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Emerging research for the effective co-management of small-scale fisheries

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ABSTRACT

Small-scale fisheries account for 40% of global fish catch, employ 90% of the world's fishers, and play a pivotal role in food security, poverty reduction, and sustainable resource utilisation for a substantial portion of humanity. Fisheries co-management is now widely considered to be the most appropriate, fair, and effective form of governance for small-scale fisheries. While fisheries co-management will continue to grow, its implementation does not guarantee positive impacts for food security, nutrition, livelihoods, or biodiversity. This article explores the question *'what makes fisheries co-management succeed or fail?'* by synthesising emerging research, the outcomes of which, if adopted, would substantially improve the potential for positive impacts of fisheries co-management systems across ecological and social dimensions. We synthesise 20 key concepts across four thematic areas: i) Ethics, laws, and principles, ii) Fisheries management, iii) Social structures, and iv) Managing for impact. It is envisioned that the successful adoption of these concepts into co-management regimes will help transform small-scale fisheries into engines of prosperity, inclusion, and sustainability.

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1. Introduction

Small-scale fisheries (SSF) employ more than 90% of the world's fishers and account for 40% of all global fish catch (FAO, 2022). SSF support the largest group of ocean users, more than all other marine sectors combined, and play a critical role in food and nutrition security, poverty eradication, equitable development, and sustainable resource utilisation for over 492 million people (FAO, 2022). However, despite this global significance, the women and men who service, fish, and trade in SSF have also been consistently marginalised from dialogues between international environmental and economic actors, leading to persistent rights violations and marginalisation from geographic, political, and economic ocean spaces (Cohen et al., 2019). Effectively and equitably managing SSF is hence vital for achieving progress towards multiple Sustainable Development Goals (SDGs).

Yet managing SSF is inherently complex in ways that are difficult to define and delineate from other bigger problems and require ongoing solutions to shifting challenges, which may need to be locally tailored and therefore are not necessarily globally scalable (Berkes, 2004; Jentoft and Chuenpagdee, 2009; Rittel and Webber, 1973). In recent decades local forms of marine management have captured global attention as the most effective and equitable mechanisms to manage SSF (Cinner et al., 2019; Steenbergen et al., 2021). These forms include community-based fisheries management (CBFM) and fisheries co-management, the latter defined as a relationship between a resource-user group (e.g., local fishers) and another entity (e.g., government agencies and non-government organisations) in which management responsibilities and authority are shared (Cinner et al., 2012; Western and Wright, 1994). Co-management is increasingly viewed as the most, and perhaps only, plausible pathway for the effective management of tropical SSF given their dispersed nature (Andrew et al., 2007).

Fisheries co-management (hereafter including CBFM) has proliferated widely across the globe and uptake will likely continue (Mills et al., 2019a; Steenbergen et al., 2021). Yet the expansion of fisheries co-management does not automatically equate to the expansion of positive impact, such as improved nutrition security or resource sustainability. Co-management can succeed or fail with respect to both the rate and extent to which it is implemented, and also for the benefits that are expected to accrue from its use. SSF co-management occurs in a diversity of contexts—i.e., ecologies, cultures, economies, and governance frameworks—with ensuing differences in both its spread and impact (Cinner et al., 2012). For instance, fewer management interventions implemented well might achieve far more than many management interventions implemented poorly, and poorly implemented fisheries co-management could be worse than no management. The expansion of fisheries co-management is therefore at crossroads; choices made now by implementers, facilitators, and managers will invariably shape future outcomes. A key research gap in the co-management of SSF is thus understanding the factors that drive positive progress towards desired outcomes and impacts. For while co-man agement has been reviewed extensively, such reviews typically remain within single disciplines or address well-established determinants of success, leaving emerging, cross-cutting concepts under-synthesised (Evans et al. 2011, d'Armengol et al., 2018). Synthesising these emerging concepts across disciplines, with an explicit orientation towards impact, is the contribution of this article.

To collate this learning, we seek to address the question: *what makes fisheries co-management succeed or fail?* We approach this question by utilising the collective expertise of researchers across a range of fields including: common pool resource governance, fisheries ecology, justice, equity, and inclusivity, conservation planning, impact evaluation, social-ecological systems research, nutrition, gender equity, human behaviour, and innovation and scaling theory. Our aim is to synthesise emerging research on fisheries co-management, written to inform managers, governments, and other practitioners that, if adopted, would substantially improve the potential for positive impacts of fisheries co-management systems across ecological and social dimensions. Our primary aim is therefore academic synthesis rather than practical guidance. At the outset we acknowledge two caveats to this approach. First, that success and failure are loaded terms, missing qualifiers such as *how, what*, and *for whom*? Second, this work only represents *a* list, and could not comprehensively be *the* list addressing all aspects of such a complex question. We therefore embrace the tensions in a multi-disciplinary approach; rather than ranking these concepts or asserting fixed causal relationships between them, we present an organising framework that situates the four thematic areas as interacting domains bearing on the social and ecological performance of co-management (Fig. 1), consistent with established diagnostic approaches to commons and social-ecological governance (Ostrom, 1990, 2009; Cox et al., 2010). In situating the concepts, we draw attention to tensions that recur across them, between equity and efficiency, local fit and scalability, and resource preservation and access, rather than treating each concept in isolation or as interlinked in a causal chain. The structure of this article is as follows: first, we briefly address the questions i) *what are small-scale fisheries?,* and, ii) *what is co-management?* The research concepts are then divided into four sections (Table 1). Section one addresses *ethics, laws, and principles* that should be present in any fisheries co-management system. Section two addresses effective *fisheries management* in terms of questions focusing on specific fisheries and their ecologies. Section three targets the *social structures* of fisheries co-management and the patterns governing their processes. Lastly, section four addresses the concept of *impact*, meaning the ultimate objectives of fisheries co-management, the processes by which they emerge, and how these processes are understood. This article was written as an expanded academic companion to the Fisheries Co-Management Guidebook, which provides extensive figures and infographics as well as the corresponding practitioner-facing guidance (Smallhorn-West et al., 2023b).

This article is a narrative review rather than a systematic review. We assembled a multidisciplinary author team to cover the range of disciplines that bear on fisheries co-management outcomes, spanning common-pool resource governance, fisheries ecology, justice, equity and inclusivity, conservation planning, impact evaluation, social-ecological systems research, nutrition, gender equity, human behaviour, and innovation and scaling theory. We include these fields because each illuminates a distinct determinant of fisheries co-management performance. For example, common-pool resource governance and social-ecological systems research speak to institutions and participation (Ostrom, 1990; Berkes, 2004; Cox et al., 2010); fisheries ecology and conservation planning to ecological outcomes (Cinner et al., 2012); justice, gender, and human rights to who benefits and who bears costs (Weeratunge et al., 2014; McDougall et al., 2021); innovation and scaling theory to how co-management spreads (Mascia and Mills, 2018); and impact evaluation and nutrition to whether intended benefits, including for food and nutrition security, are realised (Ferraro and Hanauer, 2014).

The concepts were identified and refined through successive rounds of discussion among the authors, developed in conjunction with the Fisheries Co-Management Guidebook (Smallhorn-West et al., 2023a). Each author appraised the emerging set against their own field, and the team iterated until satisfied that it captured the right themes and ideas, retaining concepts judged both emerging or underused in fisheries co-management research and practice, and materially consequential for the social or ecological performance of fisheries co-management. The retained concepts were then organised into the four thematic areas. Because each concept has its own theoretical underpinning, no single theory unifies them, and we deliberately present the concepts as an integrated but non-prioritised set (Fig. 1). We did not seek an exhaustive or quantitatively weighted list; the resulting twenty concepts represent a considered expert synthesis, and we state this openly to be transparent about the subjectivity such an exercise entails.

