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PERSPECTIVE

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# Co-management of culturally important species: A tool to promote biodiversity conservation and human well-being

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## Abstract

1. Co-management has been advocated as an effective tool to achieve natural resource conservation worldwide. Yet, the potential of co-management arrangements can fail to be realized when there is insufficient local engagement.
2. In this perspective paper, we argue that co-management schemes focusing on culturally important species (CIS) can help overcome this issue by engaging local people's interest.
3. To develop this theory, we explore published data on the outcomes of two management schemes, both encompassing multiple independent initiatives, to discuss CIS-management effects and benefits.
4. We also show a compilation of CIS examples throughout the world and discuss the potential of CIS-management to reach a global audience.
5. Based on these data, we argue that CIS-management can be an effective tool to reconcile the often intractable goals of biodiversity conservation and human welfare.

**KEYWORDS**

Amazon, *Arapaima* spp., collaborative management, cultural keystone species, culturally significant species, *Podocnemis* spp, resource use, traditional people

## 1 | INTRODUCTION

Collaborative management (co-management) of natural resources has become increasingly widespread worldwide, especially after the 1980s, when local people, conservationists, and researchers began searching for alternatives to the often unsuccessful top-down management schemes prevalent at the time (Berkes, 2009; Jentoft, 1989; Pomeroy & Berkes, 1997). Co-management implies a participatory decision-making process in which the regulation of natural resource use is shared between the users and other stakeholders, such as the national or subnational government, NGOs and local cooperatives (Berkes, Mahon, & McConney, 2001). In cases where local people are exerting continuous direct influences on species and their habitats, such locally inclusive management approaches tend to be more effective and successful for natural resource conservation than non-participatory systems (Cinner et al., 2012; Gutiérrez, Hilborn, & Defeo, 2011; McClanahan, Marnane, Cinner, & Kiene, 2006).

Despite its widely acclaimed potential, co-management arrangements can also fail (Béné et al., 2009; Jentoft, McCay, & Wilson, 1998; Terborgh & Peres, 2017), often due to lack of local community involvement (Jentoft, 2000) or frail official institutional support (Terborgh & Peres, 2017). When official enforcement is absent or ineffective, local engagement may be the only way to ensure an effective vigilance system to enforce compliance by outsiders (Cinner et al., 2012). Poor enforcement is ubiquitous

in developing countries, typically because of underfunding, understaffing, or low political priorities with conservation goals (Berkes et al., 2001; Campos-Silva, Fonseca Junior, & Silva Peres, 2015). Yet, tropical developing countries host most global biodiversity hotspots (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000), and most of the world's rural poor, who depend directly on natural resources for subsistence and to support local economies (Fisher & Christopher, 2007). Therefore, natural resource conservation based on local engagement is both ecologically appealing, and critical to maintain food security and social stability in developing countries (Adams, 2004; Adenle, Stevens, & Bridgewater, 2015).

Achieving local engagement in a co-management scheme can be challenging, as several factors may influence local interest and commitment (see e.g. Mistry et al., 2016; Ruiz-Mallén, Schunko, Corbera, Rös, & Reyes-García, 2015; Seixas & Davy, 2008). Yet, successful cases of self-organization are normally associated with users being strongly attached to the resources in focus, which either support a substantial portion of local livelihoods or have a high value assigned to its sustainability (Measham & Lumbasi, 2013; Ostrom, 2009). Otherwise, the costs of local engagement may not be worth the effort (Ostrom, 2009). In this paper, we argue that placing culturally important species as the focus of management schemes is a powerful mechanism to engage local communities with conservation initiatives.

Culturally important species are those highly significant for local people, with prominent functional roles in their diet, materials, medicine, cultural identity and/or spiritual values (Cristancho & Vining, 2004; Garibaldi & Turner, 2004). The concept of 'cultural keystone species' (CKS) was proposed to refer to these species as an analogy to the ecological concept of 'keystone species' (sensu Paine, 1969; Power et al., 1996). As such, CKS corresponds to species crucial to the survival of a people's culture, without which the society they support would be completely different (Cristancho & Vining, 2004; Garibaldi & Turner, 2004). Here we use the more comprehensive term 'culturally important species' (CIS) considering that some species may play an overriding role in people's culture yet are not necessarily irreplaceable and indispensable to the culture's survival. Nevertheless, the local extinction or decline of CIS will always be critical to local peoples, likely affecting not only their subsistence and/or spirituality, but also the transmission of Traditional Ecological Knowledge (TEK; Berkes, 2008) and the continuity of traditional practices related to the species.

Considering the huge impact CIS may have on local peoples' lives, it has been argued that these species should be taken into account by management and conservation monitoring approaches in order to ensure local people's long-term access to them (Cristancho & Vining, 2004; Noble et al., 2016). Furthermore, local people should have the inherent right to participate in the decision-making in managing these species, which have played fundamental socio-cultural roles for generations (Butler, Tawake, Skewes, Tawake, & McGrath, 2012; Garibaldi, 2009; Noble et al., 2016). Beyond the relevant issues of social justice, studies have also highlighted the potentially positive ecological consequences of CIS-management (Cristancho & Vining, 2004; Garibaldi, 2009; Garibaldi & Turner, 2004; Noble et al., 2016). These authors built their assumptions on multiple arguments, based mainly on the following ideas: (a) if local people identify strongly with a certain species, they will have a strong desire to preserve or restore such species, which favours conservation success (Garibaldi, 2009; Garibaldi & Turner, 2004); (b) focusing on CIS is a way to simultaneously address ecological and cultural concerns, and having a focal set of species may be financially and logistically more manageable (Garibaldi, 2009; Garibaldi & Turner, 2004); (c) the decline of a CIS may negatively affect local stakeholders who are effectively caring for local natural resources, which may consequently affect the stability of the ecosystem (Cristancho & Vining, 2004); (d) CIS are often vital species to the ecosystem where they occur, thereby their conservation should be beneficial for both local people and the environment (Noble et al., 2016); and (e) the population recovery of CIS and their habitats will support the reclamation of the habitat for associated species (Garibaldi, 2009).

Despite expectations about the positive outcomes potentially generated by CIS-management, studies that actually show real-world results are scarce. Moreover, the use of quantitative data to support the beneficial outcomes of using CIS-management approaches is highly limited. This limitation is problematic as policy-makers and managers often need quantitative data to support their decisions, particularly those related to species' management. Here we attempt to fill this knowledge gap by compiling quantitative data on the ecological, social, and economic outcomes of two co-management schemes focused on CIS, with the support of multiple independent initiatives. The data is literature-based, derived mostly from ecological studies. Even though both schemes are focused on CIS, these studies normally fail to address the impact of the species' cultural importance to the success of the initiatives. Success is generally attributed to the engagement of local people, but the triggers promoting such successful engagement are rarely mentioned.

By assembling arguments from CIS studies and results from the two case studies, we discuss how focusing on CIS in management schemes is a way to motivate local people interest and involvement. A consequence of local engagement will be positive conservation outcomes, even in cases where institutional resource governance is severely limited, as in most developing countries. Finally, we provide a compilation of CIS examples from around the world to discuss the potential of CIS-management to be established across a wide range of geographic contexts.

## 2 | MATERIALS AND METHODS

We analysed two prominent co-management schemes established in the freshwater ecosystems of the Brazilian Amazon. The Amazon is responsible for Brazil being one of the five countries that together contain more than 70% of the world's wilderness (Watson et al., 2018). At the same time, thousands of rural communities live in the

Amazon and rely directly on natural resources for their survival. Such a scenario makes it imperative to develop strategies seeking to reconcile biodiversity conservation with the maintenance of local people's culture and livelihoods. We chose two examples of currently CIS management strategies, which have several independent initiatives spread over a large geographic scale (Figure 1). The first one refers to the arapaima (*Arapaima* spp.; Figure 2) fisheries management, and the second to the conservation of freshwater turtles (*Podocnemis* spp.; Figure 3) through the protection of fluvial sand beaches. We explore both schemes to discuss their main outcomes and limitations. The data used comes from the literature and from personal direct observations in the field by the authors.

