Towards Biocultural Approaches to Peatland Conservation: The Case for Fish and Livelihoods in Indonesia

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ABSTRACT

Conservation projects are likely to fail if plans to preserve important wildlife habitats and species are not co-developed between conservation organisations and local communities to reflect the needs and diverse values of the latter. Tropical peatland conservation represents a case in point: local community livelihoods have only recently come into focus, particularly within academic literature. Instead, many previous studies emphasise the need to conserve intact peat swamp forests for their carbon storage, as a habitat for flagship species such as the orangutan, and to provide fire-free landscapes. Here, we explore the socio-environmental issues being faced in the peatland landscapes of Central Kalimantan, Indonesia. This includes the loss of peat-swamp forest, decreases in peatland fish populations and related socio-cultural challenges such as potential loss of fishing livelihoods along with historic and continued experiences of marginalisation of indigenous communities. To find solutions to these complex and interrelated problems, an interdisciplinary approach which focuses on interdependencies and includes multiple worldviews is required. We propose an approach which deploys both Ethan Miller's use of livelihoods (incl. Miller, 2019) and biocultural approaches to conservation to analyse human-nonhuman relationships, with a focus on fish and fishing livelihoods. We draw on data from in-depth social and ecological research in two village communities in Central Kalimantan, and in so doing illustrate how fish conservation has the potential to support important biocultural and livelihood relationships between human and nonhuman communities in peatland areas. Our findings lend support to previous calls for biocultural approaches to conservation in other socio-ecological contexts, and lead us to conclude that tropical peatland conservation initiatives that integrate such approaches will result in improved outcomes for peatlands, forests, biodiversity and people. These findings will be relevant to other tropical peatland areas with high dependence on fishing as a source of livelihood, such as the peatlands of the Amazon and Congo basins.

Key words: tropical peat, orangutan, fishing, Central Kalimantan

1. Introduction

As both one of the main drivers of change, and agents with considerable ecological knowledge, local communities are at the heart of finding solutions to environmental problems. Informal institutions within these communities, customary beliefs and traditional knowledge systems therefore have important implications for biodiversity conservation (Gadgil *et al.*, 1993; Colding and Folke, 2001, Wadley and Colfer, 2004; Berkes, 2007; Luo *et al.*, 2009; Parotta, 2012; Yuliani *et al.*, 2018). Along with the global loss in biodiversity (IPBES, 2019), we are also seeing a loss of the distinctive cultural knowledge systems that are intertwined with and have long supported biodiversity (Cocks, 2006; Stephenson *et al.*, 2014). This directly impacts the resilience of 'socio-ecological systems', which are dependent on the simultaneous health of both cultural and biological systems (Crane, 2010; Sterk *et al.*, 2017; Calvet-Mir *et al.*, 2015; Inaotombi and Mahanta, 2018). In many tropical countries, rural situations are also changing rapidly, with livelihood strategies becoming more integrated into a cash-based economy with often negative environmental consequences (Cocks, 2006; Dahlquist *et al.*, 2007; Mbaiwa and Stronza, 2010; Fisher *et al.*, 2018; Mardiyaningsih *et al.*, 2018). Here we take the example of tropical peatlands in Indonesia where the loss of peat swamp forest (PSF) is occurring at a rapid rate, along with the loss of related PSF fish populations. This negatively impacts communities dependent on fish as a main source of livelihood (the use of this term is defined in section 5). Concurrently, socio-environmental relationships are undergoing rapid changes in these environments, which have local and global consequences, as we now introduce in further detail.

2. Loss of peat swamp forests and fish species in SE Asia

The biophysical properties and resulting ecology of peatlands make these habitats globally distinctive and important. In PSF the accumulation and low decomposition rates of organic materials (i.e. leaf litter, woody debris) due to high water levels which inhibit microbial decomposition, lead to slow accumulation of peat, with surrounding waters being highly acidic, having low levels of oxygen and being deep brown in colour (so-called 'blackwaters') (Page *et al.*, 2011). These forests are host to unique floristic and faunal diversity and in Indonesia are home to the largest proportion of the remaining critically endangered Bornean orangutan population (*Pongo pygmaeus*: Wich *et al.*, 2008; Posa *et al.*, 2011; Husson *et al.*, 2018). Tropical peatlands also play a substantial role in the global carbon cycle, storing an estimated 105 Gt of carbon (Page *et al.*, 2011; Dargie *et al.*, 2017), equating to about 16% of all peat carbon and 5.5% of the global soil carbon pool (IPCC, 2013).

Despite their importance, tropical peatlands in Indonesia are undergoing rapid anthropogenic change. This is due to the expansion of plantation and smallholder agriculture, the persistence of fire in degraded peatland landscapes (along with the continued use of fire for a variety of reasons including smallholder agriculture: see Cattau *et al.*, 2016; Goldstein *et al.*, 2020), rapid urbanisation and population growth and the wider impacts of climate change. A total 1.8 Mha of PSF was lost in Borneo, Sumatra and Peninsular Malaysia from 2007 to 2015; equivalent to an annual deforestation rate of 4.1% (Miettinen *et al.*, 2017). This loss is expected to continue with over half of the remaining PSF projected to disappear over the next three decades (Wijedasa *et al.*, 2018). This has globally significant climate consequences, with 132-159 Mt of carbon emitted per year due to peatland loss and degradation in the Southeast Asian region, of which 90% comes from Indonesia (Hooijer *et al.*, 2006; Miettinen *et al.*, 2017).

Due to the unique characteristics of PSF, the rivers and waters of these forests are important fish habitats containing various endemic stenotopic species (Ng *et al.*, 1994; Noor *et al.*, 2005). PSF fish, in common with fish found in other wetland ecosystems throughout Indonesia and many other tropical regions, are also an important source of protein for human communities. In Central Kalimantan, fish have been identified as the main source of animal protein for local communities (Saman and Limin, 1999), but more recently there are indications that peatland fish populations are facing increasing pressures from overexploitation and unsustainable fishing practices, as well as water pollution and habitat loss (loss of PSF) (Thornton, 2017; Lees *et al.*, 2020). Giam *et al.* (2012) extrapolated that if PSF loss continues, 77% of fish species are likely to become extinct in Sundaland, with Central Kalimantan being most severely impacted. This will have significant consequences for the communities dependent on fish as a main source of protein and income.

