Unlocking the potential of pelagic fisheries: How can anchored fish aggregating devices be used to address food insecurity in tropical small-scale fisheries?

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The Fish and Fisheries Lab (www.fishandfisheries.com), based at James Cook University in Australia, teaches several undergraduate and masters level subjects about fisheries management. One of the most popular subjects is "Managing Tropical Fisheries", where students learn about the importance and complexity of tropical fisheries, and how they need very different management approaches compared to more traditional industrialised fisheries such as cod or swordfish. As part of the course, students are required to submit an essay on a complex area of tropical fisheries. Many students submit well written, well researched, and insightful essays that we felt are worth sharing. Following Rachel Mather's essay published in 2020,[2] we are pleased to share with you through the SPC Fisheries Newsletter the essay by Olivia Smailes, the pick of the essays submitted in 2021. Well done, Olivia.

Dr Andrew Chin – Course Coordinator

Introduction

While there is a lack of consensus on what exactly defines a small-scale fishery (SSF), their contribution to the socio-economic well-being of coastal communities is clear. Within these communities, fish are considered critical to food security and health through the provision of daily protein requirements and essential micronutrients (Gibson et al. 2020). Furthermore, the engagement in fisheries offers important livelihoods for some of society's most vulnerable people, particularly in the tropics where the greatest proportion of fish-dependent populations reside (Teh and Pauly 2018). By 2050, tropical fisheries are predicted to decline by as much as 30% due to climate change and shifts in primary production (Cheung et al. 2016). The vulnerability of SSF to such changes is further exacerbated by issues of equity and social justice (Andrew et al. 2007). Amidst such dire projections, there is an urgent need for management measures that better address food security concerns in SSF.

Nearshore anchored fish aggregating devices (aFADs) are presented as a practical and effective approach to improving local food security within SSF (Tilley et al. 2019b). The propensity for pelagic fish to aggregate around floating bodies has long been exploited by fishers to improve catch rates. Roman author Opian provided evidence for the exploitation of this behaviour to catch dolphinfish, *Coryphaena hippurus*, as early as 200 AD (Dagorn et al. 2012; Churchill 2021). The fishing practices associated with these structures extract a far greater biomass than those that target free-swimming schools (Griffiths et al. 2018). Since their conception, FADs have become an essential fishing tool around the world (Taquet et al. 2011). Of note is the successful application of nearshore aFADs in improving catch rates within SSF. These devices comprise one of two basic categories of FADs, the second being drifting FADs (dFADs) that are used by industrial purse-seine fisheries. It is important to distinguish between these two categories as the use of the dFADs is frequently criticised for its negative impacts on marine resources (Dagorn et al. 2013). The aFADs are simple structures anchored in coastal areas at a distance accessible to small artisanal fishing vessels (Beverly et al. 2012). Despite their simplicity, these devices offer an array of benefits including increased catch per unit effort (CPUE) and reduced pressure on reef ecosystems (Beverly et al. 2012). Of perhaps the greatest significance is the access provided to highly nutritious pelagic fish stocks. There is convincing evidence that indicates that aFADs directly address food security concerns by increasing both the supply and consumption of pelagic fishes (Albert et al. 2014; Bell et al. 2015a). As such, aFADs have been integrated into many national fisheries action plans and policies (Sharp 2011; Campbell et al. 2016; Tilley et al. 2019b).