In addition to the two case studies, we present a compilation of CIS examples from other parts of the world in order to illustrate the wide range of species that are highly relevant to local societies worldwide. Providing a full compilation of CIS examples from all

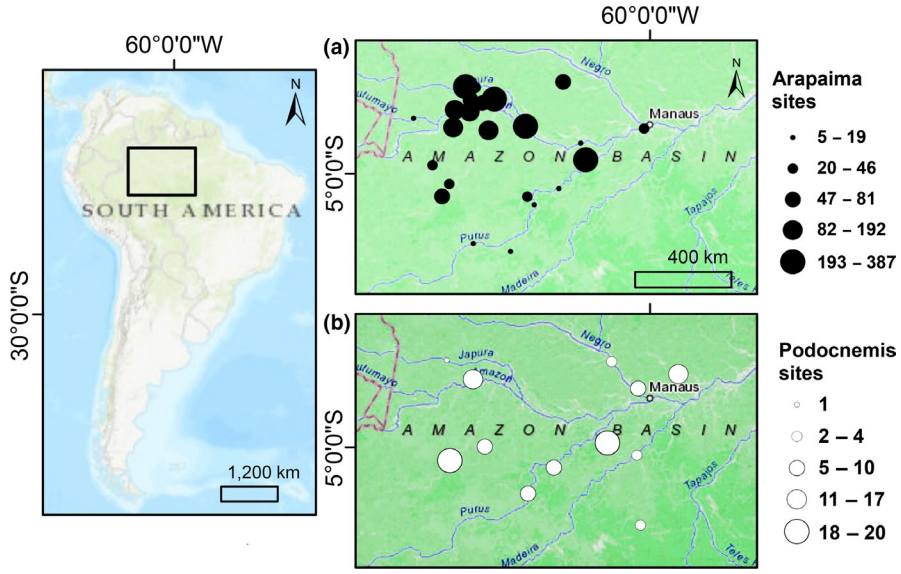


**FIGURE 1** Geographic distribution of co-management schemes for two culturally important genus (*Arapaima* spp. and *Podocnemis* spp.) within the State of Amazonas, in the Brazilian Amazon. Left: map of South America indicating the large geographic region (black rectangle) where both co-management schemes are currently established. Right: distribution of (a) *Arapaima* spp. (black circles) and (b) *Podocnemis* spp. (white circles) co-management schemes within the black rectangle. Circle sizes are proportional to the number of co-management areas (water bodies/beaches) within each location. Data on the location of arapaima co-management water bodies were obtained from the Brazilian Environmental Agency (IBAMA), while the location of protected beaches focusing on *Podocnemis* spp. conservation was obtained from a governmental official bulletin (Amazonas Official Diary, N° 33604, 14th September 2017)


**FIGURE 2** Photos of *Arapaima* spp. (a) An arapaima individual in an aquarium (Photo: Pedro Peloso); (b) Fishermen hauling arapaima into the boat during nocturnal fishing in the Juruá River basin (Photo: Carolina Freitas); (c) Fisherman weighing an arapaima individual in the Purus River basin (Photo: Carolina Freitas). Note: According to ethical standards, all persons shown here authorized the use of their photographs

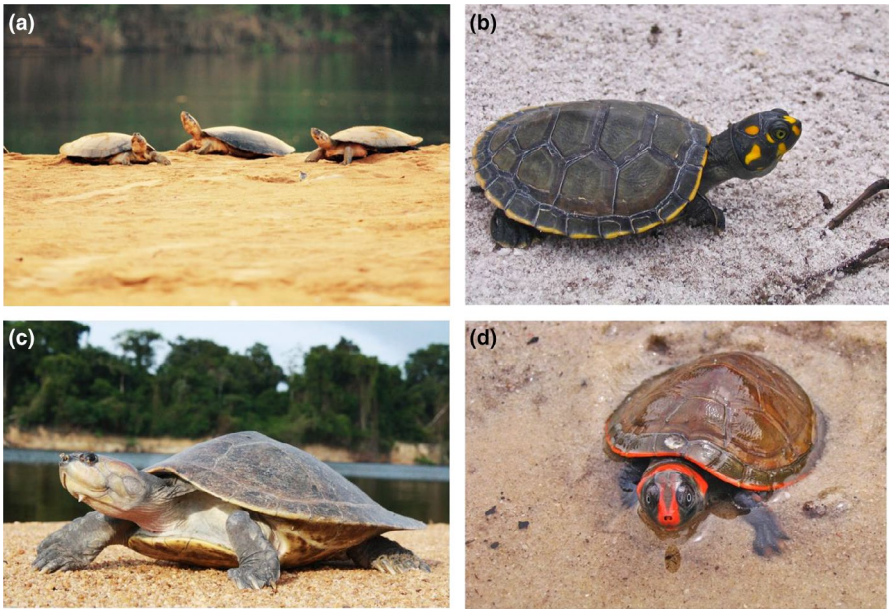


**FIGURE 3** Photos of *Podocnemis* spp. (a) *P. expansa* (Photo: Camila Ferrara); (b) *P. unifilis* (Photo: Camila Ferrara); (c) *P. sextuberculata* (Photo: Fernanda Rodrigues); and (d) *P. erythrocephala* (Photo: Camila Ferrara)

over the globe is beyond the scope of this paper. Instead, we present a limited list of examples based on an online search in the Web of Science database using the search terms '*cultural keystone species' OR 'culturally important species' OR 'culturally significant species' OR 'tabooed species' OR 'cultural taboo'* (all in English). We also used snowballing techniques, by including citations found within the search publications. Our compilation was restricted to animal species only. The examples were gathered in a table with information on (a) the common and scientific names of the species, (b) its general taxonomic group, (c) its geographic location, (d) the culture that has identified the species as a CIS, (e) the species' local uses and values, and (f) the references citing each example. The information used to fill the table came from studies found in our search and consequently do not necessarily correspond to all data available to each species in other possible sources.

## 3 | CASE STUDIES

### 3.1 | Arapaima co-management

Arapaima is one of the largest freshwater fish on Earth, and an iconic element of the Amazon (locally known as *pirarucu* in Portuguese, or *paiche* in Spanish; Figure 2). *Arapaima* spp. inhabit lakes and water channels during the dry season and migrate laterally to flooded forests when the water levels rise (Castello, 2008). The individuals are mainly fished during the dry season, when they are concentrated in the discrete water bodies. Arapaima plays a central role in the livelihood and cultural identity of many Amazonian peoples since pre-Columbian times, being an important source of animal protein (Bates, 1863; Prestes-Carneiro, Béarez, Bailon, Rapp Py-Daniel, & Neves, 2016; Veríssimo, 1895), local medicine (Alves & Rosa, 2007), and a key element in sociocultural practices and local cosmologies (Aparicio, 2014; Murrieta, 1998, 2001).

During the 19th and early 20th century, arapaima was the most important commercial fishery resource in the Brazilian Amazon (Mérona, 1993; Veríssimo, 1895), which led to its overfishing in many areas (Castello, Arantes, Mcgrath, Stewart, & Sousa, 2014). The expansion of commercial fisheries across the Amazon River and its major tributaries from the 1960s onwards, driven by increased fishing technologies, further aggravated the situation of arapaima stocks, as well as other species (McGrath, de Castro, Futemma, de Amaral, & Calabria, 1993). Facing such excessive fishing pressure and its negative consequences, some riverine communities started grassroots movements seeking to take control of local water bodies and implement local agreements to regulate fishing activities (De Castro, 2002; De Castro & McGrath, 2003; McGrath, Cardoso, Almeida, & Pezzuti, 2008; McGrath et al., 1993). These so-called *fishing agreements*, starting in the 1980s, came to be legally accepted by the Brazilian government in the late 1990s, representing an innovative formal instrument of collaborative fisheries management (De Castro & McGrath, 2003; McGrath et al., 2008). This process created the basis for the subsequent establishment of other fisheries co-management models in the Amazon, such as the arapaima co-management.