3. Lack of peatland fish research

Regardless of the local importance of fish, there is a paucity of freshwater fish research and conservation work across SE Asia (Posa *et al.*, 2011; Chua *et al.*, 2019). This lack of focus is in part because freshwater fish are not particularly charismatic (Costa and Barletta, 2016), despite these taxa comprising the most threatened group of vertebrates worldwide (Duncan and Lockwood, 2001; Oremerod *et al.*, 2010; Reid *et al.*, 2013). Only 41.3% of Sundaic freshwater fish have had their threat status formally assessed (Chua *et al.*, 2019) and little is known about PSF fish species and their threat status (Posa *et al.*, 2011). Of the freshwater fish species which *have* been assessed as threatened across Borneo, Sumatra and Peninsular Malaysia, the most significant danger to their continued survival has been reported as PSF loss due to conversion and fire (Lees *et al.*, 2020). To our knowledge, there are no projects centred on freshwater fish conservation in Kalimantan, apart from local conservation efforts in West Kalimantan focusing on Arowana (*Scleropages formosus*) (see WWF, 2011), which is a prized species in the national and international aquarium trade. This lack of (peatland) fish research and conservation is in stark contrast to efforts focused on orangutans (*Pongo* spp.) in Indonesia, which draw international and national attention and are supported by a multitude of organisations, with millions of dollars spent every year on dedicated orangutan conservation efforts (e.g. Morgans *et al.*, 2019 state that an estimated US$20-30 million is spent by government and non-government organisations in efforts to conserve the Bornean orangutan). There is, therefore, an urgent need to assess the threat status of peatland fish and Sundaic freshwater fish more widely, and to incorporate these assessments into future conservation planning (Posa *et al.*, 2011; Thornton *et al.*, 2018; Chua *et al.*, 2019; Lees *et al.*, 2020).

The importance of peatland fish conservation, central to this paper, has relevance beyond Indonesia: in the peatlands of the Peruvian Amazon, fishing is also known to be important for local communities (Coomes *et al.*, 2004; Cotta, 2015). In the Congo Basin peatland area, local populations depend heavily on fishing as a protein source, while research on the PSF fish and their ecology in these areas is also recognised as lacking but necessary (Dargie *et al.*, 2019). The discussions of this paper are therefore relevant to tropical peatland areas on other continents where there is a high dependence on fishing.

4. Further socio-cultural challenges in Central Kalimantan

Alongside continued forest loss and the decreasing fish populations which are negatively impacting fishing communities, the indigenous Dayak (predominantly Dayak Ngaju) communities of Central Kalimantan are facing additional challenges. Dayaks[1] have historically experienced marginalisation, with one of the most prominent examples of this occurring under President Suharto's New Order (1966-1998), which was also a time of increased and rapid environmental exploitation and degradation (McCarthy, 2004; Smith, 2005). During these years, the transmigration scheme that was bringing people from Java, Madura and other over-populated areas of Indonesia to Central Kalimantan was at its peak. An ethnic division rapidly emerged: those with the 'social and economic capital' needed to open and operate timber concessions tended to be Javanese and ethnic Chinese elites (McCarthy, 2004). For most rural people across Central Kalimantan a centrally (Jakartan) controlled process of resource exploitation brought very few benefits, and instead left them dealing with the negative environmental consequences (McCarthy, 2004). The rapid influx of people into Kalimantan with little regard for *adat*[2] laws, along with changing land-use behaviours, resulted in the transmigration programme and spontaneous migration ultimately fuelling increased experiences of marginalisation, tension between ethnic groups, increased land pressures and poverty levels (O'Connor, 2004; McCarthy, 2004; Schreer, 2016). Deforestation and environmental degradation are thus interlinked with increasing social injustice (Großmann, 2018).

Additionally, indigenous Dayak religious beliefs in Central Kalimantan have undergone stigmatisation, and a "*pejorative notion of backwardness and inferiority*" remains attached to these and their adherents (Schreer, 2016:70). This has led to complex tensions and engagements between traditions, indigenous identities, and efforts to be recognised as 'modern' citizens (see Schreer, 2016 for a more nuanced and in-depth discussion of this). Many of the younger generation today look towards plantation work in an aspiration for 'modern' lifestyles (Schreer, 2016). Conservation efforts in Central Kalimantan (and beyond) also still face challenges of integrating different perspectives, values, and knowledges, from communities (including Dayak) to local government, within their projects (see Harrison *et al.*, 2020). It is vital, particularly for non-local conservation researchers and scholars, to be mindful of colonial histories and violences that continue today. There is also a need to properly incorporate different worldviews into conservation approaches without treating these as merely 'myths' or 'stories'. As Hunt (2014: 30) writes (and further supported by Watts, 2013 and Todd, 2015): "*the potential for Indigenous ontologies to unsettle dominant ontologies can be easily neutralized as a triviality, as a case study or a trinket, as powerful institutions work as self-legitimating systems that uphold broader dynamics of (neo)colonial power*". This is relevant when working to integrate various ways of knowing and dynamic values within approaches to conservation and research (see Hunt, 2014 and Todd, 2015).