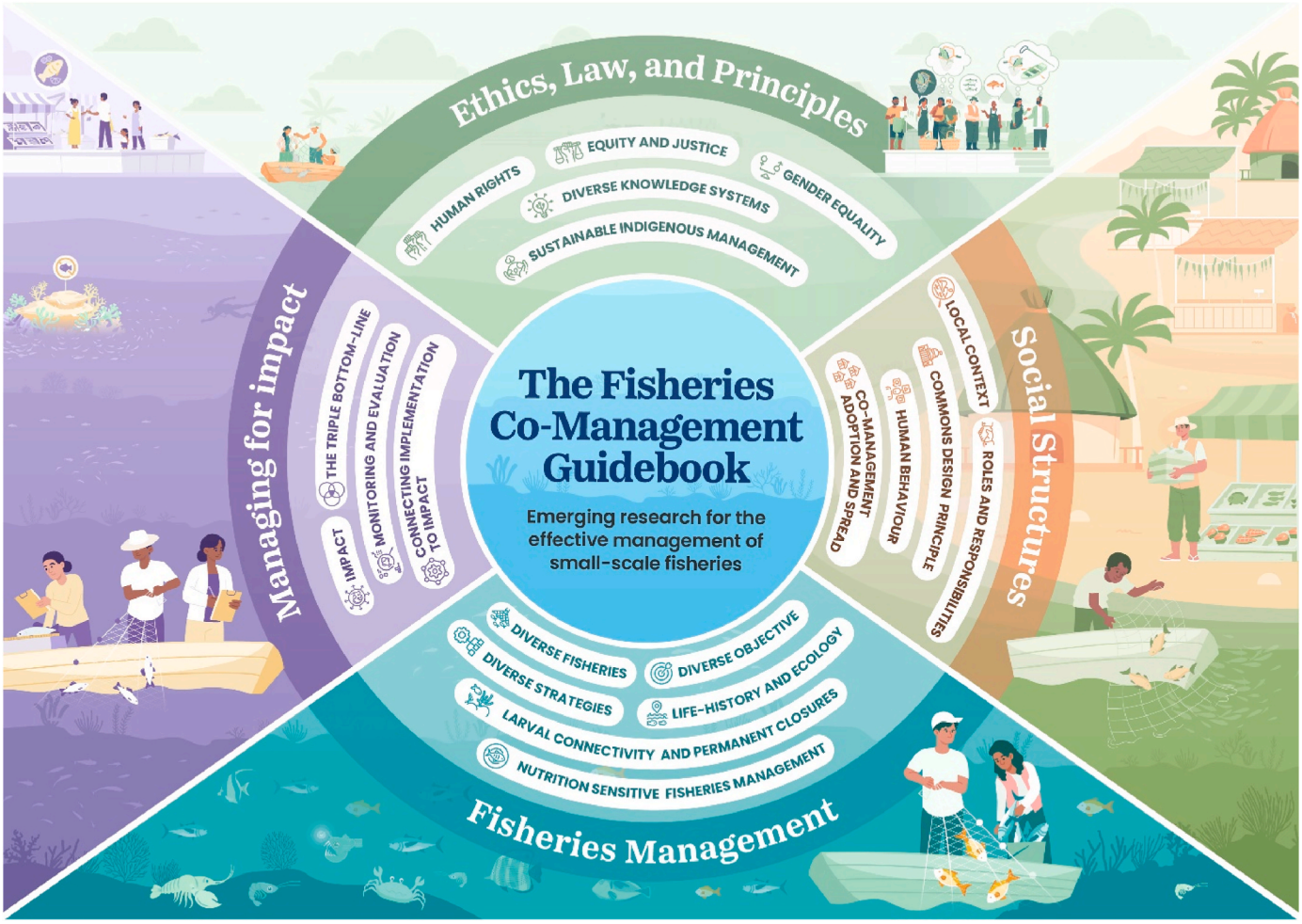

Fig. 1. The four thematic areas of small-scale fisheries co-management and their constituent concepts, centred on the Fisheries Co-Management Guidebook (Smallhorn-West et al., 2023a) and presented as interacting domains underpinning effective co-management.

2. What is small-scale fisheries co-management?

2.1. What are small-scale fisheries?

While definitions of small-scale fisheries can be broad, they typically include self-employed fishers involved in locally-based artisanal fishing, be it commercial or subsistence, encompassing all activities along the value chain – pre-harvest, harvest, and post-harvest. SSF typically involve households rather than commercial companies, who use small amounts of capital and energy, relatively small fishing vessels if any, for short trips close to shore for local consumption (FAO, 2014). They tend to be firmly rooted in local communities, traditions, and values, and as such serve as an economic and social engine, providing food and nutrition security, employment, and other multiplier effects to local economies (FAO, 2014). For many involved in the sector, it represents a way of life that embodies a diverse and cultural richness that is of global significance.

SSF account for approximately 37 million tonnes of global catch, originating primarily from Asia and Africa, and two thirds of all fish for human consumption (FAO, 2022). 60 million people are employed full or part time in the SSF sector, 53 million engaged in subsistence, and 7% of the world's population (492 million people) are dependent at least partially on SSF for their livelihoods. Annual revenue from SSF is approximately USD 77 billion, placing it among the largest industries in the ocean economy. Around 45 million women participate in SSF value chains and subsistence activities worldwide, representing 40% of all those estimated to engage in SSF (ibid). Fishing activities typically occur from small vessels (<12 m) and close to shore (within 3 km) (Basurto et al., 2017; IPBES, 2022). Small-scale fisheries occur across the globe, with well-known examples including: the Iberian freshwater fisheries in Europe (Antunes et al., 2015; Braga et al., 2019), the Hilsa fisheries of Bangladesh and India (Abdul et al., 2020; Alam et al., 2021), African great lakes (Bulengela et al., 2020; Hara and Njaya, 2016), fin fisheries of Latin America (Defeo et al., 2016; Guzmán Maldonado et al., 2017), the recreational fisheries of North America (Bartholomew and Bohnsack, 2005), and tropical coral reef fisheries of the western Indian Ocean (McClanahan, 2010) and Indo Pacific (Foale et al., 2013; IPBES, 2022; Mattson and Mattson, 2006).

Despite their importance, many small-scale fishing communities continue to be marginalised, and their contribution to food security and nutrition, poverty eradication, equitable development, and sustainable resource utilisation is not fully realised (FAO, 2014). Small-scale fishing communities are often left out of discourse among other sectors with stronger political and economic influence (e.g. energy, mining, industry, and tourism) (Cohen et al., 2019). The degree of poverty in small-scale fishing communities is also well documented (Béné, 2003), so much so that in developing countries (where 90% of small-scale fishers live) fishing has often been synonymous with poverty, and 5.8 million fishers earn less than US$1 per day (FAO, 2015). This poverty is often multidimensional in nature, caused not only by low income but also other factors that impede full realisation of civil, political, economic, social, and cultural rights (FAO, 2014). These factors include: poor access to health, education, and markets; unhealthy and unsafe working conditions, forced labour, and child labour; and pollution, environmental degradation, and climate change. All

Table 1
The four thematic areas of the review, their focus, and the constituent concepts with a key reference for each.