Arapaima co-management started as an alternative to reconcile the recovery of arapaima stocks with its sustainable harvest, since arapaima fisheries had been banned by local legislation in the 1990s but illegal fishing continued in the absence of adequate enforcement (Castello & Stewart, 2010; Cavole, Arantes, & Castello, 2015). The first arapaima co-management initiative was undertaken in the early 2000s, in the Mamirauá Sustainable Development Reserve (Solimões River basin), and showed promising results (Castello, Viana, Watkins, Pinedo-Vasquez, & Luzadis, 2009). After the proven success of this experience, the scheme was accepted by the Brazilian Environmental Agency (IBAMA) as a model to be replicated in other areas, which opened the possibility of legal arapaima fishing under specific conditions (Amazonas Normative Instruction N°1, 1st June

2005). The model is based on a quota system set according to the arapaima abundance within the management areas (Castello et al., 2009). The abundance is annually estimated by local people through direct visual counts; this is possible because arapaima is an obligate air-breather coming to surface every ~15 min, which enables fishers to count the number of individuals in the lakes and water channels based on TEK and following a standardized protocol (Castello, 2004). IBAMA is in charge of setting the next-year quota for each community, which is allocated as a one-off annual harvest, normally lasting from a few days to one month. In order to award IBAMA's approval to start an arapaima co-management system, the community must design a management plan, which includes the zoning of the water bodies (including no-take lakes) and the establishment of a local vigilance system to preclude illegal fishing (Castello et al., 2009; Amazonas Decree N° 36083, 23rd July 2015).

Arapaima co-management plans have proliferated throughout the Amazon over the last years, currently encompassing >3,000 fishing households from >450 rural communities (IBAMA, personal communication). Studies have highlighted the positive ecological and socioeconomic impacts of the activity. For instance, the number of arapaima adults increased up to 24-fold after 8 years of arapaima co-management in the Solimões River basin (Castello et al., 2009); up to 29-fold after six years of co-management in the Purus River basin (Petersen, Brum, & Rossoni, 2016); and up to 30-fold after 11 years of co-management in the Juruá River basin (Campos-Silva & Peres, 2016). In all cases, arapaima declined or remained stable at low densities in neighbouring water bodies not included in the co-management scheme (Campos-Silva & Peres, 2016; Castello et al., 2009; Petersen et al., 2016). Models testing the effect of several environmental and social predictors on the arapaima abundance, showed that the presence of the co-management scheme was the strongest one, accounting for over 70% of the observed variation in arapaima numbers (Campos-Silva & Peres, 2016). Importantly, other aquatic species also benefit from increased abundance with the protection of the water bodies, such as the high-value *tambaqui* fish (*Colossoma macropomum*; Arantes & Freitas, 2016; Silvano, Ramires, & Zuanon, 2009), freshwater turtles (*Podocnemis* spp.; Miorando, Rebêlo, Pignati, & Brito Pezzuti, 2013), and caimans (*Melanosuchus niger*; Projeto Médio Jurua, unpublished data).

Arapaima co-management also brings socio-economic benefits to the rural communities. All arapaima harvested are sold by the local people through a simplified value chain, which results in a significant extra income. After 10 years of arapaima management in the Solimões River basin, the per capita income from arapaima sales increased five-fold (Amaral, 2009). In the Juruá basin, co-managed lakes ensure an average annual revenue of nearly US$ 10,600 per community and US$ 1,050 per household (Campos-Silva & Peres, 2016), which corresponds to about four times the Brazilian minimum wage. Such extra income is highly relevant to local people, who have a largely subsistence lifestyle with limited cash-earning opportunities, often earning less than the minimum wage per month. Furthermore, revenues from arapaima sales are received as an annual windfall, which enables investments that local participants could not make otherwise, including improvements in fisheries enforcement and in communal assets, such as local schools, medical care, and power generators for household and community lighting (CTF and JVCS, personal observation). In addition to the economic outcomes and its indirect social benefits, interviews with self-declared former illegal arapaima fishers showed that most of them (75%) highlighted that arapaima co-management helps strengthen cultural values, and many (68%) declared that local people's pride and self-esteem increased due to the success they achieved in restoring arapaima populations (Campos-Silva & Peres, 2016). Some interviewees (28%) also mentioned the more equitable income distribution as another important outcome, since arapaima fisheries are now a collective enterprise rather than having the benefits concentrated in only a few experienced fishermen (Campos-Silva & Peres, 2016).

### 3.2 | Freshwater turtle conservation through fluvial sand beach protection

The genus *Podocnemis* includes four extant species of freshwater turtles in the Brazilian Amazon, all of them commonly used by local people: The giant South American turtle (females locally known as *tartaruga* and males as *capitarí*; *Podocnemis expansa*; Figure 3a), the yellow-spotted river turtle (*tracajá/zé prego*; *P. unifilis*; Figure 3b), the six-tubercled river turtle (*iaçá/pitiú*; *P. sextuberculata*; Figure 3c), and the red-headed river turtle (*irapuca*; *P. erythrocephala*; Figure 3d). These four species occur in rivers, lakes and floodplain forests, and use fluvial beaches to nest (IUCN, 2018; Smith, 1979).

*Podocnemis* spp. play a central role in the livelihood and cultural identity of many Amazonian peoples since pre-Columbian times (Bates, 1863; Carvajal, 1894; Prestes-Carneiro et al., 2016; Silva-Coutinho, 1868; Veríssimo, 1895). Local people value both adults and eggs for multiple purposes, especially as food delicacy and medicinal resource, in addition to being a highly important item in social practices and celebrations (Alho, 1985; Alves & Rosa, 2007; Alves et al., 2012; Johns, 1987; Pezzuti, Lima, Silva, & Begossi, 2010; Rebêlo & Pezzuti, 2000; Smith, 1974). *Podocnemis* spp. are also greatly valued by riverine peoples as a special food item to diversify their otherwise monotonous fish-based diet (Murrieta, 1998).

During the 18th and 19th centuries, following the European colonization, millions of freshwater turtles were slaughtered yearly, and their eggs widely converted into oil for cooking and urban lightning (Smith, 1979). This scenario led to a sharp decline in turtle populations. In the 1960s, a national law was established in Brazil banning the hunting and commercialization of wild animals (Brazilian Fauna Protection Law, N° 5,197, & 3rd January, 1967), which consequently discontinued legal trade of turtles. However, high levels of illegal harvesting continued in the absence of adequate enforcement (Fachín-Terán, Vogt, & Thorbjarnarson, 2004; Kemenes & Pezzuti, 2007; Peñaloza, Hernández, & Espín, 2013). The situation was aggravated by the construction of highways and large hydroelectric dams directly impacting the nesting beaches (Alho, 2011; Norris, Michalski, & Gibbs, 2018a; Smith, 1979). Faced with the

depletion of *Podocnemis* spp. stocks, local communities started on-the-ground conservation initiatives, focused on protecting turtle nesting beaches (Andrade, 2007). These initiatives were eventually supported by government institutions, NGOs and/or researchers, and proliferated throughout the Amazon (Andrade, 2007; Cantarelli, Malvasio, & Verdade, 2014).

The management scheme is based on the establishment of protected beaches whereby local beach guards are in charge of surveillance, and nest monitoring (IBAMA, 2016). Each protected beach is constantly surveyed, day and night, by one to three guards, to avoid poaching of adults and eggs during all the nesting period (dry season; ~5 months per year). In some places beach guards work on a voluntary basis, while in others they are financially supported by the local government and receive a monthly payment during the nesting period. The payment is delivered either in cash (amount equivalent to the Brazilian minimum wage, ~US$ 250/month) or, more commonly, as a food hamper (equivalent to less than half a minimum wage; ~US$ 110/month; Campos-Silva, Hawes, Andrade, & Peres, 2018).