5. Research approach: Elucidating socio-environmental entanglements through biocultural approaches to conservation and livelihoods

While socio-economic changes in Kalimantan may bring improved opportunities for some, they can also result in the loss of biodiversity, environmental knowledge, and livelihoods for

others (Schreer, 2016). The concept of biocultural diversity has been used to explore the link between biological and cultural diversity. Biocultural diversity is defined by Maffi (2007: 269) as "*the diversity of life in all its manifestations: biological, cultural, and linguistic – which are interrelated (and possibly coevolved) within a complex socio-ecological adaptive system*". This has been applied in the development of biocultural approaches to conservation, protection of biocultural rights and initiatives around biocultural heritage (Maffi, 2018; see also Maffi, 2004 and Pretty *et al.*, 2009 for more in-depth discussions on biocultural diversity). Biocultural approaches to conservation aim to improve conservation effectiveness by highlighting these linked issues of biological and cultural diversity loss. These approaches also draw on previous work from commons theory, social-ecological systems theory and various models of people-centred conservation such as co-management, integrated conservation and development, and community-based conservation (Gavin *et al.*, 2015; Shultis and Heffner, 2016; Gavin *et al.*, 2018). In a very similar vein to Maffi's definition of biocultural diversity, Gavin *et al.* (2015: 140) define biocultural approaches to conservation as "*conservation actions made in the service of sustaining the biophysical and sociocultural components of dynamic, interacting and interdependent social-ecological systems*". Gavin *et al.* (2018) propose biocultural approaches to conservation with the aim of re-focusing conservation on just, pluralistic and partnership-based conservation actions. In support of this, Stephenson *et al.* (2014) document examples from New Zealand and Canada where indigenous strategies and leadership in biocultural conservation have led to more effective marine conservation that supports cultural renewal alongside an improvement of biocultural diversity. The authors conclude that their case study shows that 're-connecting' social and ecological systems is possible and feasible through a biocultural approach to conservation. They also found that biocultural approaches to conservation provide one avenue for bridging the gap between non-local approaches to biodiversity conservation and local values of biodiversity (Stephenson *et al.*, 2014).

We therefore draw on biocultural approaches to conservation as part of our theoretical framework to explore socio-ecological links, i.e. the relationships between humans and nonhuman actors. Such an approach must also acknowledge the interconnectedness of ourselves with our wider ecosystems, requiring an inherent respect and incorporation of different worldviews and knowledge systems. With this in mind, we do not frame our analysis on the Ecosystem Service (ES) approach, which is widely critiqued owing to its alleged perpetuation of problematic nature-culture dualisms, its neoliberal approach to the environment, and anthropocentrism (e.g. Igoe and Brockington, 2007; Ehrenfeld, 2008; Büscher *et al.*, 2012; Sullivan, 2012; Martin *et al.*, 2013). We furthermore argue that, in contrast to Bridgewater and Rotherham (2019), 'biocultural' cannot be split between ecology on one hand, and culture on the other, for this merely perpetuates the nature-culture dichotomy. We argue that these categories (ecology and culture) need to be further integrated through a more thorough interdisciplinary approach, and that this can be achieved using an approach to livelihoods proposed by Miller (2019) as: "*a diversity of activities, a variety of skills and knowledges, a plethora of possible sites of action, and multiple configurations of ever-changing relations and processes that cannot be captured by a generality*" (p.153). This approach to livelihoods is useful as it places interdependence at its centre and provides a framework for analysis which involves humans and nonhumans as equal actors. It also highlights relational, emotional and spiritual dimensions of making a living. As culture is generated by human activity and includes collective and social modes of behaviour (Mironenko and Sorokin, 2018), livelihoods are integral to culture and vice versa. This provides the nexus of 'livelihoods', as used herein, and 'biocultural approaches to conservation'.

To further clarify our approach, we draw on a case study in the Sebangau area of Central Kalimantan, Indonesia. We explore relationships between fishers, fish, spirits and the peatland waters (the swamp and connecting rivers) in Sebangau. We structure our analysis around three different, but connected, human-nonhuman interactions, or 'acts' of fishing: 1. *catching* fish, 2. *eating* fish and 3. *selling* fish (Figure 1). We do not interpret these acts as indicative of instrumental values, but rather draw on them as opportunities to explore how they encompass more complex and multiple human-nonhuman relationships (Figure 1). These are etic 'acts' which have been chosen for their use in structuring our analysis and discussion. Analysing livelihood practices through these acts provides dual benefits: through exploring human-nonhuman relationships we avoid dichotomous approaches that separate biological diversity and cultural diversity, allowing us to explore perceptions, knowledges, practices and innovations relevant to each 'act', as integral to the biocultural approach to conservation. Through this analysis, we will illustrate how fish conservation has the potential to support important biocultural and livelihood relationships between human and nonhuman communities living around peatland areas. We also show how there has been a disconnect between (international) conservation priorities and local priorities: conservation has tended to focus on conservation of iconic species, namely the orangutan, in our study area, while it may be more effective to increase focus on more locally salient aspects of biodiversity, such as fish conservation (see also Chua *et al.*, 2020). As will become clear throughout this paper, our analysis of the acts of fishing and how these involve multiple relationships between humans and nonhumans problematises the idea of a 'human domain' of 'the economy' and 'society', as well as the nonhuman domain of 'the environment' (Miller, 2014a). This approach therefore also allows us to look beyond capitalist employment and monetary exchange as the only legitimate forms of sustenance (Miller, 2014b), which is particularly relevant to subsistence fishing and other common forms of sustenance in rural Indonesia, and beyond.

We structure our results according to the key considerations of biocultural approaches to conservation, namely perceptions, knowledge, practices and innovations of local communities with relation to their environment, as relevant (Gavin *et al.*, 2015; Figure 1). We then evaluate Bridgewater and Rotherham's (2019) definition of biocultural diversity and propose an alternative which incorporates the use of livelihoods as presented herein. Finally, we discuss the implications of our results for future approaches to biodiversity conservation of the Sebangau PSF and beyond.