Thematic area	Focus	Concepts (key reference)
1. Ethics, laws and principles	Ethics, laws, and principles that should be present in any co-management system	Human rights (Smallhorn-West et al., 2023b); equity and justice (Bennett et al., 2022); gender equality (Kawarazuka et al., 2017); diverse knowledge systems (Bevitt et al., 2022); sustainable Indigenous management (Kimmerer, 2013)
2. Fisheries management	Effective management for specific fisheries and their ecologies	Diverse fisheries, objectives and strategies (Halim et al., 2019); life-history and ecology (Abesamis et al., 2014); larval connectivity and permanent closures (Russ et al., 2004); nutrition-sensitive management (Béné et al., 2015)
3. Social structures	The contexts, institutions and patterns governing co-management processes	Local contexts (Cinner and McClanahan, 2006); roles and responsibilities (Pomeroy and Berkes, 1997); commons design principles (Ostrom, 1990); human behaviour (Cinner, 2018); co-management adoption and spread (Mascia and Mills, 2018)
4. Managing for impact	The ultimate objectives, how they emerge, and how they are understood	Impact (Ferraro and Hanauer, 2014); the triple bottom line (Anderson et al., 2015); monitoring and evaluation (Pressey et al., 2017); connecting implementation to impact (Smallhorn-West et al., 2022)

of this makes it difficult for small-scale fishers to have their voices heard, defend their rights, and secure the sustainable use of the fisheries on which they depend (FAO, 2014).

2.2. What is co-management?

In recent decades, collaborations between governments, NGOs, and resource custodians, users, and beneficiaries have become an increasingly popular governance tool by which to manage natural resources. There has been a growing realisation that, since the management of many natural resources primarily focuses on changing patterns of behaviour at the local level, they will be more effectively managed if resource users are actively involved in the process (Cohen and Alexander, 2013; Pomeroy, 1995). These collaborations, referred to as co-management (Box 1), are now globally recognised as a foundation of fair and effective management of natural resource access and use (WorldFish, 2021). Co-management is distinctly different from more centralised governance arrangements, in which natural resource management is undertaken by a central governing authority. Co-management is now widely considered to be the most appropriate and effective form of governance for diverse and distributed SSF (Evans et al., 2011), and is hence recognised and recommended by global fisheries commitments including the *Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of National Food Security and Poverty Eradication* (FAO, 2014).

Fisheries co-management can take many different forms in terms of the resources being managed, the rules by which they are managed, the people and groups involves in management, and the relationships among management partners and governing bodies (WorldFish, 2021). These roles exist along a continuum of both governing responsibility and power, and are often nested, with specific roles in the local, national, and regional context. The spectrum of local and external engagement varies from "instructive" management, with fishers merely consulted by external actors, to "informative" management by which external actors delegate most authority to the user groups (Sen and Nielsen, 1996; WorldFish, 2021). Ideally, fisheries co-management complements the capacity and aspirations of local fishers and community with the abilities of external actors to provide enabling legislation and oversight (Pomeroy and Berkes, 1997).

3. Part 1: Ethics, laws, and principles

3.1. Human rights

Human rights are possessed by all persons, by virtue of their common humanity, to live a life of freedom and dignity (Winer et al., 2007). They are universal and non-discriminatory (held equally by all human beings), inalienable (they cannot be taken away), unconditional (they do not depend on behaviour), indivisible and interdependent (they are all equally important and they cannot be separated) (Newing and Perram, 2019). They are based on principles of dignity, equality, and mutual respect, shared across cultures, religions, and philosophies (UN, 1948). While human rights include civil and political rights, they also include economic, social, and cultural rights, which include the right to food, water, housing, and decent work, and the rights of children, migrants, and women. These rights are each supported by legal frameworks that collectively form international human rights law. As rights, international law requires "duty bearers", that is the actors collectively responsible for the realisation of these rights (depending on circumstance either state and non-state actors), to respect (refrain from taking action that violates), protect (prevent the violation by others), and fulfil (enable people to claim and enjoy) the rights of "rights holders", that is the individuals that have particular entitlements in relation to duty bearers (Winer et al., 2007).

There are legal, ethical, and practical arguments for why fisheries co-management should consider human rights (Smallhorn-West et al., 2023b). First, the legal obligation to respect human rights is categorical – whether support for human rights is given by the fisheries sector should not be based on the extent to which upholding human rights fulfils the needs of the sector (e.g., profits). Ethically, it is also wrong for one people to dispossess, subjugate, or exterminate another people to promote their own ideological views. Practically, there is an increasingly large body of empirical evidence showing how supporting the rights of local people leads to consistently positive and enduring impact across multiple ecological and socioeconomic dimensions (e.g., Dawson et al., 2021; Oldekop et al., 2016).

Box 1
The definition of fisheries co-management adopted in this review, and the stakeholders and external agents that typically support it.

Fisheries co-management can be defined as "a relationship between a resource-user group (e.g., a group of fishers or a fishing community) and another organisation or entity (usually a government agency) for the purposes of fisheries management in which some degree of responsibility and/or authority is conferred to both parties" (Evans et al., 2011). Support and assistance are also often provided from other stakeholders (e.g., boat owners, fish traders, fish processors, boat builders, businesspeople, etc.) and external agents (e.g., non-governmental organisations (NGOs), academic and research institutions) (Berkes et al., 2001).

A Human Rights-Based Approach (HRBA) is a conceptual framework for the process of human development that is based on international human rights standards and directed to promoting and protecting human rights (OHCHR, 2006, p. 15). Simply put, an HRBA means that fisheries management policies, governance, and management do not violate human rights and that those implementing such policies actively seek ways to support and promote human rights in their design and implementation (Boyd and Keene, 2021). In the context of fisheries co-management, an HRBA is operationalised through the SSF Guidelines (FAO, 2014). These Guidelines translate human rights principles into concrete commitments on tenure, gender equity, and participation, and provide a reference point against which co-management arrangements can be assessed (Smallhorn-West et al., 2023b). Importantly, an HRBA is not meant to replace other strategies such as co-management, but rather provides the legal framework through which they can ensure the support of people's rights.

Acknowledging the contextuality of fisheries co-management activities, generalised guidance can be generated to foster greater support for human rights and HRBA in the sector. We suggest that, in general, programmes aligned with an HRBA and respecting, protecting, and fulfilling people's rights will have many of the characteristics in Box 2, noting that this list is non-exhaustive (Smallhorn-West et al., 2023b).

3.2. Equity and Justice

The processes of fisheries co-management can benefit, or disadvantage, specific people and sectors of society, exacerbating power imbalances with costs disproportionally falling on those with the least power (Grantham et al., 2020; Kleiber et al., 2019). Equity and justice in SSF generally pertain to the right and fair treatment of people (Bennett et al., 2022). Enabling just and equitable co-management involves acknowledging, legitimising, respecting, and valuing diverse views, identities, and interests (Gurney et al., 2021). Developing just and equitable management systems also requires understanding how costs and benefits associated with management are distributed, and ensuring the fair treatment and meaningful involvement of all people in decision-making and management processes (Bennett et al., 2022; Ruano-Chamorro et al., 2022). For example, in some instances fisheries co-management can facilitate, rather than restrict, elite capture, since local elites are often in a better position to capitalise on newly created participatory spaces and to make decisions on behalf of communities (Wong, 2013). Such understandings need to be aligned with local, contextual understandings of what is fair (Lau et al., 2021; Estévez et al., ; Gurney et al., 2021). Community agreement also does not necessarily guarantee that all members have had their views heard and respected. For example, in many Pacific Island nations, the 'culture of silence', whereby people do not contradict the views of those with authority, often limits the full participation of women in management decisions (Vunisea, 2008), as well as other marginalised groups (i.e., youth, migrant fishers). In these instances, the continued expansion of programmes that do not incorporate gender-sensitive facilitation techniques therefore will likely also continue to disempower. As such, working towards just management systems might require challenging broader structural barriers, such as discriminatory social norms and laws (Ruano-Chamorro et al., 2022), while explicitly acknowledging differences in circumstances and allocating resources and opportunities accordingly ensures they are equitable (Schreckenberg et al., 2016).