Studies have highlighted positive impacts of turtle management schemes. For instance, comparisons between areas with and without the scheme, showed that in the Lower Amazon the managed areas had ten-fold more *P. sextuberculata*, and accounted for 91% of the total individuals caught in the entire study area (Miorando et al., 2013). In the Juruá basin, managed areas had 58 times more *P. expansa*, six times more *P. unifilis*, and three times more *P. sextuberculata* (Campos-Silva et al., 2018); moreover, 99% of all *P. expansa* nests recorded on unprotected beaches were raided by poachers compared to only 2.1% on adjacent protected beaches (Campos-Silva et al., 2018). Studies tested the effect of several environmental and social variables on turtle abundance, and community-based beach protection was the strongest one for both *P. sextuberculata* (Miorando et al., 2013) and *P. expansa* (Campos-Silva et al., 2018). Data accumulated through the *Podocnemis expansa* Conservation Program across nine states of the Brazilian Amazon showed that protected beaches produced at least 46 million hatchlings in 30 years, and resulted in *P. expansa* population recovery in most areas (Cantarelli et al., 2014). Furthermore, a study focusing on *P. unifilis* showed that two years of government enforcement patrols had no effect on nest illegal harvesting, whereas one year of co-management in the same area resulted in almost three-fold reduction of harvest levels (Norris, Michalski, & Gibbs, 2018b). In addition to *Podocnemis* spp., protected beaches benefit species from several other groups, such as beach-nesting birds, large catfishes, terrestrial invertebrates, river dolphins, caimans and green iguanas (Campos-Silva et al., 2018). The magnitude of differences in the abundance varies across species, with some being overwhelmingly more abundant on protected beaches (e.g. 83-fold for black skimmers, *Rynchops niger*; Campos-Silva et al., 2018).

In contrast to the arapaima co-management, the turtle management scheme does not represent a cash-earning opportunity for the community and cannot become financially self-sufficient over time, due to the legal impediment to the harvest and trade of turtles and their eggs in Brazil (Brazilian Fauna Protection Law, N° 5197, 3rd January 1967; Brazilian Environmental Crimes Law, N° 9605, 12th February 1998). The material benefits, if any, are restricted to the beach guards' nominal payment only, and are negligible considering the high workload the activity demands and the risks involved (Campos-Silva et al., 2018; Pezzuti et al., 2018). Indeed, beach guards are exposed to frequent threats of violence from poachers, including death threats (CTF and JVCS personal observation). The absence of tangible financial return is frequently mentioned by beach guards as one of the main concerns for the long-term sustainability of the activity (Campos-Silva et al., 2018). They also complain about the lack of appreciation of their role by government authorities and the wider society, who fail to adequately recognize the considerable time and effort they invest in the conservation scheme, and the personal risks they incur from confronting recalcitrant poachers (Campos-Silva et al., 2018). Another often expressed concern is the insufficient support from government agencies, both in terms of financial assistance—e.g. investment on basic equipment or on fuel for patrols—and official enforcement—e.g. application of formal sanctions to identified poachers (Campos-Silva et al., 2018; Pezzuti et al., 2018; CTF and JVCS personal observation). At the same time, however, beach guards often highlight the strengthening of local cultural values as a great positive outcome from the turtle conservation scheme (Campos-Silva et al., 2018). Furthermore, communities where protected beaches emerge are seen as privileged areas, and residents feel proud of the increasingly abundant turtle population (Pezzuti et al., 2018).

## 4 | CIS THROUGHOUT THE WORLD

The initiatives focusing on *Arapaima* spp. and *Podocnemis* spp. show important similarities and differences (Table 1) that have direct implications to their ecological, social, and economic outcomes (see Section 5). Despite particular bottlenecks, both case studies can be considered successful examples of CIS-management. Inspired on those experiences, other initiatives of CIS-management could be reproduced across multiple contexts. Each culture has its own CIS and often these have a strong effect on the ecosystem they inhabit, which make them especially relevant to management and conservation purposes (Close, Fitzpatrick, & Li, 2002; Noble et al., 2016). To illustrate the potential of CIS-management to span a wide geographic scale, we show a compilation of CIS examples in Table 2. Although this list is nowise exhaustive, it gives a sense of the comprehensive range of CIS existing worldwide, encompassing several taxonomic groups and environments, as well as different uses and values for various peoples.

## 5 | DISCUSSION

Even though the initiatives focusing on *Arapaima* spp. and *Podocnemis* spp. are naturally restricted to the Amazon, they bring relevant insights into wildlife management and conservation, applicable to multiple contexts throughout the world. Hereafter, we discuss some of the key learnings from our study and propose a general framework regarding CIS-management schemes.

**TABLE 1** Similarities and differences between *Arapaima* spp. fisheries co-management, and *Podocnemis* spp. conservation through the protection of fluvial beaches

| | ***Arapaima* spp. co-management**  | ***Podocnemis* spp. co-management**  |
|---|---|---|
| *Target species* | | |
| Cultural importance | High | High |
| Historical commercial overpressure | High | High |
| Current illegal harvest pressure | High | High |
| *Co-management features* | | |
| Rules focusing on habitat protection | Yes | Yes |
| Surveillance/enforcement | Local | Local |
| Participants' engagement | High | High |
| Community involvement | Strong | Moderate[a] |
| Main stimuli to local engagement | Economic and cultural | Cultural and moral/ethic |
| Personal risk to participants | High | High |
| Societal recognition and outreach | High | Low |
| Possibility of financial self-sustainability | Yes | No |
| Legal permission to trade the target species | Yes[b] | No |
| *Benefits from the management scheme* | | |
| Increased abundance of the target species | Yes | Yes |
| Increased abundance of non-target species | Yes | Yes |
| Ecological benefits for the ecosystem | Yes | Yes |
| Contribution to food security | Yes | Yes |
| Strengthening of cultural values | Yes | Yes |
| Strengthening of local pride and self-esteem | Yes | Yes |
| Income generation | Yes | No[c] |
| Income distribution within the community | Yes | No |

*Note:* Illustrations: Karla Koehler.

[a]Community involvement on turtle co-management (beach protection) varies across different locations. In many cases, however, only one to three beach guards are in charge of the management rather than the whole community.

[b]Trade of wild arapaima is allowed only under co-management schemes approved by the Brazilian Environmental Agency (IBAMA), who is in charge of setting annual quotas to each management unit according to the local arapaima abundance.

[c]In some locations beach guards receive a monthly payment during the turtle nesting period. This payment may be delivered either in cash or as a food hamper, and needs to come from external sources (e.g. local government or NGOs). The activity itself does not generate income due to Brazilian legal restrictions.