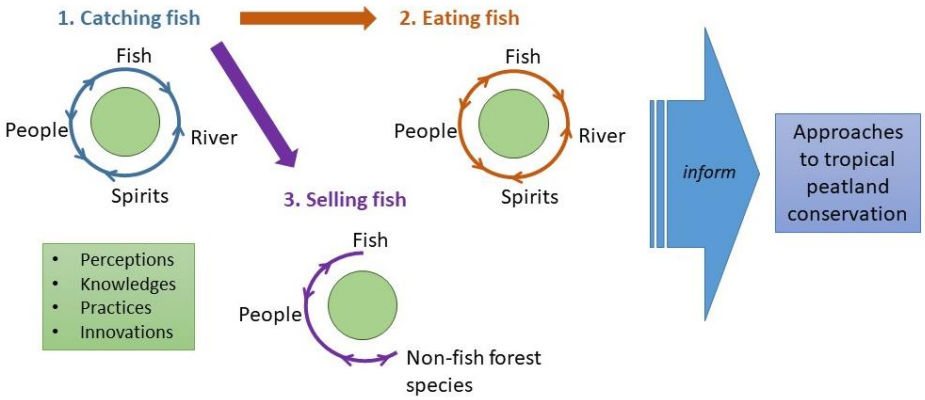

Figure 1: The three livelihood 'acts' explored in this paper, which allows us to explore integral aspects of bio-cultural approaches to conservation (green box) for each act. The arrows indicate that relationships are bi-

directional and encompassing both human and nonhuman beings and entities. Understanding these acts allows us to inform interdisciplinary approaches to tropical peatland conservation.

6. Case Study: The Sebangau peatland landscape in Central Kalimantan

The Sebangau PSF, around which this study was conducted, is one of the largest unfragmented areas of forest remaining in Borneo's lowlands, and it has been the site of several decades of conservation research. Two organisations at the forefront of this research are Borneo Nature Foundation (BNF; a not-for-profit conservation and research organisation founded in 1999) and the Centre for International Cooperation in Sustainable Management of Tropical Peatland (UPT LLG CIMTROP) based at the University of Palangka Raya. BNF's founders identified the Sebangau forest as home to what was then considered the world's largest orangutan population (Morrogh-Bernard *et al.* 2003), which helped provide the evidence base to support the designation of the Sebangau National Park in 2004. The forest is still under threat, predominantly from fires: during the disastrous 2015 fires it has been estimated that over 10% of forest cover within the National Park was lost (Mang, 2017). Declines in fishing harvests by local communities have also been reported in the area (Lyons, 2003; Schreer, 2016; Thornton, 2017).

In Central Kalimantan, where Sebangau is located, most of the 2.4 million inhabitants (BPS, 2016) live in rural areas, in villages by rivers. We chose two case study communities, Taruna Jaya and Kereng Bangkirai, both located on peatland near the Sebangau PSF (Figure 2; see Table 1 in supplementary info for further village characteristics). Taruna Jaya is on a heavily degraded peatland, which is part of the former Mega Rice Project area (ex-MRP), and has difficult access to the provincial capital of Palangka Raya (1 hour by motorbike using an uneven dirt road, or 2.5 hours by motorised canoe). Kereng Bankgirai is located close to the predominantly intact Sebangau PSF and has easy access to Palangka Raya (20 minutes by motorbike on an asphalt road). These contrasting peatland locations allowed us to elucidate the relationships between fish and people and to explore whether their geography (proximity to PSF, rivers and the provincial capital of Palangka Raya) impacted these relationships and livelihood practices.

Semi-structured interviews and questionnaires were conducted in both villages between May 2015 and March 2016. On-site and opportunistic recruitment was used for interviews and questionnaires (Clifford *et al.*, 2016). Twenty interviews, half with women and half with men, were conducted in each location. Fishers and non-fishers were interviewed, and respondents were all over the age of 18 (see Supplementary Information for a graph illustrating the age ranges of participants). Interviews were conducted at participant's houses or in front of their houses, except for one in Taruna Jaya (TJ9M, interview, 18/02/16), which was conducted in front of a shop where appropriate seating was available. These locations were chosen as the settings were informal, easily accessible and somewhere the participants felt at ease (Clifford *et al.*, 2016). At the beginning of the interviews, a ranking task was used to explore local perceptions of various forest species, including fish. This consisted of asking participants to place 16 coins on various pictures of forest species according to how 'important' they deemed them to be to their lives, not only economically. Their reasoning was then discussed in relation

to the other ranked species. Interviews were manually coded and thematically analysed (Squires, 2009; see Supplementary Information for codes used). Participants were anonymised and are referred to by a code (KB or TJ plus the interview number and F for female or M for male). Where relevant, for example when discussing beliefs, the ethnicity and religion of the respondent is indicated. We conducted a total of 40 interviews, with each interview lasting on average 1 hour (range: 30-120 minutes; see Supplementary Information for interview guide). Full ethical approval was granted by the University of Leicester.

