest replacement estimates (land and water) for protein and the micronutrients contribution in the Lower Mekong River Basin and related countries. In W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard & R. Welcomme (Eds.), *Freshwater, fish and the future: Proceedings of the global cross-sectoral conference* (pp. 169–182). Rome, Italy, East Lansing, MI and Bethesda, MD: Food and Agriculture Organization of the United Nations, Michigan State University and American Fisheries Society.

Lynch, A. J., Cooke, S. J., Deines, A. M., Bower, S. D., Bunnell, D. B., Cowx, I. G., … Beard, T. D. (2016). The social, economic, and environmental importance of inland fish and fisheries. *Environmental Reviews*, *24*, 115–121. https://doi.org/10.1139/er-2015-0064

Lynch, A. J., Cowx, I. G., Fluet-Chouinard, E., Glaser, S. M., Phang, S. C., Beard, T. D., … Youn, S. (2017). Inland fisheries - Invisible but integral to the UN Sustainable Development Agenda for ending poverty by 2030. *Global Environmental Change*, *47*, 167–173. https://doi.org/10.1016/j.gloenvcha.2017.10.005

McIntyre, P. B., Liermann, C. A. R., & Revenga, C. (2016). Linking freshwater fishery management to global food security and biodiversity conservation. *Proceedings of the National Academy of Sciences of the United States of America*, *113*, 12880–12885. https://doi.org/10.1073/pnas.1521540113

MEA (2005). *Ecosystems and human well-being: Synthesis*. Washington, DC: Island Press.

Moyle, P. B., & Leidy, R. A. (1992). Loss of biodiversity in aquatic ecosystems: Evidence from fish faunas. In P. L. Fiedler & S. K. Jain (Eds.), *Conservation biology* (pp. 127–169). Boston, MA: Springer. https://doi.org/10.1007/978-1-4684-6426-9_6

Mozaffarian, D., & Rimm, E. B. (2006). Fish intake, contaminants, and human health: Evaluating the risks and the benefits. *JAMA*, *296*, 1885–1899. https://doi.org/10.1001/jama.296.15.1885

Mumba, P. P., & Jose, M. (2005). Nutrient composition of selected fresh and processed fish species from Lake Malawi: A nutritional possibility for people living with HIV/AIDS. *International Journal of Consumer Studies*, *29*, 72–77. https://doi.org/10.1111/j.1470-6431.2005.00377.x

Muthmainnah, D., & Prisantoso, B. I. (2016). Integrated swamp management to promote sustainability of fish resources: Case study in Pampangan District, South Sumatra Province, Indonesia. In W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard & R. Welcomme (Eds.). *Freshwater, fish and the future: Proceedings of the global cross-sectoral conference* (pp. 319–324). Rome, Italy, East Lansing, MI and Bethesda, MD: Food and Agriculture Organization of the United Nations, Michigan State University and American Fisheries Society.

Nilsson, C., Reidy, C. A., Dynesius, M., & Revenga, C. (2005). Fragmentation and flow regulation of the world's large river systems. *Science*, *308*(5720), 405–408. https://doi.org/10.1126/science.1107887

Nyasa Times (2013). *Two children dumped in Lake Chilwa over unpaid wages*. Retrieved from https://www.nyasatimes.com/two-children-dumped-in-lake-chilwa-over-unpaid-wages-malawi-worst-form-of-child-labour/

Orr, S., Pittock, J., Chapagain, A., & Dumaresq, D. (2012). Dams on the Mekong River: Lost fish protein and the implications for land and water resources. *Global Environmental Change*, *22*, 925–932. https://doi.org/10.1016/j.gloenvcha.2012.06.002

Pauly, D. (2007). The Sea Around Us Project: documenting and communicating global fisheries impacts on marine ecosystems. *AMBIO: A Journal of the Human Environment*, *36*, 290–295. https://doi.org/10.1579/0044-7447(2007)36[290:TSAUPD]2.0.CO;2

Pirot, J.-Y., Meynell, P. J., & Elder, D. (2000). *Ecosystem management: Lessons from around the world. A guide for development and conservation practitioners*. Gland, Switzerland and Cambridge, UK: IUCN.