**TABLE 2** Examples of Culturally Important Species (CIS) throughout the world[a]

| CIS general group | CIS common and scientific names | People[b] | Country/Nation[b] | Local values and uses mentioned[b,c] (listed in alphabetical order) | References[b] |
|---|---|---|---|---|---|
| Bird | Cassowary (*Casuarius casuarius johnsonii*) | Djiru (Mission Beach) | Australia | Food, identity | Hill et al. (2010) |
| | | Karam (Kaironk Valley) | Papua New Guinea | Oral tradition, symbolic value | Bulmer (1967) |
| | Glaucous-winged gull (*Larus glaucescens*) | Huna Tlingit (Southeastern Alaska) | USA | Food (eggs), identity, social practices, spirituality | Hunn, Johnson, Russell, and Thornton (2003) |
| | Kereru [New Zealand pigeon] (*Hemiphaga novaeseelandiae*) | Tuawhenua | New Zealand | Celebrations, food, spirituality, symbolic value | Timoti, Lyver, Matamua, Jones, and Tahi (2017) |
| | Muttonbird [Sooty shearwaters] (*Puffinus griseus*) | Rakiura | New Zealand | Celebrations, ceremonies, food, economy, social practices, spirituality, symbolic value | Mccarthy et al. (2014); Moller, Kitson, and Downs (2009); Moller, O'Blyver, et al. (2009) |
| | Ostrich (*Struthio camelus*) | Ikoma [some Abhaghetigha clans] (Serengeti District) | Tanzania | Sacred species, symbolic value | Kideghesho (2008) |
| | Vulture (*Gyps* spp.) | Parsee | India | Legends, practical utility (cleaning the environments and disposing human bodies), symbolic value | Markandya et al. (2008) |
| | White Stork (*Ciconia ciconia*) | Polish rural people | Poland | Beliefs, folklore, pest regulator in agriculture, symbolic value | Kronenberg, Andersson, and Tryjanowski (2017) |
| Crustacean | Crayfish (*Jasus edwardsii*) | Kaikōura | New Zealand | Food, identity, symbolic value | Mccarthy et al. (2014) |
| | Crayfish [Freshwater crayfish] (*Astacoides* spp.) | Betsileo and Tanala (Fianarantsoa Province) | Madagascar | Economy, food, social practices | Jones, Andriahajaina, Ranambinintsoa, Hockley, & Ravoahangimalala, (2006) |
| | Crayfish [Freshwater crayfish] (*Cambarus* spp. and *Astacus* spp.) | Cherokee, Chitimachas, Houmas, Choctaw, Attakapas | USA | Food, legends | Irwin (2014); Noble et al. (2016) |
| | Crayfish [Freshwater crayfish] (*Paranephrops planifrons* and *P. zealandicus*) | Māori | New Zealand | Food | Kusabs and Quin (2009); Noble et al. (2016) |
| | Crayfish [Murray crayfish] (*Euastacus armatus*) | Aboriginal peoples of the Murray-Darling River basin | Australia | Food | Humphries (2007); Noble et al. (2016) |
| | Marron (*Cherax tenuimanus* and *C. cainii*) | Aboriginal peoples of the Murray-Darling River basin | Australia | Food | Noble et al. (2016) |
| | Yabby (*Cherax destructor*) | Aboriginal peoples of the Murray-Darling River basin | Australia | Food | Humphries (2007); Noble et al. (2016) |

(Continues)

**TABLE 2** (Continued)

| CIS general group | CIS common and scientific names | People[b] | Country/Nation[b] | Local values and uses mentioned[b,c] (listed in alphabetical order) | References[b] |
|---|---|---|---|---|---|
| Fish | Eel [American eel] (*Anguilla rostrata*) | Mi'kmaq | Canada | Ceremonies, food, legends, medicine, social practices, spirituality, symbolic value | Davis, Prosper, Wagner, and Paulette (2004); Mainland Nova Scotia Mi'kmaq (2011); Prosper and Paulette (2002); SRSF (2002) |
| | Eel [New Zealand freshwater eel] (*Anguilla dieffenbachia*, *A. australis* and *A. reinhardtii*) | Māori | New Zealand | Food, legends | McDowall (2011); Noble et al. (2016) |
| | Eel [Short-finned eel] (*Anguilla australis*) | Māori | New Zealand | Food, legends | Dolamore, Puddick, and Wood (2016); Mccarthy et al. (2014) |
| | | Aboriginal peoples of Southwest Victoria | Australia | Ceremonies, economy, food, social practices, symbolic value | Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation (2004); Noble et al. (2016) |
| | Herring [Pacific herring] (*Clupea pallasii*) | Heiltsuk (British Columbia) | Canada | Ceremonies, economy, food, social practices | Gauvreau (2015) |
| | | Haida (Queen Charlotte Islands, British Columbia) | Canada | Bait for fishery, food, economy, oil source | Jones (2007) |
| | | Alaska natives | USA | Celebrations, food | Moss (2015) |
| | Kahawai [Australian salmon] (*Arripis trutta*) | Te Whānau-a-Hikarukutai/ Ngāti Horomoana people | New Zealand | Celebrations, ceremonies, food, identity, narratives, social practices, spirituality, symbolic value | Maxwell, Horomoana, Arnold, and Dunn (2018) |
| | Lamprey [Pacific lamprey] (*Lampetra tridentata* and *Entosphenus tridentatus*) | Indigenous people of the Columbia River Plateau (e.g. Nez Perce, Umatilla, Warm Springs and Yakama) | USA | Ceremonies, celebrations, food, medicine, spirituality | Close et al. (2002); CRITFC (2011) |
| | Murray cod (*Maccullochella peelii*) | Aboriginal peoples of the Murray Darling River basin | Australia | Cosmology, economy, food, identity, symbolic value | Ginns (2012); Noble et al. (2016) |
| | Salmon [Atlantic salmon] (*Salmo salar*) | Mi'kmaq (Nova Scotia) | Canada | Celebrations, ceremonies, food, social practices, spirituality | Denny and Fanning (2016) |
| | Salmon [Pacific salmon] (*Oncorhynchus* spp.) | Gitga'at and other coastal peoples of British Columbia | Canada | Economy, food, identity | Garibaldi and Turner (2004); Healey (2009) |
| | | Aboriginal peoples from Alaska, Canada, and the Pacific Northwest (300+ tribes) | USA Canada | Celebrations, ceremonies, food, economy, identity, spirituality | Bruce Johnsen (2009); Cozzetto et al. (2013); Dittmer (2013); Galbreath, Bisbee, Dompier, Kamphaus, and Newsome (2014); Garibaldi (2009); Haggan et al. (2004); Landeen and Pinkham (1999) |

(Continues)

**TABLE 2** (Continued)

| CIS general group | CIS common and scientific names | People[b] | Country/Nation[b] | Local values and uses mentioned[b,c] (listed in alphabetical order) | References[b] |
|---|---|---|---|---|---|
| Mammal | Beaver (*Castor canadensis*) | Dene, Cree, and Métis (Fort McCay, Alberta) | Canada | Ecosystem function, technology | Garibaldi (2009) |
| | Boar [Wild Boar] (*Sus scrofa taiwanus*) | Truku | Taiwan | Food, legends, social practices, spirituality, symbolic value | Simon (2013) |
| | Beluga (*Delphinapterus leucas*) | Qeqertarsuaq Inuits (Disco Island) | Greenland | Celebrations, Economy, food, identity, social practices | Sejersen (2001); Tejsner (2014) |
| | | Inuvialuit (Western Arctic Inuit) | Canada | Economy, food, social practices | Loseto et al. (2018); Tyson (2017) |
| | | Nunavik Inuit (Northern Quebec) | Canada | Cosmology, economy, food, social practices | Tyrrell (2008) |
| | Bush buck (*Tragelaphus scriptus*) | Ikoma and Natta (Serengeti District) | Tanzania | Sacred species, symbolic value | Kideghesho (2008) |
| | Caribou [Barren-ground caribou] (*Rangifer tarandus groenlandicus*) | Inuvialuit | Canada | Food, fur, social practices | Tyson (2017) |
| | Caribou [Woodland caribou] (*Rangifer tarandus*) | Gwich'in, Tlicho, Denesuline, and Inuit | Canada | Economy, food, identity, spirituality | Prowse, Furgal, Wrona, and Reist (2009) |
| | Collared Peccary (*Pecari tajacu*) | Mayan and mestizo peoples of the Lacandon Rainforest (Chiapas) | Mexico | Food, medicine, narratives | García del Valle et al. (2015) |
| | Cow (*Bos taurus indicus*) | Meena, Bhils, and Kathodi (Rajasthan) | India | Magical-spiritual use; sacred species | Kushwah, Sisodia, and Bhatnagar (2017) |
| | Deer [Common deer] (*Mazama gouazoubira*) | Chapada do Araparipe villagers (Ceará) | Brazil | Food, medicine, symbolic value | Bonifácio, Freire, and Schiavetti (2016) |
| | Deer [White-tailed deer] (*Odocoileus virginianus*) | Mayan and mestizo peoples of the Lacandon Rainforest (Chiapas) | Mexico | Food, medicine, narratives | García del Valle et al. (2015) |
| | Dugong (*Dugong dugon*) | Aboriginal peoples of the Hope Vale community (Cape York Peninsula) | Australia | Food, identity, social practices, symbolic value | Nursey-Bray (2009); Nursey-Bray, Marsh, and Ross (2010) |
| | | Torres Strait islanders | Australia | Celebrations, ceremonies, food, social practices | Butler et al. (2012); Delisle, Kiatkoski Kim, and Stoeckl (2018); Kwan, Marsh, and Delean (2006); Marsh, Grayson, Grech, Hagihara, and Sobtzick (2015) |
| | Elephant (*Loxodonta africana*) | Ikoma and Natta (Serengeti District) | Tanzania | Sacred species, symbolic value | Kideghesho (2008) |
| | Gorilla [Cross River gorilla] (*Gorilla gorilla diehli*) | Villagers around Bechati-Fossimondi-Besali forest (Lebialem Division) | Cameroon | Narratives, medicine, symbolic value (totem) | Etiendem, Hens, and Pereboom (2011) |