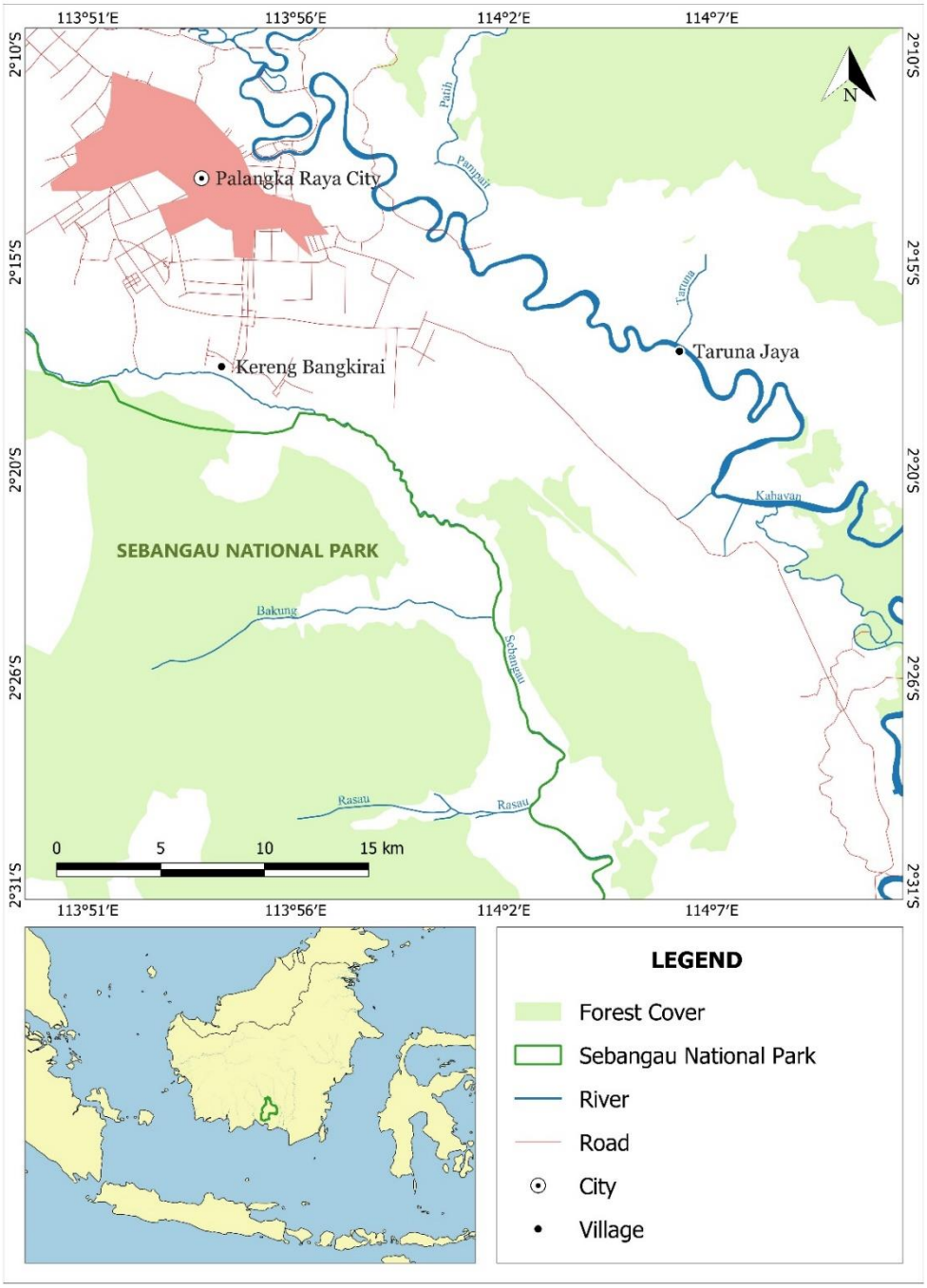

Figure 2: Site locations in relation to rivers, Sebangau National Park (and peat-swamp forest) and Palangka Raya City, in Central Kalimantan, Indonesia.

Questionnaires were used to gather information surrounding fishing incomes and fish consumption. Of the 206 questionnaires completed, 197 were from Kereng Bangkirai and only 9 from Taruna Jaya. More questionnaires were planned for Taruna Jaya, but these had to be cancelled following the 2015 fire and haze disaster, due both to health and safety concerns and potential influence on responses, making these non-comparable to the pre-fire dataset. We instead use the questionnaire results as an average for the 'Sebangau area', which has obvious limitations. We therefore focus most of our analysis in the following sections on the in-depth interviews.

Our research team and the co-authors of this paper comprised of UK and local researchers and fishers, together co-constituting knowledge in a way that attempts to transcend western vs local/ indigenous dichotomies. We must stress that any attempts to present indigenous or local knowledge always runs the risk of altering, or falsely 'fixing' it in time. The presentation of the knowledge within this paper is not done in an attempt to 'fit' it within the proposed framework, but to do the opposite: to suggest how contemporary conservation must do better in incorporating local knowledge and concerns.

6.1. Act 1: *Catching fish*

6.1.1. Innovations

Fishing in the Sebangau area involves the use of several different methods, including rods, nets, traps and electricity, among others (also reported by Smith, 2002). One of the most popular choices of fishing tool is a trap such as the *tampirai*. In Katingan, Central Kalimantan, 41 different methods have been documented as being used in 1938, with 25 methods still in use in 2016 (Schreer, 2016). According to discussions with local elders, Schreer (2016) ascribes the discontinuation of some methods to the amount of time needed to prepare and make the traps. Participant KB2M also reported that fishing methods in Sebangau have changed due to an increased number of canals in the area (interview, 15/01/2016). Fishing methods change with the environment, over time and with technology, and are categorised through discourses of 'traditionally used' designs using materials such as rattan (as found in interviews; e.g. KB2M, KB4M, TJ12F, TJ18F) versus the adoption of new, 'modern' materials (e.g. wire traps); i.e. they are "*inextricably linked to a dynamic waterscape*" (Schreer, 2016: 167). There is a large variety of fishing methods because of the high diversity of fish species, their respective behaviours and niches (our fish surveys produced a list of 55 species in Sebangau: Thornton *et al.*, 2018). Therefore, fish behaviours require certain innovations and determine aspects of human behaviours in Sebangau: fish are actively relating to human societies, being both affected and affective (Bear and Eden, 2011). These relationships are also changing temporally as a part of the dynamic biocultural diversity of the ecosystem.