Porter, M. (2012). Why the coast matters for women: A feminist approach to research on fishing communities. In M. J. Williams, M. Porter, P. S. Choo, K. Kusakabe, V. Vuki, N. Gopal & M. Bondad-Reantaso (Eds.), *Gender in aquaculture and fisheries: Moving the Agenda forward. Asian Fisheries Science Special Issue* (Vol. *25S*, pp. 59–73). Serdang, Malaysia: Asian Fisheries Society.

Pottala, J. V., Yaffe, K., Robinson, J. G., Espeland, M. A., Wallace, R., & Harris, W. S. (2014). Higher RBC EPA+ DHA corresponds with larger total brain and hippocampal volumes: WHIMS-MRI study. *Neurology*, *82*, 435–442. https://doi.org/10.1212/WNL.0000000000000080

Quisumbing, A. R., Brown, L. R., Feldstein, H. S., Haddad, L., & Peña, C. (1996). Women: The key to food security. *Food and Nutrition Bulletin*, *17*, 1–2. https://doi.org/10.1177/156482659601700116

Rajaratnam, S., Cole, S. M., Longley, C., Kruijssen, F., & Sarapura, S. (2014). Gender inequalities in access to and benefits derived from the natural fishery in the Barotse Floodplain. In S. A. Zambia, I. N. Gopal, M. Williams, M. Porter & K. Kusakabe (Eds.), *Gender in aquaculture and fisheries: The long journey to equality. Asian Fisheries Science Special Issue Publication 29S*(pp. 49-71). Serdang, Malaysia: Asian Fisheries Society

Ricciardi, A., & Rasmussen, J. B. (1999). Extinction rates of North American freshwater fauna. *Conservation Biology*, *13*, 1220–1222. https://doi.org/10.1046/j.1523-1739.1999.98380.x

Roos, N. (2016). Freshwater fish in the food basket in developing countries: A key to alleviate undernutrition. In W. W. Taylor, D. M. Bartley, C. I. Goddard, N. J. Leonard & R. Welcomme (Eds.), *Freshwater, fish and the future: Proceedings of the global cross-sectoral conference* (pp. 35–44). Rome, Italy, East Lansing, MI and Bethesda, MD: Food and Agriculture Organization of the United Nations, Michigan State University and American Fisheries Society.

Roos, N., Mazharul Islam, M., & Thilsted, S. H. (2003). Small fish is an important dietary source of vitamin A and calcium in rural Bangladesh. *International Journal of Food Sciences and Nutrition*, *54*, 329–339. https://doi.org/10.1080/09637480120092125

Shiklomanov, I. A. (1993).World freshwater resources. In P. H. Gleick (Ed.), *Water in crisis: A guide to the world's fresh water resources* (pp. 13–24). New York, NY: Oxford University Press.

Siason, I., Tech, E., Matics, K., Choo, P., Shariff, M., Heruwati, E., … Sunderarajan, M. (2002). *Women in fisheries in Asia*. Penang, Malaysia: The Worldfish Center. Retrieved from http://pubs.iclarm.net/Pubs/Wif/wifglobal/wifg_asia.pdf

Skinner, E. (2011). *Gender and climate change overview report*. Brighton, UK: Institute of Development Studies.

Song, A. M., Bower, S. D., Onyango, P., Cooke, S. J., Akintola, S. L., Baer, J., … Chuenpagdee, R. (2018). Intersectorality in the governance of inland fisheries. *Ecology and Society*, *23*(2), 17. https://doi.org/10.5751/ES-10076-230217

Swartz, W., Sumaila, R., & Watson, R. (2013). Global ex-vessel fish price database revisited: A new approach for estimating 'missing' prices. *Environmental and Resource Economics*, *56*, 467–480. https://doi.org/10.1007/s10640-012-9611-1

Tai, T. C., Cashion, T., Lam, V. W., Swartz, W., & Sumaila, U. R. (2017). Ex-vessel fish price database: Disaggregating prices for low-priced species from reduction fisheries. *Frontiers in Marine Science*, *4*, 363. https://doi.org/10.3389/fmars.2017.00363

Taylor, W. W., Bartley, D. M., Goddard, C. I., Leonard, N. J., & Welcomme, R. (Eds.) (2016). *Freshwater, fish and the future: Proceedings of the global cross-sectoral conference*. Rome, Italy, East Lansing, MI and Bethesda, MD: Food and Agriculture Organization of the United Nations, Michigan State University and American Fisheries Society.