Tackling food insecurity and micronutrient deficiencies with fish

Food insecurity persists as one of the most significant public health challenges across the developing world. Unreliable access to food contributes to child wasting, stunting and micronutrient deficiencies (FAO 2018). Across the world, an estimated 1.5 billion people are affected by one or more forms of micronutrient deficiency and 2 billion people lack key micronutrients such as iron and vitamin A (Global Nutrition Report 2017; FAO 2018). Due to the lack of even progress in tackling malnutrition, food and nutrition security have remained high on the global development agenda. Fish are presented as a practical solution to address these issues as they are rich sources of bioavailable micronutrients (Hicks et al. 2019). As such, they remain a key focus of food and nutrition policy, particularly within

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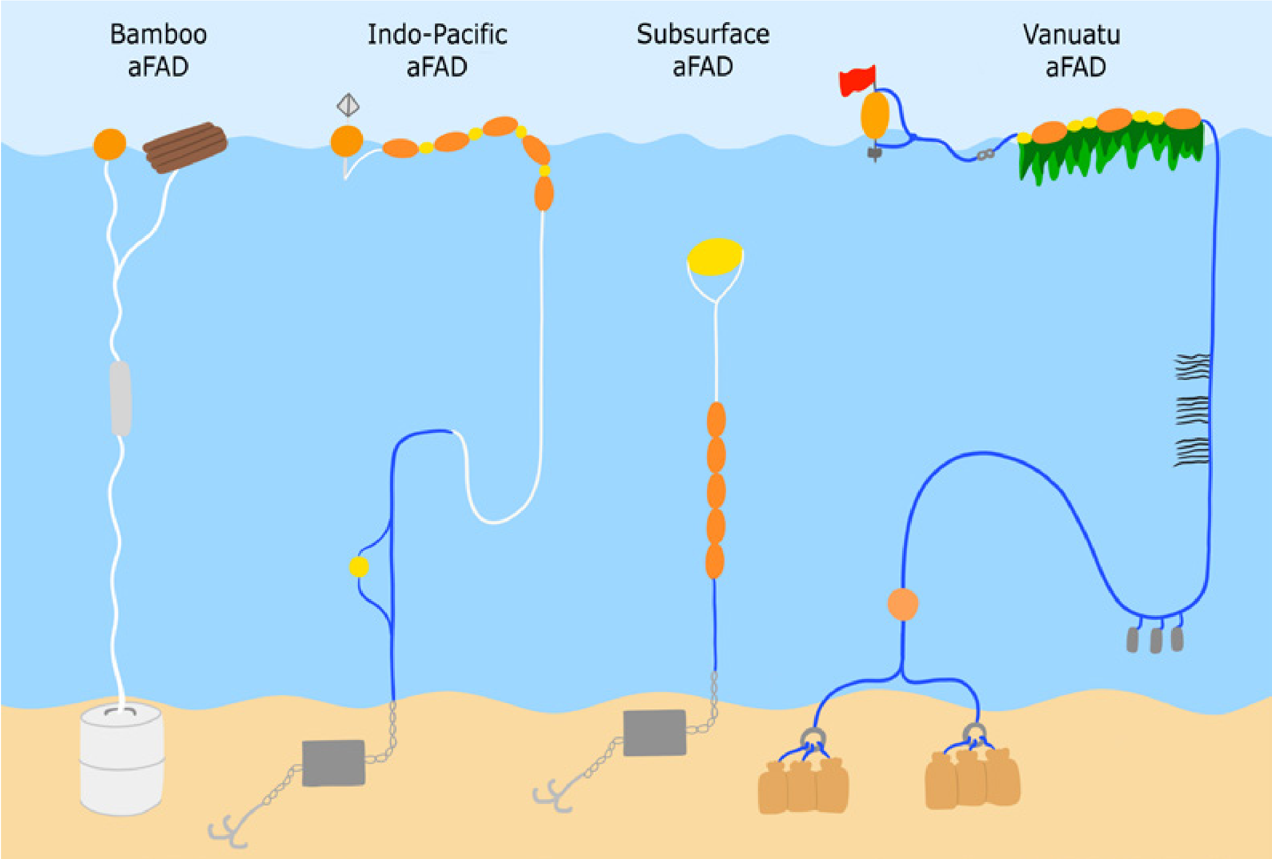

Figure 1. The diversity displayed in artisanal FADs. FAD design typically differs based on location and the given context – no one-size-fits-all. (Illustration: Olivia Smailes; adapted from Sokimi et al., 2020).

the tropics, where fish are widely harvested and traded due to the scarcity of arable land (Bell et al. 2015a). Throughout the tropics, small-scale fishing makes a vital contribution to the livelihoods of some of society's poorest and most marginalised people (Teh and Pauly 2018). The small-scale sector is responsible for 55% of the annual capture fisheries production. Of this amount, 62% is used directly for local consumption within developing countries. The proportion of fish consumed locally can be used as an indicator for the contribution of fish and fisheries to food and nutritional security (Mills et al. 2011).