6.1.2. Knowledges

Successfully catching fish requires a deep understanding of, and relationship with, the wider local environment. To be a successful fisher it is necessary to think in certain ways and be 'smart' (KB10M, interview, 20/01/16). This mirrors the skills used by, for example, UK anglers who, as described by Bear and Eden (2011), try to 'think like a fish' to decide on fishing locations, based on consideration of various environmental factors and their experiences of fishing in the past. Just as in the UK, fishers in this study discussed a need to be able to read

the environment ("*membaca alam*") and know which methods are appropriate to use in which season: *"Fishermen are smart people, it means they can read the environment, can read the situation, and situation of fish. If you read wrong situation there will be no fish. So, every weather, every season they already anticipate, 'oh, this is the tool'"* (KB10M). Deep waters are perceived as favourable for fish catches by some of the fishers interviewed in both Kereng Bangkirai and Taruna Jaya (e.g. KB2M, KB16F, TJ3M, TJ10M). Scientific knowledge concurs that water depth influences fish assemblages in streams (Harvey and Stewart, 1991; Matthews, 1998; Carvalho and Tejerina-Garro, 2014; Marion *et al.*, 2015), as deep water is related to environmental stability (e.g. damping temperature variation) and allows greater vertical separation of fish species' microhabitats (e.g. Baker and Ross, 1981; Gorman, 1988a, 1988b; Jackson *et al.*, 2001). Increased habitat stability favours higher species richness and abundance (Winemiller *et al.*, 2000; Grenouillet *et al.*, 2004; Jardine *et al.*, 2015). Integrating both local and non-local knowledge shows us that water depth can influence fish catches. Oxygen levels in the water are also considered by Sebangau fishers, with for example an abundance of many small fish such as *Osteochilus spilurus* at the surface perceived to indicate low oxygen levels (Dudin, pers. obs. 2014-2015). Low oxygen levels are negatively correlated with fish captures (Thornton *et al.* 2018; it must be noted that this data was not used to 'test' local knowledge, but to add to our understanding of the fish-river-human entanglements). This illustrates how Sebangau fishers must read the water surface for signs, understand what lies beneath the water surface and thereby know, without seeing, the underwater terrain: in sum, they employ 'watercraft' (Burton, 2008).

Male and female participants explained that they sometimes relied on 'feeling' to choose fishing locations, which is based on their accumulative knowledge formed through fishing experiences. In this way, their local knowledge is gained during an apprenticeship that is a gradual process of engaging with the environment, tools, fish, water, etc. (Ohmagari and Berkes, 1997; Berkes *et al.*, 2000; Olsson and Folke, 2001; Williams and Hardison, 2013). This is not an experience specific to Kereng Bangkirai and Taruna Jaya fishers, as Scheer (2016: 169) describes the process of boys learning to fish in Katingan, Central Kalimantan; *"By following…others in their daily routine, the boys observe, listen, smell, and feel fish; they learn how to handle tools, and how to read the signs of the waterscape. Prompted by their "teachers", they practice themselves, thereby receiving instructions and explanations. It is through a fully sensory experience with the water, fish, and tools that they learn how to fish."* This sensitivity and the use of 'feeling' by Sebangau and Katingan fishers is comparable to Ingold's (2000: 25) discussion of intuition and sentient ecology: *"Intuitive understanding…rests in perceptual skills that emerge, for each and every being, through a process of development in a historically specific environment".* The knowledge that all these fishers have is encoded in the landscape and requires situating information and understanding its meaning through direct engagement with the environment (Ingold, 2000).

6.1.3. Practices

For some, fishing also requires negotiating relationships with spiritual nonhumans. This can take the form of offerings given to ask for permission from spirits, the fish or the river (TJ2W, Dayak, Christian; TJ14M, Dayak, Muslim) during fishing or other activities including hunting (Perez, 2010; Perez, 2018). Offerings are given to the river so that more fish come to the traps and other nonhumans do not interfere with the fishing locations (KB18F, Dayak, Muslim; KB19F, Dayak, Christian). Offerings can also include placing a yellow flag on the riverbank (KB19F, Dayak, Muslim), which is a common practice in Central Kalimantan (Perez, 2010).

Yellow flags may be used to mark spiritual sites at the mouths of rivers or at specific locations on river banks that cannot be disturbed (Purnama *et al.*, 2012), as further explained by interviewee KB13F (Javanese, Muslim): "*This is because spirits have a home, and the yellow flags show that there are guardians which protect the area, so you put the flag there so that they don't get bothered*." (Interview, 25/01/16). Interviewees reported placing flags by the river's edge to warn other people against crocodiles, snakes and "*strange*" things (KB11M; Banjar, Muslim, interview, 25/01/16) or alternatively to "*thank God*" if fish catches had been good (KB12W; Banjar, Muslim, interview, 25/01/16). Schreer (2016) draws on work from Dove and Kammen (1997), who write that this interaction constitutes a 'moral ecology': a "*morality governing the resource exchange between humans and the non-human*" (Schreer, 2016: 120). There were indications that this human-nonhuman relationship seemed to be changing temporally: Participant KB8F explained that offerings may not be used as much as previously because fishing methods have become more 'modern', more effective, and thereby offerings are not needed: "*In the past yes, they used to give offerings in the wet season. Now they don't anymore because of the change in methods. Because in the past they used traditional methods, now they use more modern methods so it's easier to catch fish*." (Interview, 18/01/16). Changing fishing methods can therefore have direct consequences for how human-nonhuman relationships function. Furthermore, with the intensification of fishing, and particularly if undertaken in an ecologically unsustainable way, there will not only be a change in human-spirit relations, but also a loss in fish populations as has been reported in the Sebangau area in the past (Lyons, 2003). Biodiversity and culture are intertwined.

In the Sebangau River, fish catches tend to follow the seasons, with the greatest catches usually occurring around May/June when the wet season transitions into the dry (Dudin pers. obs.; Thornton *et al.*, 2018). The changing of fishing seasons is a clear example of environmental fluctuations that are usually predictable as well as complex, involving a multitude of factors such as water depth, precipitation, dissolved oxygen levels, water temperature, etc. (Thornton *et al.*, 2018). As Perez (2010:101) writes; people's "*livelihood repertoire (…) is inextricable from the environment, just as the rhythms of everyday life are intertwined with the rhythms of natural seasons*". From our questionnaires, 67% of fisher respondents reported that they mainly fished at the beginning of the dry season, with 62% reporting that they caught the most fish at this time (n=50). This was also the time when many of the women in Kereng Bangkirai joined the men in fishing activities. In locations with more options for alternative income sources, such as Kereng Bangkirai, fewer people will therefore be dependent on fishing as a main livelihood and will engage in other income-generating activities outside of the main fishing season (further elaborated on in Section 6.3). These fish-river-human relationships, and their dynamics and seasonality, impact livelihood activities (and their own temporalities) and thereby determine how the villages function. These relationships are also location-dependent, which will further determine what appropriate approaches to conservation look like in each location.