(Continues)

**TABLE 2** (Continued)

| CIS general group | CIS common and scientific names | People[b] | Country/Nation[b] | Local values and uses mentioned[b,c] (listed in alphabetical order) | References[b] |
|---|---|---|---|---|---|
| | Hyena [Spoted hyena] (*Crocuta crocuta*) | Ikoma and Natta [clans: Abhaghetigha and Abasaye] (Serengeti District) | Tanzania | Sacred species, symbolic value | Kideghesho (2008) |
| | Ibex (*Capra sibirica*) | Western Pamir | Tajikistan | Clothes, folklore, food, materials, symbolic value | Jackson and Jain (2006) |
| | Fin whale *(Balaenoptera physalus)* | Inuit | Greenland | Economy, food, social practices | Caulfield (1997) |
| | Leopard (*Panthera pardus*) | Natta [Abasaye clan] (Serengeti District) | Tanzania | Sacred species, symbolic value | Kideghesho (2008) |
| | Lion (*Panthera leo*) | Ikoma [some Abharanche clans] (Serengeti District) | Tanzania | Sacred species, symbolic value | Kideghesho (2008) |
| | Marco Polo sheep (*Ovis ammon polii*) | Kyrgyz (Eastern Pamir) | Tajikistan | Clothes, folklore, food, materials, symbolic value | Jackson and Jain (2006) |
| | Minke whale *(Balaenoptera acutorostrata)* | Inuit | Greenland | Economy, food, social practices | Caulfield (1997) |
| | Moose (*Alces alces*) | Dene, Cree, and Métis (Fort McCay, Alberta) | Canada | Food, technology | Garibaldi (2009) |
| | | Aboriginal peoples from Yukon | Canada | Economy, food, recreational value, spiritual value | Jung, Czetwertynski, and Schmiegelow (2018) |
| | Monkey [any species, or specifically tantalus monkey, mona monkey and/or Sclater's monkey, depending on the community] (*Chlorocebus tantalus, Cercopithecus mona, Cercopithecus sclateri*) | Igbo (Lagwa and Akpugoeze villages, in Imo and Enugu States) | Nigeria | Folklore, identity, narratives, sacred species, symbolic value | Baker, Tanimola, Olubode, and Garshelis (2009); Baker (2013) |
| | Monkey [mainly spider monkey and woolly monkey] (*Ateles paniscus, Lagothrix lagothricha*) | Matsigenka (Manu biosphere Reserve) | Peru | Beliefs, food, identity, narratives, social practices | Shepard (2002) |
| | Narwhal (*Monodon monoceros*) | Nunavut Inuits | Canada | Economy, food, social practices, source of ivory | Diduck et al. (2005) |
| | | Qeqertarsuaq Inuits (Disco Island) | Greenland | Economy, food, social practices | Tejsner (2014) |
| | Paca (*Cuniculus paca*) | Mayan and mestizo peoples of the Lacandon Rainforest (Chiapas) | Mexico | Food, medicine, narratives | García del Valle et al. (2015) |

(Continues)

**TABLE 2** (Continued)

| CIS general group | CIS common and scientific names | People[b] | Country/Nation[b] | Local values and uses mentioned[b,c] (listed in alphabetical order) | References[b] |
|---|---|---|---|---|---|
| | Polar bear (*Ursus maritimus*) | Inuit (Nunavut) | Canada | Cosmology, economy, food | Freeman and Wenzel (2006); Wenzel (2005) |
| | Tiger [Bengal tiger] (*Panthera tigris tigris*) | Meena, Bhils, and Kathodi (Rajasthan) | India | Magical-spiritual use; sacred species | Kushwah et al. (2017) |
| Mollusk | Abalone (*Haliotis* spp.) | Māori | New Zealand | Food, identity, medicine, social practices, spirituality, symbolic value | Mccarthy et al. (2014) |
| | | Gitga'at (British Columbia) | Canada | Food, identity | Garibaldi and Turner (2004) |
| | Cockle [Basket cockle] (*Clinocardium nuttallii*) | Gitga'at (British Columbia) | Canada | Food, identity | Garibaldi and Turner (2004) |
| | Cockle [Mangrove cockle] (*Anadara tuberculosa*) | Isla Costa Rica villagers (El Oro) | Ecuador | Economy, food | Beitl (2011) |
| | Cockle [New Zealand cockle] (*Austrovenus stutchburyi*) | Puketeraki and Ōtakou Marae | New Zealand | Food, identity, symbolic value | Mccarthy et al. (2014) |
| | Mussel [Green Lipped Mussel] (*Perna canaliculus*) | Māori | New Zealand | Economy, food, social practices | Paul-Burke, Burke, Bluett, and Senior (2018) |
| | Mussel [New Zealand freshwater mussel] (*Echyridella menziesi*) | Māori | New Zealand | Ceremonies, food, medicine, spirituality, tools | McDowall (2002); Noble et al. (2016) |
| | Oyster (*Crassostrea virginica*) | Chesapeake Bay coastal communities | USA | Economy, food | Paolisso and Dery (2010) |
| Reptile | Snake [Cobra, Green mamba, Python and/or Puffadder] (*Naja haje*, *Dendroaspis angusticeps*, *Python spp*, *Bitis arietans*) | Ikoma [clans: Wahikumari, Abharanche, Abhaghetigha, Abhamwancha and Abhahimurumbe] (Serengeti District) | Tanzania | Sacred species, symbolic value | Kideghesho (2008) |
| | Tortoise [Leopard tortoise] (*Geochelone pardalis*) | Natta [Abasaye clan] (Serengeti District) | Tanzania | Sacred species, symbolic value | Kideghesho (2008) |

(Continues)

**TABLE 2** (Continued)

| CIS general group | CIS common and scientific names | People[b] | Country/Nation[b] | Local values and uses mentioned[b,c] (listed in alphabetical order) | References[b] |
|---|---|---|---|---|---|
| | Turtle [Green turtle] (*Chelonia mydas*) | Torres Strait islanders | Australia | Celebrations, ceremonies, food, social practices | Butler et al. (2012); Delisle et al. (2018); Johannes and MacFarlane (1993) |
| | | Aboriginal peoples of the Hope Vale community (Cape York Peninsula) | Australia | Food, identity, social practices, symbolic value | Nursey-Bray (2009); Nursey-Bray et al. (2010) |
| | | Miskitu | Nicaragua | Economy, food, leather, oil, social practices | Lagueux (1998); Nietschmann (1974) |
| | | Bahía Magdalena villagers (Pacific side) | Mexico | Celebrations, food, medicine | Nichols, Bird, and Garcia (2000) |
| | | Seri (Sonoran coast and islands of the Gulf of California) | Mexico | Food, legends, symbolic value | Nabhan, Govan, Eckert, and Seminoff (1999) |
| | | Coastal and island villagers | Papua New Guinea | Celebrations, ceremonies, economy, food, legends, symbolic value, social practices, tools | Spring (1981,1979) |
| | Turtle [Hawksbill turtle] (*Eretmochelys imbricata*) | Solomon Islands villagers (Melanesia) | Solomon Islands | Food, economy | Hamilton et al. (2015) |
| | Turtle [Leatherback turtle] (*Dermochelys coriacea*) | Kei Island villagers (Maluku) | Indonesia | Food, social practices | Suarez and Starbird (1995) |
| | Turtle [Olive ridley turtle] (*Lepidochelys olivacea*) | Ostional villagers (Nicoya Peninsula) | Costa Rica | Aphrodisiac, food, local economy | Campbell (1998,2003) |
| | Turtle [Sea Turtles] (no specific species) | Wayuú (Guajira Peninsule) | Colombia and Venezuela | Ceremonies, food, legends, medicine, spiritual value, symbolic value | Barrios-garrido (2018a, 2018b) |
| | | Caroline Islands villagers | Micronesia | Ceremonies, food, social practices, symbolic value | McCoy (1995) |
| | | Dangme and Fante (Ada Peninsula and Winneba) | Ghana | Legends, sacred species | Alexander, Agyekumhene, and Allman (2017) |

*Note:* Species are listed in alphabetical order of their general taxonomic group (bird, crustacean, fish, mammal, mollusk, reptile) and then of their common name.