The value of pelagic fisheries

Pelagic fisheries demonstrate a number of desirable characteristics that favour their use in SSF. They comprise robust migratory stocks that, due to direct feeding on planktonic systems, exhibit high concentrations of omega-3 fatty acids and protein (Hicks et al. 2019). Their nutritional value is much higher than the nutrient-poor imported foods that are pervasive within regions of the tropics such as the Pacific (Bell et al. 2015a). Because pelagic fishes grow rapidly and are short lived, they support very productive populations upon which fisheries heavily rely (Morais and Bellwood 2020). This productivity can potentially sustain heavy fishing for decades, thus highlighting its potential in addressing food security concerns. Due to their propensity to roam throughout a greater area of the ocean, pelagic fishes also possess the capacity to rapidly replace harvested stocks. Furthermore, they are less sensitive to harvest due to the fundamentally different ecosystem processes that take place in the open ocean (Birkeland 2017). In Hawaii, nearshore pelagics such as *Selar crumenophthalmus* and *Decapterus macarellus* displayed resistance to overexploitation despite three decades (1966–1997) of high catch rates (Birkeland 2017). The favourable characteristics displayed by pelagic fisheries demand a shift away from coral reef species, which currently dominate catches in SSF.

Using aFADs to unlock the benefits of pelagic fisheries

Despite increasing awareness about the value of pelagic fisheries, a gap is emerging between the amount of fish required for optimal nutrition and coastal fish catches. This gap is largely driven by exponential population growth and the deterioration of coastal fisheries production (based mainly on coral reefs) due to overexploitation (Bell et al. 2018). By increasing access to pelagic fish resources, aFADs present a practical solution to helping feed rapidly expanding coastal populations. In contrast to their industrial counterparts, aFADs are relatively rudimentary and highly diverse (Fig. 1) (Sokimi et al. 2020). These purpose-built structures are anchored offshore (at depths between 100 and 1500 m) to benefit from the tendency of pelagic species to aggregate (thigmotropism) (Fig. 2). While there is little known about the mechanism that underlies this phenomenon, it has been suggested that fish aggregate around artificial floating objects for reasons including refuge and feeding (Beverly et al. 2012).

Qualitative modelling indicates that despite their simplicity aFADs are among the innovations with greatest positive effect on food security (Bell et al. 2015b). The access provided by aFADs to underutilised pelagic resources can produce sizeable increases in fish yields (Beverly et al. 2012). While the assemblage of species caught around aFADs is less diverse than that associated with reef fishing, it comprises highly productive species that are relatively resistant to exploitation (Tilley et al. 2019b). Of the species caught, tuna is the most prevalent and can be caught year-round. An aFAD programme implemented in Mauritius revealed that tuna accounted for 78% of the artisanal catch weight (Beverly et al. 2012). The value of tuna caught around FADs typically exceeds the costs of materials and installation (Bell et al. 2015b). Given the substantial contribution of tuna to food security, providing better access to this resource is high on development agendas. The expansion of aFADs can help enhance both the catch and supply of tuna in SSF and should therefore be at the focus of national infrastructure for food security (Bell et al. 2015b).