3.3. Gender equality

Gender equality is a foundational principle for just and equitable fisheries. Evidence suggests that progressing gender equality can lead to both improved social outcomes (e.g., for human development including enhanced wellbeing or economic empowerment) and ecological outcomes (e.g., improved biodiversity and ecosystem function) (Kawarazuka et al., 2017; Kleiber et al., 2019; 2018). Gender refers to the social expectations about what it means to be a woman or a man, and profoundly shapes people's experiences, opportunities, and barriers in SSF systems (United Nations Office of the Special Adviser on Gender Issues and Advancement of Women, 2002). Although there are contextual variations, unequal gender norms and power relations tend to mean men hold greater influence in decisions related to access, use and management of productive assets (including, but not limited to, fishing grounds and stocks), and are more likely to capture and control a disproportionate share of the social and economic benefits (Harper et al., 2013; 2022; Lawless et al., 2019). Despite women's high participation and contribution to economic and food security derived from SSF globally, women are consistently undervalued, underrepresented, and marginalised in both formal and informal sector activities (Lawless et al., 2021; Mangubhai et al., 2022).

Gender-nuanced SSF research, policy and practice presents diverse opportunities to address these challenges. Fisheries data collection (i.e., related to employment, fish landings) is increasingly becoming disaggregated by sex, providing a more accurate representation of women's

Box 2
Characteristics of fisheries co-management programmes aligned with a human rights-based approach (HRBA). The list is non-exhaustive (after Smallhorn-West et al., 2023b).

Fisheries co-management characteristics

1. Acknowledge that all people have basic rights that must be supported and understand that managers are dutybound to respect those rights.
2. Support the empowerment of fishers, Indigenous Peoples, and local communities, as leaders of nature stewardship in their own right, as well as allies in support of biodiversity conservation.
3. Acknowledge that not all people in situations of vulnerability have deep connections to country, but all people still have fundamental rights regardless of their ability to support fisheries co-management.
4. Include inherent respect for anti-racism, non-discrimination, diversity, and gender equality principles.
5. Recognise people as key actors in their own development, rather than passive recipients of commodities and services.
6. Encourage supportive actions towards those most marginalised, disadvantaged, and excluded.
7. Promote long-term environmental and social security over short-term targets, since short-termism exacerbates inequitable results and leads to net negative impacts over time.
8. Acknowledge that increased vulnerability reduces people's agency to adopt sustainable practices, and hence securing human rights can be a good conservation investment.
9. Implement policies and actions that address the root causes of vulnerabilities and insecurities.
10. Understand that fisheries gains achieved through human rights violations will increase disenfranchisement, widen inequalities, potentially increase resource dependence, and heighten resistance to current and future conservation activities.

role and contribution across all nodes of the value-chain. Gender analyses are increasingly applied to reveal qualitative insights into the role of gender norms and relations in determining women's and men's differing freedoms, opportunities, and rights in the sector (e.g., Kawarazuka et al., 2017; Stacey et al., 2019). Understanding these gendered nuances means management measures are designed to respond to gender differences, for instance, accounting for the capacities of different women and men to access fisheries extension services and support structures (e.g., markets and educational opportunities; Cohen et al., 2016) and engage with livelihood innovations (Locke et al., 2017). Without these insights, SSF projects can unintentionally increase women's labour and time burdens (Lawless et al., 2019) and even lead to backlash (particularly where gender relations have not been engaged with; Mangubhai et al., 2023). External co-management partners are becoming more gender-inclusive with how they engage with SSF communities, for instance, going beyond merely including women in discussions or projects, to reimagining how SSF interventions can 'empower' women (i.e., advance women's agency or positions within the household, community, or society; Mangubhai and Lawless, 2021). At the frontier of gender best practice are approaches that 'transform' the structural causes of gender inequality through SSF (Cole et al., 2020). Although only in their infancy in the SSF sector (Lawless et al., 2022), these approaches target the root causes of gender inequality through transforming inequitable social structures and institutions (Cole et al., 2020).

3.4. Diverse knowledge systems

Evidence and information come in many forms. For example, the experiential and lived reality of fishing communities in of itself constitutes a substantial source of evidence based on deep and enduring relationships with resources (Bevitt et al., 2022). Knowledge co-production, whereby stakeholders, researchers, and knowledge holders work together to develop research and management protocols, is a key process for effectively and equitably combining diverse knowledge systems and thus improving the legitimacy of fisheries co-management and the associated outcomes (Chambers et al., 2021). Recognising multiple knowledge systems means respecting, listening to, and considering all viewpoints and knowledge types, such as local, Indigenous, social, political, moral, religious and institutional knowledge. The goal of knowledge co-production is then to leverage and integrate these multiple views to generate stronger evidence. Knowledge co-production also requires working to enhance the legitimacy of various knowledge systems, since if decision-makers do not buy into the legitimacy of the knowledge systems from which the evidence was generated, they will not use it to inform decisions.

At the same time, effective knowledge co-production also means acknowledging the biases that all humans are prone to, both within western scientific thought and Indigenous and other local knowledge systems (Cinner, 2018). For example, it is still the case that many western scientists do not sufficiently understand the diversity of values and perceptions of nature that occur in other cultures (Allison et al., 2020; Jupiter, 2017). Concurrently, it is also common for SSF communities engaged in co-management to perceive improvement in fish abundance, size, and diversity, within unrealistically short timeframes, including for very long-lived and wide-ranging species. Disregarding these biases undermines and disrespects the main goals of fisheries co-management – such as sustainable fisheries and improved human well-being.

3.5. Sustainable indigenous management

The traditional ecological knowledge of Indigenous harvesters is rich in prescriptions for sustainability, and hence have substantial practical application for improving fisheries co-management. The principles and practices present in Indigenous science and philosophy, lifeways, and most of all stories, govern the exchange of life and shape relationships with the natural world, reining in tendencies to overconsume so that natural resource harvests can be sustained for future generations (Kimmerer, 2013). For example, collectively this cannon can be known as the Honourable Harvest, and while details can be highly specific to different cultures and ecosystems, the fundamental principles are often shared among peoples living close to land and sea country (ibid.). These practices often amount to specific protocols designed to maintain the health and vigour of species and ecosystems, which, like government regulations, are also based on sophisticated ecological knowledge and long-term monitoring of populations. In *Braiding Sweetgrass,* Robin Wall Kimmerer lays out the often unwritten 'rules for the Honourable Harvest', which are as applicable to the co-management of SSF as they are to the management of terrestrial systems. The Honourable Harvest recognises beings harvested as persons, non-human, but still vested with awareness, intelligence, and spirit, and that killing a 'who' demands greater care than killing an 'it' (Kimmerer, 2013). The Honourable Harvest does not say 'don't take', but instead offers a model for what we should take, and how, so that we can consume in a way that does justice to the lives that are taken.