[a]This table does not provide a comprehensive compilation of CIS examples from around the world, but a list of examples found in our search (see Methods section) in order to illustrate the wide range of species that are highly relevant to different peoples worldwide.

[b]The information about each species came from the studies found in our search (see Methods section) and do not necessarily correspond to all data available to the species (ie. to its whole geographic distribution, to all the cultures linked to the species, to all local uses and values, or to all references about the species and its cultural importance).

[c]All species included in this table were clearly mentioned to be highly culturally important to local people. The number of uses/values listed in the table does not necessarily correspond to the degree of the species' cultural importance.

[Correction added on 13 May 2020, after first online publication: the information on 'Bush buck' has been moved to the 'Mammal' section within the table in this version.]

## 5.1 | Key learnings

### 5.1.1 | Learning from similarities between the case studies

The strong connection local people have with a species tends to promote a deep cultural incentive to seek the recovery of its population to sustainable levels, which stimulates communal engagement and continued on-the-ground enforcement of conservation practices related to the species. The two case studies addressed here are real examples of that, and in both cases local engagement was so effective that it has become the strongest predictor of *Arapaima* spp. and *Podocnemis* spp. abundance across multiple contexts (Campos-Silva et al., 2018; Campos-Silva & Peres, 2016; Miorando et al., 2013). Indeed, if local people are thoroughly engaged in a certain initiative, there is better potential for full-time physical presence and effective local surveillance, as they are residents in the target areas (Jentoft et al., 1998; Ostrom, 2007; Pomeroy, Katon, & Harkes, 2001). Even though kinship ties may represent a barrier for local sanctions (Crawford, Siahainenia, Rotinsulu, & Sukmara, 2004), peer pressure and moral obligation are often stronger determinants of people's behaviour than formal rules, especially in places where official surveillance is low or non-existent (Crawford et al., 2004; Kaplan, 1998; Sutinen & Kuperan, 1999).

Despite having a CIS in focus, CIS-management schemes are not supposed to concentrate on benefiting the target species only. Instead, the initiatives should be based on rules that embrace the ecosystem scale and ensure direct benefits to various co-occurring non-target taxa. This is exactly the case in both *Arapaima* spp. and *Podocnemis* spp. management schemes (Table 1) – whereas the former is grounded on the zoning of the water bodies, including no-take lakes, the latter is centered on the protection of the entire fluvial beach. Therefore, these management initiatives could be considered examples of Ecosystem-Based Management (EBM; Pikitch, 2004). Similar management schemes, focusing on CIS but grounded on procedures aimed at protecting the entire ecosystem, would be strongly advised to other contexts as well. The focus on CIS may be a trigger to spark local people's motivation and real engagement in EBM schemes.

The establishment of a spatial zoning based on a source-sink model is also strongly advised for CIS-management initiatives, since it enables the species to recover in no-take areas and spill-over to other areas (Campos-Silva, Peres, Antunes, Valsecchi, & Pezzuti, 2017; Di Lorenzo, Claudet, & Guidetti, 2016; Stobart et al., 2009), as it happens in the *Arapaima* spp. and *Podocnemis* spp. managements. It is also important to design monitoring strategies aiming at verifying population trends over time. Quantitative studies are especially advantageous in this case, as they enable following up on the changes in an objective way, comparable at both temporal and spatial scales, and may also be useful to avoid misinterpretations of the stocks condition due to the 'shifting baseline syndrome' (sensu Pauly, 1995). Yet, community-based monitoring should be prioritized, as local people are an essential part of the scheme, and ought to be empowered and recognized as protagonists, and duly rewarded for their efforts.

### 5.1.2 | Learning from differences between the case studies

Income generation viability may be a relevant factor to ensure the long-term sustainability of any management initiative (Pomeroy et al., 2001). Some people might be interested in a certain initiative due to cultural or moral motivation only, and be willing to sacrifice income or incur personal costs to carry out a moral duty (Sutinen & Kuperan, 1999). This is the case of the turtle management scheme, for example, in which community ethics and emotional connection with *Podocnemis* spp. are the main motivations for local engagement (Pezzuti et al., 2018; Table 1). Nevertheless, motivations can change over time. Indeed, many beach guards anticipate that social and market pressures might have a negative effect on beach guards' long-term engagement with beach protection, or on their replacement by future generations (Campos-Silva et al., 2018). If a beach guard gives up or has no successor, all the conservation gains made over the years can be quickly lost. In contrast, in the arapaima co-management, sales of sustainably harvested fish bring direct economic benefits for many families in the community, which entails compliance and long-term engagement among the entire fishing village, and encourages community-led surveillance and widespread peer pressure. Finding ways of generating income from any CIS-management may enhance communal involvement and long-term commitment with the scheme, reduce poaching, and make the activity less vulnerable to oscillations in political interests and external support.

Yet, the striking financial contrast between our two case studies is consequence of an intrinsic difference between them: while national legislation prevent turtle harvesting in Brazil, specific legal norms allow regulated arapaima trade (e.g. Acre Normative Instruction N° 01, 30th May 2008; Amazonas Normative Instruction N° 1, 1st June 2005; Rondônia Normative Instruction N° 2, 13th May 2019). Even though delayed sexual maturity may impose higher vulnerability to the exploitation of turtle's juveniles and adults (Thorbjarnarson, Lagueuz, Bolze, Klemens, & Meylan, 2000), a recent study focusing on *P. unifilis* showed that increasing first-year survival could generate rapid population increases and even compensate for population losses due to adult harvesting (if adult female harvest remains <25%; Norris, Peres, Michalski, & Gibbs, 2019). Studies have also shown that the sustainable harvest of turtle eggs can represent a viable management alternative (Alho, 1985; Campbell, 1998; Caputo, Canestrelli, & Boitani, 2005; Escalona & Fa, 1998; Pezzuti & Vogt, 1999), especially in places where a high proportion of nests is normally lost for natural causes, as in many Amazonian fluvial beaches (Caputo et al., 2005; Pezzuti & Vogt, 1999). Scholars have advocated that arrangements enabling regulated turtle harvest may be the most effective way to ensure the long-term conservation of *Podocnemis* spp. in the Amazon, considering the current scenario of deficient enforcement associated with high levels of illegal harvest (Alho, 1985; Campos-Silva et al., 2017, 2018; Pezzuti et al., 2019; Pezzuti & Vogt, 1999). Similar to the Amazonian turtle case, other CIS-managements worldwide can find analogous obstacles, and efforts may be needed to overcome them.