Convincing evidence indicates that aFADs greatly increase the efficiency of fishing in SSF. Tilley et al. (2019b) identified a significant positive effect of aFADs on catch rates and CPUE in Timor-Leste. Increases in the quantity of fish landed contributed to improvements in rural access to fish and thus micronutrient availability. In Yap State, Federated States of Micronesia, deployment of aFADs led to an increase in CPUE from 10.91 to 24.94 kg/hr/boat (Sharp 2014). As observed in the Solomon Islands, improvements in fishing efficiency can increase household income and nutrition (Albert et al. 2014). According to accounts from a fisher focus group in Adara, Timor-Leste, the reduced time required to catch enough fish is considered the primary benefit of aFADs. The use of these devices allows fishers to allocate additional time to other livelihoods such as land and

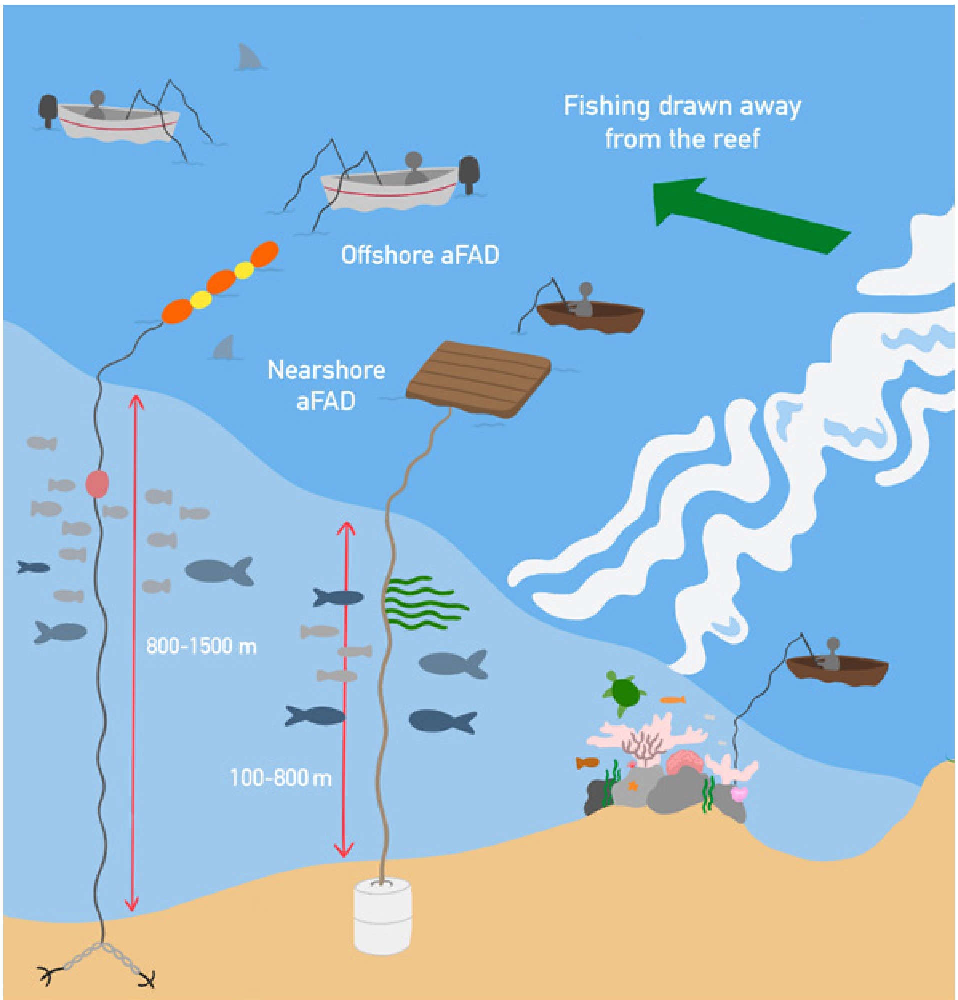

Figure 2. FADs are installed at depths of up to 1500 m. Fishing is drawn away from heavily exploited nearshore reefs and catch is instead focused on productive pelagic fish resources.
(Illustration: Olivia Smailes)

livestock cultivation (Tilley et al. 2019b). Livelihood diversity is considered an important factor in increasing the adaptive capacity of a community. By providing households with the ability to spread their efforts across different livelihoods, it allows them to better cope with environmental and economic shocks. In doing so, it buffers against the impacts on food security (Mills et al. 2017). This is especially significant for SSF, which are inherently dynamic and subject to extreme uncertainty and change (Finkbeiner 2015).