4. Part 2: Fisheries management

4.1. Diverse fisheries, objectives, and strategies

At the outset, evaluating the performance of SSF co-management is made difficult by the extraordinary diversity of i) fisheries, ii) objectives, and iii) strategies. First, SSF themselves are largely defined through the socioeconomic attributes of fishers rather than specific species targeted or methodologies employed (Halim et al., 2019). SSF are defined by the United Nations (UN) Food and Agriculture Organization (FAO) as "traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amounts of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption" (Halim et al., 2019). Hence, this broad definition includes: i) many geographies, for example both the inland freshwater fisheries of the Congo and coastal fisheries of Bangladesh; ii) many targeted species, for example the many hundreds of coral reef fish species targeted within the Indo-Pacific; and iii) many fishing methods, for example in Solomon Islands gleaning, night-time spearfishing, trolling, and dynamite fishing can all occur on the same reef within a single day (Cohen and Alexander, 2013). Second, the strategies employed for co-managing SSF are broad and multifaceted. While all strategies function by regulating patterns of resource use through space and time, this can be achieved through spatial restrictions, including access restrictions, permanent closures, and periodically-harvested closures, as well as by regulating the species that are able to be caught or the method by which they can be targeted (Jupiter et al., 2014; Gelcich et al., 2019). Third, fisheries co-management is expected to deliver on multiple diverse objectives: for people's health and livelihoods, cultural practices, perceptions of justice and equity, and the conservation of biodiversity. These objectives can be broadly categorised using the UN Sustainable Development Goals (SDGs), for which fisheries co-management contributes most strongly to 11 targets across five SDGs (Smallhorn-West et al., 2022).

4.2. Life-history and ecology

In many fisheries co-management scenarios, objectives that build off changes in resource abundance, such as improving livelihoods, are a greater priority than those specifically focused on the resources themselves (e.g., biodiversity conservation). Nevertheless, aligning management strategies to the life-history and behaviour of target species is fundamental to achieve impact towards all objectives, since these are non-negotiable characteristics of targeted organisms. Patterns of longevity, growth, movement, and reproduction vary by orders of magnitude between species, and this variability dictates the success of any strategy (Abesamis et al., 2014; Green et al., 2014; Mcleod et al., 2018; Shikuku et al., 2017; Weeks et al., 2016). For instance, target species with slow growth rates, low fecundity, late maturation, long life-spans, large home ranges, or specific

habitat requirements will be more vulnerable to even minor rates of exploitation (Jennings et al., 1998; Hamilton et al., 2016). For no-take marine reserves, life-history can determine how long populations take to recover inside reserve boundaries, as well as their propensity to spill over into openly fished areas and hence improve fisheries yields (Harrison et al., 2020). For periodically-harvest closures, if cycles of opening do not match species vulnerability to exploitation and recovery thereof, then it is unlikely they will be sustainable Goetze et al., (2016); Smallhorn-West et al., (2022). In these instances, either cycles of harvesting need to change to match the recovery rate of select species, or, if socioeconomic or cultural factors preclude changing harvesting regimes, species should be targeted whose recovery allows harvesting at that rate. Likewise, if the area of spatial management is smaller than the home range of the species they aim to protect, then only limited benefits from protection will accrue (Weeks et al., 2016). Modelling studies estimate that marine reserves of 10 km diameter or more are needed to include the home range of ~70% of reef fish species (Krueck et al., 2018). These described characteristics are non-negotiable and represent a hard wall in how co-management systems should be designed. Regardless of socioeconomic condition, or the cultural significance of various harvesting practices, the ecology of target species is inflexible, and acknowledging and dealing with design trade-offs through understanding life history traits is key for effective fisheries co-ma nagement (Viana et al., 2019).

4.3. Larval connectivity and permanent closures

No-take areas that permanently prohibit resource extraction within their boundaries can and do act as important fisheries management tools (Russ, 2002; Russ et al., 2004, 2015). There is strong evidence that recovering populations within no-take areas act as significant and consistent sources of larval export of key target species to areas beyond their boundaries (Harrison et al., 2012, 2020; Hopf et al., 2016), which can partially or fully compensate for the displaced fishing effort and lost access to resources (Pelc et al., 2010). Furthermore, this has been demonstrated both in top-down and bottom-up approaches to marine resource governance, for which the ecological mechanisms underpinning their value are the same (Almany et al., 2013, 2017). Permanent closures are desirable because impacts can take a long time to accrue (Hopf et al., 2016; Harrison et al., 2020), but can decline rapidly when opened to fishing (Cohen and Alexander, 2013; Russ and Alcala 2013; 1989).

There is increasing awareness of often inequitable outcomes associated with implementing permanent no-take closures when people depend on the resources within their boundaries (Christie, 2004; Jupiter, 2017). This is often framed as a 'hidden' conservation agenda promoting biodiversity preservation at the expense of people's access to resources, thereby affecting their livelihoods or wellbeing (Ban et al., 2019). Indeed, many organisations from western countries do in fact promote western values of nature preservation without sufficient acknowledgement of different value systems in the countries in which they operate (e.g., Chapin, 2004; Smallhorn-West et al., 2023b). It is important to acknowledge the very real record of substantial socio-economic costs borne by small-scale fishers and driven by conservation movements, such as forced displacements, evictions, and losses of livelihoods (Cohen et al., 2019; Singleton et al., 2017). However, the focus should not be on whether permanent no-take closures should be employed, but instead on how they can be implemented equitably and as specific fisheries management tools, if the objective is primarily resource focused. The benefits of permanent no-take closures can be robust to changes in reserve size and spacing, allowing desirable targets such as protecting 30% of the area to be achieved through flexible design, without adversely affecting any single fishing community. Larval dispersal is often sufficiently limited to ensure that local reserves will benefit local fisheries, and co-operation between neighbouring communities can be mutually beneficial (Almany et al., 2013). However, as over-exploited resources can often take many years to recover even within no-take boundaries (Russ and Alcala, 2010; McClanahan et al., 2007), their implementation must also be considered alongside interim measures to ensure their intended benefits have time to accrue.

4.4. Nutrition sensitive fisheries management

Aquatic foods are a significant source of essential micronutrients for more than four billion consumers and provide more than one sixth of global demand for animal protein (Béné et al., 2015; Cohen et al., 2019). It is estimated that nearly two billion people lack key micronutrients, underlying nearly half of all deaths under five years of age and reducing gross domestic product in Africa by estimates of up to 11% (Hicks et al., 2019). Despite limited evidence thus far linking fisheries co-management to changes in human health, because of its prevalence as a fisheries management tool in developing countries where malnutrition is greatest, fisheries co-management nevertheless has enormous potential to drive positive impacts towards improved food and nutrition security.

Nutrition sensitive approaches to fisheries co-management recognise that in the context of persistent poverty, the most important role of SSF, and hence its management, is its contribution to nutrition security (Andrew et al., 2007; Hicks et al., 2019; Kawarazuka and Béné, 2011). These approaches involve thinking beyond the resource and its economic returns, and instead holistically considering the contribution of fisheries to improved health outcomes. Recognising aquatic foods as part of a diverse, nutritious diet, fisheries managers must incorporate indicators that mark key processes shaping the pathway of fish from landings to consumption, and beyond to health outcomes (Hicks et al., 2019). Nutrition-sensitive management also recognises and incorporates the multiple pathways to improving nutrition security from fisheries – for example, techn ology-based interventions that reduce food loss by improving cold chain systems (assuming in water management is in place; (Genschick et al., 2015), or education programmes that highlight the health benefits of fish consumption at different life stages (e.g., for children in the first 1000 days; Mahmudiono et al., 2020). This approach hence needs to provoke a shift in the way management is conceived and structured, so that those involved, the management institutions, and the research and monitoring processes, collectively incorporate nutrition into their design principles. For example, a nutrition-sensitive approach could be utilised to make policy decisions about whether to invest in various interventions based on optimal nutrition outcomes for those most vulnerable. Likewise, it could lead to new approaches for designating fisheries closures, based on when other important sources of nutrition (e.g., household gardens) are at their most productive.