6.2. Act 2: *Eating fish*

6.2.1. Practices and knowledge

Fish are still the main source of protein for most rural people, fishers and non-fishers alike, in Central Kalimantan (Schreer, 2016). From the questionnaires, we found the average annual amount of fish consumed per person was 49.4 kg; about 2.4 times more than the global average

of 20.3 kg (estimates for 2016: FAO, 2018). These numbers could potentially be higher in Taruna Jaya as it is less connected to Palangka Raya and other markets. Our figures are also comparable to previously reported annual fish consumption data reported by Saman and Limin (1999), which were 40.1 kg per person in 1998 for Central Kalimantan. These figures thus illustrate a continued and high local dependence on fish as a main source of protein. Spiritual relationships not only influence fishing behaviours but can also determine the ways in which people relate to other nonhumans through the taboos surrounding eating and cooking fish. There are many sorts of *pali* (sins or taboos) in Central Kalimantan (Lumholtz, 1920; Zuesse, 1974) but the literature on these beliefs or norms is very limited and mostly quite old. The act of breaking/committing *pali* can lead to miserable lives, sickness, and even death of individuals, families and communities (Zuesse, 1974). Ancestral taboos are also often inherited through the family line (Couderac and Sillander, 2012). For those who believe in *pali*, this determines the relationship which people have to certain fish species. Table 2 in the supplementary information lists the fish species that were considered *pali* to eat, the reasons for these beliefs, and the ethnicity and religion of the participants that identified these fish as *pali*.

One other example is the story of the *saluang karing/bahandang* (*Rasbora kalochroma*) which we learned from both men and women in Kereng Bangkirai and Taruna Jaya (see also Couderac and Sillander, 2012). Participant KB2M (Dayak, Muslim) told us that "*you can't bake saluang karing as you will become possessed. You can't bake anywhere in Sebangau, but you can fry it. There are no other fish that I know that are like this*" (Interview, 15/01/2016). In Taruna Jaya, participant TJ18F (Banjar, Muslim) reported that spirits would come and strangle you to death if you baked the fish in the forest. TJ14M (Dayak, Muslim) also explained that he had heard about the consequences of baking *saluang*: "*There were people from Rungan and one of my cousins burned saluang and one of the children from the group disappeared. They later found the child but he had died and around his neck there was bruising. The child was stolen by a spirit. This was saluang bahandang, you can't bake it in the forest.*" (Interview, 25/02/16). Participant TJ13M (Banjar, Muslim) also experienced consequences of baking a certain fish in the forest: "*We saw giants last year in the dry season. "Oooomm", the giants made that sound. They were red coloured and had big feet. They came because we were baking eels in the forest. Saluang [=small fish species], udang [=shrimp], lindung [=eel], pehang [=snakehead fish], you can't bake these in the forest in the afternoon, as this invites something not good to come. There were two giants: one female and one male. They came because we broke adat, so they bothered us*" (Interview, 22/02/16). These examples represent important rules that govern certain human-nonhuman relationships and the misuse of fish can therefore have severe consequences.

The observance of *pali* can be a way to maintain ritual relations with ancestors, as well as symbols of descent lines, and to ensure continued alliance with powerful spirits (Couderac and Sillander, 2012). While there was no explicit link made between ancestors and *pali* in the interview data, it was common to see familial and generational aspects of *pali* (e.g. TJ17F whose parents determined what was *pali*), and that eating a *pali* fish could lead to a curse on your children and even lead to their death. As seen from this study and in accordance with Couderac and Sillander (2012), there are people who adhere to ancestral taboos which run in their descent lines. These spiritual relationships can have direct implications for how certain human-fish relationships function with both humans and nonhumans exhibiting agency in the peatland ecosystem.

6.3. Act 3: *Selling fish*

6.3.1. Practices

Another important aspect of the human-fish relationship is the use of fish as a source of monetary income for some community members. This relationship differed with geography and remoteness: residents in Taruna Jaya reported much higher dependency on fishing as their main source of income (89%) (supported by Suyanto *et al.*, 2009; who reported 97% of respondents in their study of the ex-MRP area engaged in fishing), compared to Kereng Bangkirai (52%) (See Supplementary Figure 1). In Taruna Jaya, wood collecting, logging, building, work as civil servants, and as chicken and cow breeders are other sources of income, but very few people are involved in these compared to fishing. All participants in Taruna Jaya reported a need to find new sources of income, and they were interested in developing farming and animal breeding in the area. However, regular flooding and wildfires make this challenging. In Kereng Bangkirai, additional income sources included bird hunting, chicken farming, working as civil servants and builders. There were more people involved in these alternative sources of income in this village compared to Taruna Jaya, as indicated by the lower percentage dependent on fishing. This is predominantly because Kereng Bangkirai is located closer to the provincial capital of Palangka Raya, it has good road access to the capital, better education opportunities (see section 6), and therefore residents have better accessibility to a greater variety of income options, particularly outside of the main fishing season.

In both Kereng Bangkirai and Taruna Jaya it was common, as with other peatland communities across Kalimantan (e.g. Gönner, 2011; Shreer, 2016), to rely on a range of income sources; adapting to shifting resources in a flexible and dynamic way. Where fishing was not seen as a 'main source of income', it was often still an important source of food for the household. For example, we found in Kereng Bangkirai that 'stay at home moms' (as self-identified) often still fish in their spare time close to their house for food (also supported by Graham, 2013). In Taruna Jaya, the women who did not identify their main job as 'fishers', such as the shopkeepers, also fished on the side for consumption purposes. This subsistence fishing is still significant in its contribution to the household and is a part of the local livelihood practices. Yet, these types of practices are often discounted in our understanding and analysis of (local) economies as they do not involve any monetary exchange and they take place away from the domain of the 'market' (e.g. see Miller, 2014). To our knowledge, no publications explicitly deal with this contribution of subsistence fishing to peatland communities in Indonesia.