In addition to increasing the supply and consumption of nutrient-rich pelagic fishes, aFADs also offer an alternative source of fish that can provide communities with the opportunity to transfer some of their fishing effort away from heavily exploited coral reefs (Bell et al. 2015a) (Fig. 2). Over 75% of coral reef fisheries are currently fished at levels deemed to be unsustainable (MacNeil et al. 2015). The overexploitation of these fisheries poses a significant threat to the millions of people who depend on them for livelihoods and food. SSF concentrate a large proportion of fishing effort on reefs that are dominated by slow-growing, late-maturing species (Sharp 2014; Birkeland 2017). In Yap State, Federated States of Micronesia, reef fish comprise 74% of total reported catch (Sharp 2014). These fisheries are not capable of yielding the recommended 35 kg of fish per person per year, nor are they able to fulfil demand (Bell et al. 2015a). In areas where productivity of reef fisheries is limited, fishers have reported declines in catch volume and fish sizes. Under such circumstances, there is a need to diversify fisheries to exploit more productive pelagic stocks (Tilley et al. 2019a). The use of aFADs presents an opportunity to shift fishing effort away from reefs, towards abundant pelagic resources. A community-based aFAD programme in Uripiv Island, Vanuatu, provides evidence for this shift in fishing effort. Following the implementation of this programme there was a 76% reduction in landings of reef fishes as effort was transferred to FADs and over deep slopes (Amos et al. 2014). When Marine Protected Areas (MPAs) are established, aFADs also offer an alternative source of fish. These spatial protections are an efficient way of relieving pressure on reef ecosystems, yet they are often contested for squeezing out small-scale fishers from their traditional fishing grounds (Cohen et al. 2019). Under such circumstances, aFADs provide fishers with the opportunity to shift their effort away from MPAs towards abundant pelagic fish stocks. While these examples illustrate the potential of aFADS to offset MPA impacts or shift fisheries to more resilient species, the changes in fishing behaviour following the installation of aFADS need to be better documented.

Optimising the use of aFADs in SSF: recommendations for fisheries managers

Harnessing the potential benefits of aFADs needs careful planning and consideration about the design, implementation and use of these structures.

Practical and financial considerations in FAD deployment and beyond

From a practical perspective, there are a number of technical aspects involved in the successful deployment of aFADs within an SSF. Bell et al. (2015a) highlight four important considerations (Fig. 3).

- Coastal communities should be closely consulted with to help identify sites where optimal catches of tuna and other pelagic fish species have been made
- Sufficient distance (~1 km) must exist between aFADs and coral reefs to prevent the translocation of reef-associated fish species such as Spanish mackerel and trevally.
- So as not to compromise the potential for each aFAD to aggregate pelagic fish such as tuna, aFADs should be positioned at least 20 km apart.
- To ensure that artisanal vessels can easily access aFADs, they should be located at a close enough distance to coastal villages. Exceptions can be made in certain situations, for example, where the shoreline bathymetry is not suitable.

So that they are best placed to meet food security commitments, aFADs should be deployed close to communities where dependence on fish is high and access to productive fishing areas is limited (Albert et al. 2015). In cases where resources are scarce, focus ought to be concentrated on maximising the benefits of existing aFADs to prevent a "quantity over quality" scenario. In doing so, it will optimise the use of aFAD programmes and maximise their potential to meet food security commitments (Campbell et al. 2016). There is convincing evidence to support the concept that the longer the life of an aFAD, the higher the return on investment. To realise the full financial potential of aFADs, management measures should therefore target longevity (Beverly et al. 2012). Sufficient budget needs to be allocated to the ongoing maintenance of an aFAD and clear guidelines must be in place that stipulate who is responsible for maintenance tasks (Sharp 2011). In Timor-Leste, a positive effect was identified between aFAD longevity and overall revenue. To maximise the benefits of this effect, fishers were encouraged to cooperatively engage in aFAD maintenance (Tilley et al. 2019b).