Thilsted, S. H., Thorne-Lyman, A., Webb, P., Bogard, J. R., Subasinghe, R., Phillips, M. J., & Allison, E. H. (2016). Sustaining healthy diets: The role of capture fisheries and aquaculture for improving nutrition in the post-2015 era. *Food Policy*, *61*, 126–131. https://doi.org/10.1016/j.foodpol.2016.02.005

Thorncraft, G., Phonekhampheng, O., Baumgartner, L., Martin, K., Pflugrath, B., Brown, R., … Navarro, A. (2013). *Optimising fish-friendly criteria for incorporation into the design of mini-hydro schemes in the Lower Mekong Basin*. Vientiane, Lao PDR: National University of Laos.

Thorpe, A., Reid, C., Anrooy, R. V., Brugere, C., & Becker, D. (2006). Poverty reduction strategy papers and the fisheries sector: An opportunity forgone? *Journal of International Development: The Journal of the Development Studies Association*, *18*, 489–517. https://doi.org/10.1002/jid.1245

Thorpe, A., Zepeda, C., & Funge-Smith, S. J. (2018). Chapter 5: The economic value of Inland fisheries. In S. J. Funge-Smith (Ed.), *Review of the state of world fishery resources: Inland fisheries*. FAO Fisheries and Aquaculture Circular No. C942 Rev. 3. (pp. 216–255). Rome, Italy: Food and Agriculture Organization of the United Nations.

Toppe, J., Beveridge, M., & Graham, E. (2017). *A case for fish to lead greater food security and nutrition outcomes*. FAO Aquaculture Newsletter (56), 43. Rome: Food and Agriculture Organization of the United Nations.

Vörösmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D., Prusevich, A., Green, P., … Davies, P. M. (2010). Global threats to human water security and river biodiversity. *Nature*, *467*(7315), 555. https://doi.org/10.1038/nature09440

Walakira, E. (2010). *Child labour in fisheries and aquaculture in East Africa with a deeper insight into the Uganda case*. Presentation to the Workshop on Child Labour in Fisheries and Aquaculture in cooperation with the ILO, Rome, 14–16 April 2010. Rome: Food and Agriculture Organization of the United Nations.

Weeratunge, N., Snyder, K. A., & Sze, C. P. (2010). Gleaner, fisher, trader, processor: Understanding gendered employment in fisheries and aquaculture. *Fish and Fisheries*, *11*, 405–420. https://doi.org/10.1111/j.1467-2979.2010.00368.x

World Bank (2008). *Small-scale capture fisheries: A global overview with emphasis on developing countries*. Washington, DC: World Bank.

World Bank (2012). *Hidden harvest: The global contribution of capture fisheries*. Report No. 66469-GLB. Washington, DC: The World Bank.

WWF (2016). *Living planet report 2016: Risk and resilience in a new era*. Gland, Switzerland: WWF International.

Xie, P., & Chen, Y. (1999). Threats to biodiversity in Chinese inland waters. *Ambio*, 674–681.

Youn, S.-J., Taylor, W. W., Lynch, A. J., Cowx, I. G., Beard, T. D. Jr, Bartley, D., & Wu, F. (2014). Inland capture fishery contributions to global food security and threats to their future. *Global Food Security*, *3*, 142–148. https://doi.org/10.1016/j.gfs.2014.09.005

Zeller, D., Palomares, M., Tavakolie, A., Ang, M., Belhabib, D., Cheung, W., … Pauly, D. (2016). Still catching attention: Sea Around Us reconstructed global catch data, their spatial expression and public accessibility. *Marine Policy*, *70*, 145–152. https://doi.org/10.1016/j.marpol.2016.04.046

Zhao, L., Sun, J., Yang, Y., Ma, X., Wang, Y., & Xiang, Y. (2016). Fish consumption and all-cause mortality: A meta-analysis of cohort studies. *European Journal of Clinical Nutrition*, *70*, 155–161. https://doi.org/10.1038/ejcn.2015.72

How to cite this article: Funge-Smith S, Bennett A. A fresh look at inland fisheries and their role in food security and livelihoods. *Fish Fish*. 2019;00:1–20. https://doi.org/10.1111/faf.12403