5. Part 3: Social structures

5.1. Local contexts

The contexts in which fisheries co-management operates is just as relevant as the specific strategies that are employed. Hence, understanding the socioeconomic, cultural, and political factors that situate co-management impacts is key to predicting the potential of new programmes, and understanding why existing programmes might succeed or fail. Contextual factors can be external to communities, such as market access (Brewer et al., 2009, 2012, 2013; Cinner, 2005; Cinner and McClanahan, 2006), or internal, such as levels of fishing pressure (Cinner et al., 2016, 2018; Cinner and Aswani, 2007; Daw et al., 2011a) and resource dependence (Cinner et al. 2005; 2006, 2012, 2016). For example, market access and population pressure are both very strong predictors of whether SSF co-management is likely to improve the status of marine resources or increase overexploitation (Brewer et al., 2013; Cinner et al., 2018). Understanding how people interact with markets before the introduction of fisheries improvement projects therefore helps to avoid unexpected outcomes (Barclay and Kinch, 2013). Likewise, the strength of tenure systems is tightly bound to levels of community engagement (Cinner et al., 2016; Gurney et al., 2016), degree of dependence on fisheries, and local ecological knowledge and customs (Cinner et al., 2006).

These contextual factors can influence the degree to which people have incentives to work together (Ostrom, 1990), and the ability for ecological responses to manifest. For example, Agrawal and Goyal (2001) found that medium sized groups were more likely than small or large groups to participate in key co-management activities. Likewise, some ecological benefits from co-managing coral reef fisheries were highest in locations with moderate human disturbance (Cinner et al., 2012). In the most disturbed locations, reefs were too degraded to respond to management, while ecological conditions in less disturbed locations were already good, so management had less additional benefit.

5.2. Roles and responsibilities

Given that fisheries co-management involves actions by both external actors (e.g., government, NGOs, academia) and community, successful co-management requires clear delineation and support for the specific roles and responsibilities of each party. These roles exist along a continuum of both governing responsibility and power, and are often nested, with specific roles in the local, national, and regional context. The spectrum of local and external engagement varies from "instructive" management, with fishers merely consulted by external actors, to "informative" management by which external actors delegate most authority to the user groups (Sen and Nielsen, 1996; WorldFish, 2021). In many instances informal local management often occurs with little external influence from government, and in some instances formal legal recognition of these arrangements requires communities to give up certain rights (e.g., an ability to enforce tenure), thereby reducing acceptance of co-management as a useful innovation (Mangubhai et al., 2020). In co-management, the key responsibilities of the resource users are to have sufficient interest and willingness to engage, knowledge of the system, and organisation to enable collective action, as well as commitment to complete specified roles such as enforcement or data gathering. The key responsibilities of external actors are to foster the conditions for equitable and effective co-management by creating legitimacy and accountability for local organisations through recognition of rights and rules. The government, through its legislative and policy instruments, defines power-sharing and decision-making arrangements; only the government can legally establish and defend user rights and security of tenure. Importantly, co-management must aim at building an adaptive governance structure which incentivises the continuous involvement of resource users and managers at different scales (Plummer et al., 2012).

Ideally, fisheries co-management complements the capacity and aspirations of local fishers and community with the abilities of external actors to provide enabling legislation and oversight (Pomeroy and Berkes, 1997). Yet to understand the contributions of various parties to ultimate impacts and outcomes it is critical to acknowledge subsidiarity (i.e., that the level of governance needs to match the scale of issues to be governed). For example, investments in specific communities at the local scale are unlikely to address global challenges such as climate change, which require bold actions from international actors. Likewise, it is often the case that targets are set at regional or national levels, for example, to combat overfishing, that ultimately have limited influence on local patterns of resource use. In both instances, any changes enacted at the wrong scale are likely to become too diluted to be relevant. Hence when undertaking evaluations of SSF co-management, it is critical to be realistic about the capacity for the level of governance to deal with the scale of various issues.

5.3. Commons design principles

Open access systems such as fisheries, grazing lands, and even the global carbon budget, are notoriously difficult to manage. This is because they often incentivise individuals to act in their own self-interest at the expense of the wider system, a situation commonly referred to as the 'tragedy of the commons' (Hardin, 1968). Institutions are the rules, norms, and strategies that shape behaviour (High et al., 2004; Ostrom, 1999), so the principles by which they are constructed have bearing on how open access natural resource systems are managed. Research has identified a series of design principles that characterise a robust 'institutional architecture' for managing common-pool natural resources, including fisheries co-management (Cox et al., 2010; Ostrom, 1990), and avoid the 'tragedy of the commons' (Hardin, 1968). These principles include having clearly defined users and resources, and graduated sanctions for rule violations. If, for example, these principals are not in place, then it is much more difficult for co-management to be effective as the legitimacy of the system will be called into question. These principles are influential, but they were derived largely from long-enduring, relatively bounded common-pool resource institutions, and their direct transfer to the dynamic, open, and multi-scale settings of small-scale fisheries co-management is debated. Later work has broadly supported the principles while also refining them (Cox et al., 2010), and Ostrom's own subsequent framework moved towards a wider social-ecological diagnostic to accommodate this complexity (Ostrom, 2009).

5.4. Human behaviour

Management is fundamentally about regulating human behaviour (Cinner, 2018). Yet conventional attempts to manage SSF often fail because of inadequate understanding of how people make decisions, and the institutions that shape these decisions (Quigley, 2013; Thaler, 2018). Insights into inducing behavioural change based on what decisions people are exposed to can therefore also influence the impact of fisheries co-management (Cinner, 2018). These behavioural 'nudges' towards better outcomes can take advantage of cognitive biases (Ariely et al., 2003; Thaler, 2018), which make people behave in seemingly strange but predictable ways, or through social influence, which is the idea that we are profoundly influenced by our innate desire for prestige, reputation, conformity and reciprocity (Abrahamse and Steg, 2013; Nyborg et al., 2016; Arlidge et al., 2023). Importantly, while interest in behavioural insights to conservation theory and practice are expanding, they have included limited engagement with questions of equity and power. Considerations must be made for understanding the potential misapplication of behavioural approaches to conservation, such as unanticipated negative social welfare and distributional costs. Hence, equity must be centred when applying behavioural insights to fisheries co-management (Crosman et al., 2022). A concrete example is Rare's Fish Forever programme, which has used Pride social-marketing campaigns, grounded in behavioural science, to build community support for rights-based management and no-take reserves. A multi-site evaluation across 41 sites (260 communities) in Brazil, Indonesia, and the Philippines documented associated changes in community support, fisher behaviour, and ecological and socioeconomic indicators (McDougall et al., 2021).

5.5. Co-management adoption and spread

The expansion of fisheries co-management is non-random, the sum of many diverse actions and actors, an integral part of innovation processes (rather than a post-innovation endeavour). Expansion is shaped by both directed interventions and the contextual conditions of the environment. Uptake trajectories of management measures often follow specific patterns and trends consistent with diffusion innovation theory (Mascia and Mills, 2018). Most initiatives display slow-fast-slow dynamics, typical of spread driven by interactions between existing and potential adopters (Mills et al., 2019b; Smallhorn-West et al., 2020a). At the beginning, adoption rates are likely slow because the small number of initial adopters limits the rate of spread. Later, this typically gives way to a rapid growth phase as increasing numbers of adopters share their experiences within a large pool of potential adopters. Over time, the uptake rate slows down again as the broader system adapts to the established presence of a 'new' integrated and proven innovation.