While deployment is a contributing factor to success, it alone cannot guarantee the delivery of aFAD benefits. Short funding timeframes often lead to the over-allocation of project resources to deployment activities. In consequence, long-term monitoring, evaluation, and adaptation processes are often neglected. Such processes are critical to helping ensure development objectives are being fulfilled and, in cases where they are not, identifying feasible alternatives (Campbell et al. 2016). This short-term, project-based approach might perhaps explain the frequent failure of aFADs to live up to expectations (Sharp 2011; Bell et al. 2015a). It is also a contributing factor to the scarcity of data

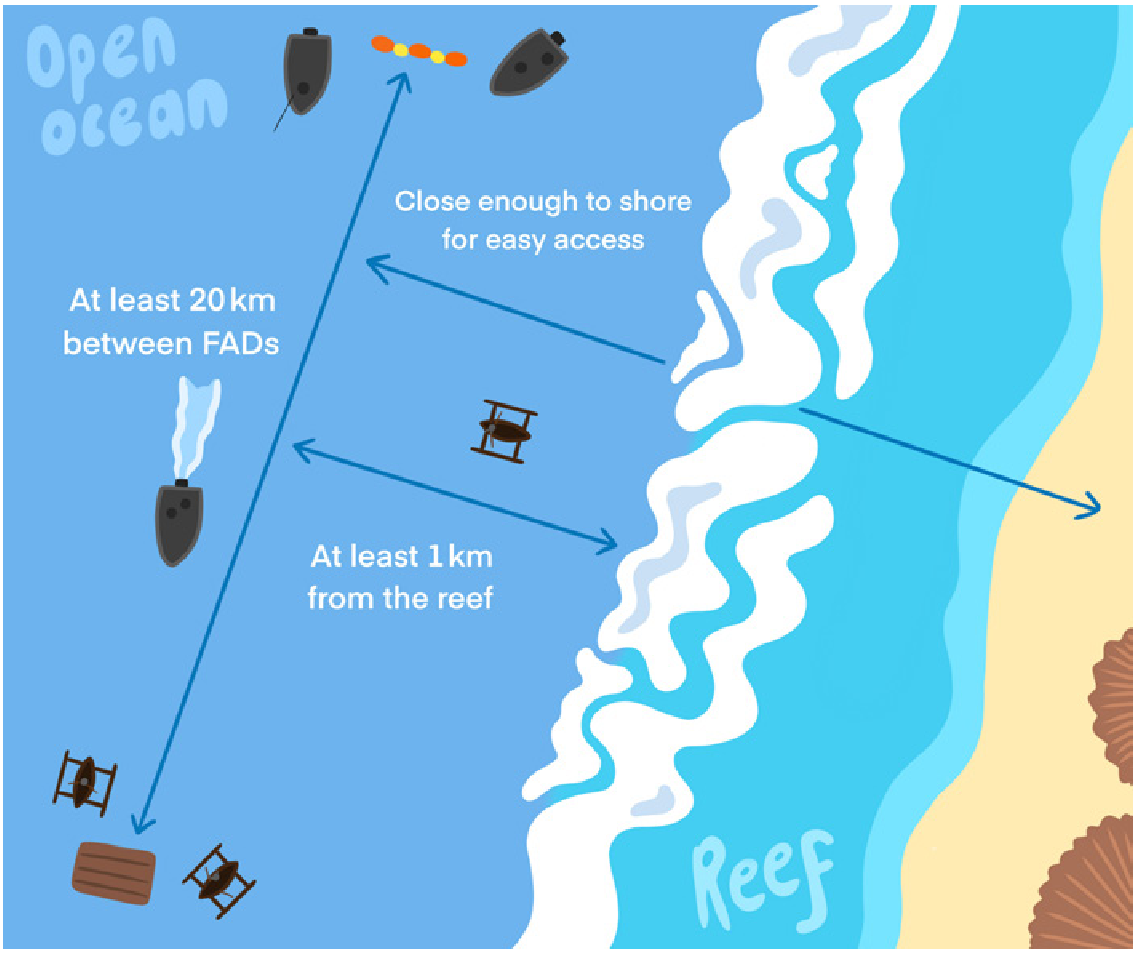

Figure 3. The practical considerations required for successful deployment of aFADs for small-scale fishing communities. (Illustration: Olivia Smailes)

pertaining to the delivery of aFAD benefits. For example, there is much uncertainty as to whether more fish are consistently caught around aFADs and whether these fish are being consumed by people most in need. This lack of key information presents several challenges including the following (Campbell et al. 2016):

- the inability to adapt aFAD programmes so that they are better positioned to meet food security commitments
- difficulty in conducting a cost-benefit analysis of aFADs in SSF
- the undermining of proposals to secure sustained, external funding support.

Considering these challenges, funding programmes and managers need to provide adequate support that enables fisheries managers to establish long-term aFAD programmes that reach far beyond deployment.

Addressing the ownership and right-based use of aFADs in SSF

Effective operationalisation of aFADs within SSF requires an understanding of the complex politics and institutional landscapes that can exist (Bell et al. 2015a), without which conflicts can arise. Often these conflicts take place over ownership and to a greater extent, the rights-based use pertaining to a particular aFAD (Beverly et al. 2012). Vandalism is a persistent problem and arises due to aFAD access inequities (Albert et al. 2014). To reduce the occurrence of such conflicts, fisheries managers need to understand the local mix of use rights, customary tenure, and ownership (Albert et al. 2014). Community consultation is therefore vital in facilitating this understanding. Consultations must