The role of education and outreach is another important aspect to be considered in any CIS-management initiative. A striking difference between our two case studies reinforce this point. While arapaima co-management has been acclaimed by the media, the government and NGOs, and there is a widely built perception that the scheme is fruitful for the community and relevant to conservation (CTF and JVCS personal observation), beach protection is a neglected initiative with little public profile throughout the region, despite its long history and great importance (Pezzuti et al., 2018; Table 2). Such lack of societal appreciation, together with the poor financial viability of the initiative, might lead to its future failure, as anticipated by many beach guards (Campos-Silva et al., 2018). We advocate that CIS-management initiatives worldwide should consider the relevance of formal recognition as a way to stimulate local engagement and peer pressure, since it reinforces the wide collective perception that the scheme is beneficial and therefore morally and ethically defensible (Crawford et al., 2004).

## 5.2 | CIS-management and its applicability to multiple contexts worldwide

The extensive variety of CIS existing worldwide, partially demonstrated on Table 2, awakens us to the possibility of motivating the establishment of CIS-management initiatives across various contexts. Yet, when designing a CIS-management proposal it is indispensable to analyse the singularities of each reality. The cultural importance of a species is always context-dependent, and a certain species that is highly important to one group may not be to another, even if both groups are in contact with the same species (Garibaldi & Turner, 2004). The relevance and uses of a species may also change over time, as cultures are dynamic and adaptive (Cristancho & Vining, 2004). Furthermore, each ecosystem will function in a particular way (and also change over time), and rules or strategies operating in one place may not be suitable to another, even if the target species are the same. Developping CIS-management proposals in close partnership with local people is therefore crucial to ensure that the proposed scheme is culturally, socially and ecologically relevant and approriate, in addition to being flexible to changes. However, it is important to evaluate the impact that the target CIS may have on the natural ecosystem functioning, avoiding efforts to support eventual non-native species that have become a CIS (Nuñez & Simberloff, 2005).

The general steps and feed processes expected to be found in any CIS-management initiative are outlined as a flow chart in Figure 4. The process illustrated in this figure can be briefly described as following: an ecosystem-based co-management scheme with a focus on CIS will likely arouse local people interest on the initiative, stimulating their engagement (Figure 4). Such engagement will likely result in local compliance and surveillance, and consequently bring dividends to ecosystem conservation and species recovery. Species recovery will likely generate direct and indirect ecological, cultural, social, and economic benefits, which may reinforce local people interest in the initiative, resulting in further reinforcing feedback to the system (Figure 4).

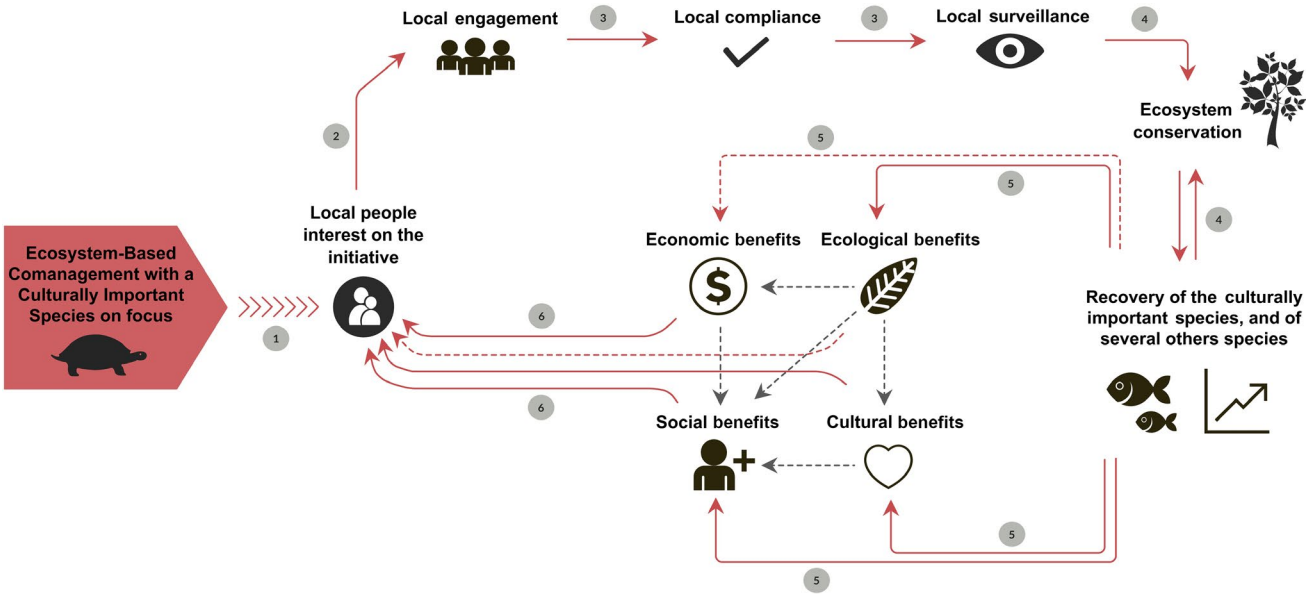


**FIGURE 4** Flow chart representing steps and feed processes expected to be found in any conservation initiative focusing on Culturally Important Species (CIS). Continuous lines indicate processes very likely to happen, while dashed lines indicate processes that may happen depending on the context. In general, the flow chart shows that (1) ecosystem-based co-management schemes focusing on a CIS will likely arouse local people interest on the initiative; (2) once local people are interested, they will be keen to get engaged on it, which will likely result in (3) local compliance and surveillance, and consequently bring dividends to (4) ecosystem conservation and species recovery. Species recovery will likely (5) bring direct and indirect ecological, cultural, social, and economic benefits, which will (6) reinforce local people interest in the initiative, resulting in further reinforcing feedback to the system [Colour figure can be viewed at wileyonlinelibrary.com]

As such, management schemes focusing on CIS may trigger positive socio-ecological consequences at multiple scales in many different contexts throughout the world. The positive impact of CIS-management may be especially meaningful in developing countries, where not only official enforcement tends to be weak or non-existent (Berkes et al., 2001; Campos-Silva et al., 2015), but also corruption tends to be high (Transparency International, 2018). The common mismanagement of public finances and/or bribery of officials, frequently happening in these countries, further aggravates difficulties in implementing effective enforcement schemes (Agnew et al., 2009; Smith, Muir, Walpole, Balmford, & Leader-Williams, 2003). Therefore, triggering local people interest and consequent engagement on conservation initiatives may often be the best solution for ensuring the perpetuation of local natural resources.

## 6 | CONCLUSIONS

The cultural importance of any given species should be regarded as a highly relevant aspect in conservation strategies designed for areas where natural resource use is critical to local livelihoods. Given that local people have the most to gain from CIS population recovery, management initiatives focusing on those species have a strong potential to stimulate local people interest, and their consequent engagement, compliance and enforcement. Such local, full-time surveillance is potentially much more effective than official mechanisms of institutional enforcement, which are typically deficient and deployed sporadically, especially in countries with low governance levels. Importantly, the proposed focus on CIS does not mean that the management initiatives should be designed to benefit the target species only. We advocate management schemes with rules embracing the ecosystem scale and ensuring that many other species, and the environment as a whole, will also benefit from the conservation initiative. The focus on CIS may be a trigger to spark local people's motivation and real engagement in the conservation scheme. As such, the scheme will likely achieve a wide range of positive ecological, social, cultural and economic outcomes. Therefore, we claim that CIS-management can be an effective socio-ecological tool to reconcile biodiversity conservation with local people quality of life, keeping with the Sustainable Development Goals set out by the United Nations to guide developing policies (United Nations, 2015).

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### CONFLICT OF INTEREST

The authors declare no conflict of interest.

### AUTHORS' CONTRIBUTIONS

C.T.F. conceived the central idea, did the literature review, and drafted the manuscript; P.F.M.L., J.V.C.S., M.M.N., R.B. and C.A.P. gave critical suggestions for its content and design, and revised it critically; M.M.N. did the maps. All authors gave final approval for publication.

### DATA AVAILABILITY STATEMENT

This manuscript is literature-based. Therefore, the data used have already been published elsewhere. The source for each data is mentioned in the respective citation, and the citation is fully stated in the References section.

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