Critically, however, lasting expansion of fisheries co-management across a seascape hinges not on the performance of single innovation

uptake trajectories, but rather evolves as a sum of many innovation trajectories involving actions, processes and structural conditions (Steenbergen et al., 2021). After all, co-management fundamentally occurs within the socio-political environment and "cultural dimensions of how people live their lives and manage risk" (Steenbergen et al., 2021). Several drivers are suggested to influence the spread of co-management initiatives, for example, their perceived relative advantage (Mascia and Mills, 2018, Lewis-Brown et al., 2021), availability of extension support (Mascia and Mills, 2018), and donor push and politics (Lund et al., 2017). However, there is still little empirical work comparing their relative importance within different contexts. Adoption of co-management programmes is also non-linear (Abernethy et al., 2014) and a co-management programme, which generally involves multiple dimensions (e.g. decision-making process, changes in behaviour, technology) will change to suit the context (e.g. the socio-political environment and culture; (Steenbergen et al., 2021). Thus, what spreads is not the same fisheries co-management package but instead behaviour change that reflects collective action principles or a local vision for what sustainable human-environment dependencies should look like. The actions and interventions to achieve this are thus determined by some combination of implementing communities, stakeholders and partner (government or non-government) agencies, and what is feasibly possible in local context. Critically, the expansion of adoption does not equate impact, as co-management initiatives can be rapidly abandoned with external disruptions and/or shifts leading to reprioritising of local interests on-the ground, and/or ineffective implementation and enforcement. Effective expansion programmes therefore cannot rely solely on direct interventions or their diffusion between communities, but also need to understand their embeddedness in the broader arena and engage with all aspects of governance to set the enabling conditions for substantial, lasting change (SPC, 2021; Steenbergen et al., 2021; Mahajan et al., 2021).

6. Part 4: Managing for impact

6.1. Impact

Impact is defined as the intended or unintended consequences that are directly or indirectly caused by an intervention, over and above the counterfactual of no intervention or a different intervention (e.g., fisheries co-management; Ferraro and Hanauer, 2014; Ferraro and Pressey, 2015, Ferraro et al., 2015). Thus defined, achieving positive impact is the ultimate aim of any intervention. Fisheries co-management can only achieve impact by changing patterns of human behaviour. Therefore, logic dictates that the extent to which it alters human activity will be directly correlated to the scale of impact it can achieve (Smallhorn-West and Pressey, 2022). This means that if management is implemented in a way that is residual, that is with little or no overlap with extractive activities, then impact will also be negligible. This can manifest in two ways. First, implementing management might not actually reduce net pressures across a system, but only displace them from one location to another, with low corresponding impact (Daw et al., 2011b). In these instances, impact can be overestimated because the difference between managed and un-managed locations are simply a product of shifting pressure across the system, rather than any net reduction. Second, implementing management in locations that already have low overlap with human pressures also results in minimal impact, since until patterns of behaviour have changed, no impact has been achieved (Pressey et al., 2017; Pressey et al. 2021). In these instances, the only chance of management making a difference is by its potential effects on future human actions. Yet this is problematic in three ways: first, it lets business as usual continue in locations with the greatest need; second, it passes the responsibility of changing behaviour on to future generations that bear no responsibility for the present or future situations; and, third, there is always the possibility that future management practices could change, such as degazettement if resources become more appealing at a future date (Mascia and Pailler, 2011).

While residual management can appear politically expedient since it minimises conflict, it also creates substantial risk by undermining the goals of co-management. This is not to say that conflict should actively be sought out, but instead that this framing of potential management solutions is critical to enable honest and accountable evaluations of potential and existing projects. For example, it is now well established that protected areas, both on land and in the oceans, have been systematically configured at a global scale to have almost no overlap with resource extraction, thereby raising doubt as to the ultimate use of these tools for conservation (Cockerell et al., 2020; Devillers et al., 2015; Joppa and Pfaff, 2009, 2011). While these concepts might appear to suggest no correct courses of action, of note is that some preliminary research indicates that if the correct incentives are in place, then the issue of residual management can be partially avoided by using participatory and bottom-up approaches (Smallhorn-West et al., 2020a). Further, shifting the terminology and framing of co-management to avoid perverse targets (e.g., outputs – size of co-managed areas, or number of communities involved), instead focusing directly on impact (i.e., the differences an action makes) will also enable much more clear and accountable conversations to unfold.

6.2. The triple bottom-line

Natural resource management, including fisheries co-management, requires constant decisions about how to allocate limited financial, human, social, and political resources. As such trade-offs are inevitable. The triple bottom line is a business concept based on the need to comprehensively measure impact and success beyond profits, that is the financial "bottom line", which historically has led to considerable shortcuts in equity and sustainability (Anderson et al., 2015; Halpern et al., 2013). A triple bottom line framework acknowledges that successful strategies are those that are strong across three components, the planet (i.e., sustainability), people (i.e., social impacts), and profit (i.e., economic considerations). This framework can be used both during implementation and evaluation to ensure that decisions are made in ways which balance, or at least set minimum targets, across these three domains of success. It posits that a successful fisheries innovation (e.g., co-management) involves securing the status of the resource, ensuring the rights of those involved in the sector (i.e., across the value chain) are secure, and the financial structure and stability of the system is secure. Fundamental to this notion is that a successful strategy cannot exist in which one of these factors is neglected.

The triple bottom line framework emphasises how neglect to one dimension of the framework can lead to exacerbation of issues in other dimensions. For instance, investments that strengthen access to markets and value chain improvements should not be pursued without also ensuring the sustainability of the resource and social well-being of those involved. In the first instance, failing to sustain the fishery in the presence of increased market demand will lead to over-exploitation of resources. In the second, prioritising profits without considering well-being can lead to elite-capture and increased marginalisation of vulnerable groups. For example, sustainable fisheries labelling that provides premium prices to sellers should not be implemented unless full monitoring has been undertaken to evaluate sustainability status. The consequence of not doing so is a 'race to the bottom', as fishers have secured access to price premiums without sustainability measures put in place. Likewise, prioritising resource sustainability at the expense of social well-being and economic realities can also lead to problems. In the first instance, the conservation sector is replete with examples where people have been displaced from protected areas, thereby leading to considerable human rights violations (Chapin, 2004; Newing and Perram, 2019). In the second, lost income from livelihood displacement by similar approaches has also been prolific.

6.3. Monitoring and evaluation

Prior to implementing actions or policies, managers should seek to use strategies that are likely to make the greatest possible difference to desired objectives for a given cost (Ferraro and Pattanayak, 2006). Yet understanding the efficacy of interventions is difficult, and requires

knowledge of whether, and how, changes occur. Monitoring and evaluation are therefore key conditions to understanding how fisheries co-management unfolds. Yet fisheries co-management is an extraordinarily complex innovation, occurring within complex social-ecological systems, with many factors influencing observed conditions (O'Garra et al., 2023). Hence, failure to link observed changes to interventions, for example, through faulty assumptions, can lead to dangerous inefficiencies and potential exacerbation of existing problems. For instance, in contexts where the status of a fishery is under-exploited, implementing co-management could be deemed successful since fish stocks are maintained. However, in this instance one must ask whether the status of the fishery is a result of co-management *per se*, or simply the stability of the resource to begin with, in which case it would have remained stable even without intervention.

Specifically, inputs (e.g., costs), outputs (e.g., number or extent of management), and outcomes (e.g., changes within a system) are often easiest to quantify and are thus the most used proxies to evaluate fisheries co-management. While the implicit assumption is that these metrics correlate with impact, this is often incorrect, promoting inefficiencies and misleading actions (Devillers et al., 2015). Impact evaluation remains nascent in its application to natural resource management, and lags well behind its application in other fields with similar missions, such as medicine and education (Sutherland et al., 2004; Pressey et al., 2017). In-depth monitoring and evaluation programmes can indeed be expensive, but this is not necessarily a given. Much research remains on identifying efficient, cost-effective, and simple methods to understand impact.