equitably represent the diversity of views from different stakeholders, including women whose role in SSF is substantial. An estimated 47% of workers in the SSF sector are women. In the Pacific, this accounts for half of the annual coastal fisheries catch (Mangubhai and Lawless 2021). Given the integral involvement of women, their role in SSF aFAD programmes must not be overlooked (Beverly et al. 2012). Their inclusion in the planning and implementation of these programmes is vital to addressing gender issues in SSF. Beyond community engagement, aFAD governance must also be considered. Credence is given to efforts that promote co-managed aFADs in regions of the tropics such as the Eastern Caribbean (Pittman et al. 2020). Co-management embodies several principles reminiscent of "good" governance including democracy, transparency and sustainability (Andrew and Evans 2011). Such principles may be translated across to SSF management through the implementation of co-managed aFAD programmes. In doing so, co-management serves to reduce conflicts such as vandalism and helps optimise the contribution of aFADs to local food security (Bell et al. 2015a; Pittman et al. 2020).

Conclusion

Despite the critical role that SSF play in poverty alleviation and food security, there is a significant lack of effective assessment and management measures that ensure sustainability. The scarcity of such measures highlights a need for innovation that addresses both the diversity and vulnerability of SSF. The use of aFADs presents a feasible solution by increasing access to highly productive, nutrient-rich pelagic fishes. In doing so, aFADs can help better align fisheries management and development activities with key priorities such as food security. Furthermore, they can aid with the capacity building of small-scale fishing communities and thus enhance the community's ability to meet its own needs. So that aFADs are best placed to fulfil their potential, fisheries managers must approach aFAD programmes as long-term investments, with particular focus on the current scarcity of monitoring and evaluation information. Given the prevalence of issues pertaining to ownership and user rights, efforts should be focused on establishing clearly defined boundaries. Community consultation is critical to this process as it offers important insights into the social complexities of SSF.

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