While monitoring studies vary in the rigour with which they determine impact (and therefore their reliability), formal impact evaluations involve counterfactual analysis, which supports causal inference by asking: *what would have happened in the absence of the intervention* (Pressey et al., 2015, 2017; Adams et al., 2019). Counterfactual analysis involves identifying how much observed conditions are due to the intervention, and how much to confounding factors that can mask intervention failure or exaggerate success (Adams et al., 2019). For example, a randomised controlled trial of a pay-to-release programme for endangered sharks and rays in Indonesian SSF found that conventional monitoring of live releases implied clear success, whereas the experimental counterfactual revealed that the payments also induced some vessels to increase their catch, leaving the true impact far smaller for wedgefish and negative for hammerhead sharks (Booth et al., 2025). Of note is a subtle difference between this framing and the use 'controls', as in 'control-intervention' (CI), and 'before-after-control-intervention' (BACI) studies. These experimental designs are only able to quantify impact if the 'control' groups accurately depict what the 'intervention' areas would have looked like if the intervention had not occurred, which in practice is rarely justified (Smallhorn-West et al., 2020b). Importantly, counterfactual analysis can be both quantitative and qualitative, and does not always require substantial investment or advanced technical skill, or the use of controls. This is useful in circumstances where it would be unethical to utilise controls, such as when external actors harvest data from communities to which no additional support is provided. In these instances, quantitative approaches such as statistical matching and modelling could be used to assess impact while utilising a phased approach, whereby community interventions are staggered through time. Alternatively, developing qualitative theories of change that map out presumed causal links between actions and consequences, and feedback loops, is useful as a cost-effective starting point (Ferraro and Pressey, 2015; Margoluis et al., 2013; Pressey et al., 2017). These can then be turned into expert-elicited predictions, which can then be scrutinised and refined, subjected to sensitivity analysis, and used to explore various interactions between pressures, rather than relying on implicit models within managers' heads Pressey et al., 2015, 2017; Gurney et al., (2015). In practice, these low-cost approaches can build on fisher-collected or existing catch data rather than bespoke monitoring, and a regional synthesis from the South Pacific illustrates both the value and the current limits of the resulting evidence (Smallhorn-West et al., 2022).

6.4. Connecting implementation to impact

The objectives for which fisheries co-management is expected to deliver benefits are diverse: for people's health and livelihoods, cultural practices, perceptions of justice and equity, and the conservation of biodiversity (Jupiter et al., 2014; Smallhorn-West et al., 2022). Yet it should not be assumed that all SSF co-management strategies will achieve all objectives equally, or even that evidence for progressing various objectives will be equal. Further, some objectives will be contingent on others being reached first, so that, like an electric circuit, there will be a series of links (i.e., individual connections) and pathways (i.e., the series of connections across multiple links) that must occur for certain objectives to be reached. For example, management implementation, constituting a formal change in patterns of behaviour and resource use, can lead directly to changes in both access rights (i.e., who is fishing), as well as the status of the resource (i.e., how much fish). More indirect objectives include those such as changes in catch, livelihoods, consumption, and nutrition, which are all largely (although not exclusively) contingent on changes in the status of the resource and how it is accessed. It might therefore be unrealistic to expect fisheries co-management to improve livelihood or health outcomes unless a series of links are substantiated prior. First, the status of the resource must change, which must then lead to improved yields, followed by changes in either economic benefits, consumption, or both.

Understanding the efficacy of fisheries co-management is strongly tied to understanding the strength of evidence for these various links and pathways. For example, a review of 52 studies from the South Pacific demonstrated that evidence for no-take reserves and periodic closures improving the status of resources is generally strong, but that there is far less support for any co-management strategies improving patterns of catch and livelihoods, and almost none for patterns of consumption and nutrition (Smallhorn-West et al., 2022). It is also increasingly difficult to evaluate impacts further along the theory of change, since increasing distance leads to the introduction of many more confounding factors. For example, changes in patterns of food and nutrition security in fishing communities involved in co-management could be due to management interventions or could be due to changes in the availability of imported foods. Ultimately, we suggest that both communities and external actors need to enter into co-management agreements carefully, understanding that it is not a panacea for all problems, and understanding that 'leaps of logic' are likely to lead to poor outcomes, inefficiencies, and unrealistic expectations.

7. Conclusion

Although fisheries co-management is becoming increasingly recognised as the most effective form of governance for SSF, gaps remain in our current understanding of what factors help drive progress towards ultimate long-term impact. Across the four thematic areas, a consistent message emerges. Outcomes depend less on any single concept than on the alignment among a programme's ethical foundations, ecological strategy, social structures, and the way impact is defined and evaluated, and on how the recurring tensions between equity and efficiency, local fit and scalability, and resource preservation and access, are navigated. Bridging the gap between emerging research and its practical application is hence a necessary and important step. In conjunction it is hoped that both the Fisheries Co-Management Guidebook (Smallhorn-West et al., 2023a) and this article can be used to address these knowledge gaps. For governance and policy, the implication is that expanding fisheries co-management is worthwhile only where the conditions for positive impact are also in place, since spreading weakly implemented co-management interventions risks harm at scale. The evidence base, however, is uneven. Ecological recovery in no-take and periodically harvested areas is comparatively well supported across fisheries co-management interventions, whereas effects on catch, livelihoods, and nutrition remain less well evidenced, and counterfactual impact evaluation and behavioural approaches in data-limited settings are still emerging. Closing these gaps, and testing how the concepts interact in specific contexts, are priorities for future research.

Subsequent efforts should be directed towards sharing the information from this article and the associated Fisheries Co-Management Guidebook (Smallhorn-West et al., 2023a) to fishers and co-management partners. Workshops and trainings can play a crucial role in facilitating knowledge dissemination, two-way learning, and skill-building. Finally, it is essential to continue to develop collaborative networks among stakeholders including government agencies, NGOs, academia, and local communities in order to build a network of support to ensure a sustained effort of this knowledge sharing. Taken together, the concepts synthesised here offer a common structure for diagnosing where, and why, co-management succeeds or fails, and a forward agenda for turning its continued spread into genuine impact.

CRediT authorship contribution statement

Patrick Smallhorn-West: Writing – review & editing, Writing – original draft, Conceptualization. **William N.S. Arlidge:** Writing – review & editing. **Rene A. Abesamis:** Writing – review & editing, Conceptualization. **Delvene Boso:** Writing – review & editing. **Joshua Cinner:** Writing – review & editing. **Philippa J. Cohen:** Writing – review & editing, Conceptualization. **Nicholas Ford-Learner:** Writing – review & editing, Conceptualization. **Stefan Gelcich:** Writing – review & editing. **Hugo B. Harrison:** Writing – review & editing. **Geoffrey P. Jones:** Writing – review & editing. **Stacy D. Jupiter:** Writing – review & editing. **Firoz Khan:** Writing – review & editing. **Jacqueline Lau:** Writing – review & editing. **Sarah Lawless:** Writing – review & editing. **Sangeeta Mangubhai:** Writing – review & editing. **David J. Mills:** Writing – review & editing. **Morena Mills:** Writing – review & editing. **Hoyt Peckham:** Writing – review & editing. **Sushil Raj:** Writing – review & editing. **Cristina Ruano-Chamorro:** Writing – review & editing, Conceptualization. **Alexander Tilley:** Writing – review & editing. **Jada Tullos:** Writing – review & editing. **Hadayet Ullah:** Writing – review & editing.

Declaration of competing interest

Authors declare no competing interest.

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Data availability

No data was used for the research described in the article.

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