6.3.2. Perceptions

We found that fishing in our two Sebangau villages was mainly seen as a fall-back option. It was often described as a job that does not allow an improvement of life but merely sustains it, with KB3M also describing fishing as "scraping a living" (*menyambung hidup*, interview; 18/01/2016). This is in agreement with Schreer's (2016) findings in the nearby Katingan area where, due to declining fish stocks, fishing now often fails to provide a guaranteed and sufficient income to cover people's needs. In both our case study villages, fishing is perceived as the likely job to go into if you have no higher formal education and no other job opportunities. Both men and women are more dependent on fishing as a main source of income in Taruna Jaya due to a combination of lower access to education and, again, other job opportunities (Table 1 in supplementary information). This stresses the importance of fishing

as an insurance option, although it seemingly still fails to lift people out of poverty. In line with this, our species ranking exercise (Figure 4) showed a clear trend for most coins being placed on the fish compared to all other forest species, with a mean of 8.75 coins placed on fish in Kereng Bangkirai, and of 9.90 coins placed on fish in Taruna Jaya (differences between villages were not significant: t=-0.69, df=36, p=0.494). The difference between the number of coins placed on fish and all other species was statistically significantly in both locations (t>4.77, p <0.01 in all cases). In both villages, most coins were placed on fish due to fishing being a primary source of income and food for households: "*Fish has the most because I am a fisherwoman. You can eat fish and I sell fish. It is for income, for life and my work*" (KB19F, interview, 02/02/16) and "*95% of people here are fishers. They focus on fishing here, and it is for their everyday lives. 5% have other jobs for example sellers. There are no other options other than fishing.*" (TJ11M, interview, 22/02/16). Fish are therefore the most relevant to participants' lives (e.g. KB11M, KB13F, and KB14F) and these views predominantly fall within utilitarian attitudes (Kellert, 1996; Montgomery, 2002). The income earned from fishing also has links to many other important aspects of villagers' lives, such as the desire and ability to send children to school (e.g. KB13F). To some, the green leaf bird (*Chloropsis sp.*), which is hunted and sold to be kept as a pet, was also given a high ranking as it was a source of income for both male and female participants. Again, the ranking was driven by economic motivations due to its wider implications to their livelihoods and wellbeing.

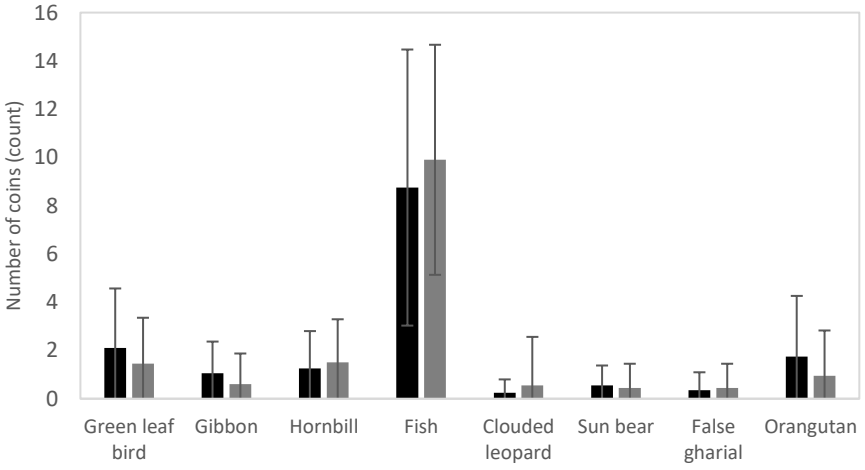

Figure 4: Average number of coins (count) placed on each forest species for the two case study locations; Kereng Bangkirai (black) and Taruna Jaya (grey), error bars showing standard deviation.

Notably, fish were ranked higher than any other species, such as the orangutan, despite this species having a high national and international conservation importance. In addition to the other human-nonhuman relationships as discussed in previous sections, there is clear imbalance between faunal species that are perceived as a priority by the international community versus those of importance to local people and their livelihoods. If a biocultural approach is taken, i.e. one that considers local values, cultures and relationships to the environment, then a local conservation focus on fish would take a higher precedence than is currently the case, particularly in comparison to the main present focus on orangutan conservation (see also Chua *et al.*, 2020).

7. Conclusions and recommendations for peatland and fish conservation

In this article we have used Miller's (2019) definition of 'livelihoods' to explore the human-nonhuman relationships that constitute fishing in the Sebangau landscape. This includes the use of fish as a food source for communities, the taboos that can be associated with eating or preparing fish in a certain way, the act of fishing itself and how 'watercraft' is learned, along with the environmental and spiritual relationships that some fishers need to navigate for successful catches. These human-nonhuman relationships are dynamic and change temporally, as seen with the temporality of the fishing seasons and changing fishing methods. This highlights how biocultural diversity is never fixed in time, supporting Gavin *et al.* (2015) who stress that biocultural approaches to conservation require adaptive governance. We have illustrated how nonhumans as well as humans are both participating in the negotiations and dynamics of making a living (Miller, 2014a; 2019), an understanding that an ES approach would not allow us to reach (as it focuses on the unidirectional benefits which people get from the environment). We did not find an expressed emotional connection to fishing as a job in the Sebangau (e.g. that it is linked to personal identities). However, we see that through exploring the various elements involved in the acts of fishing, there are more intricacies beyond monetary income in the fisher-fish-river-spirit relationships. We have also outlined how spiritual relationships have direct implications for human-fish relationships and thereby need to be considered in our discussions on fish, fishing and wider resource use in Central Kalimantan.

From this study we learned that fish are considered the most important and relevant local faunal group to village members' lives compared to other forest species, such as the flagship orangutan. Given the value of fish as a source of food and livelihood, this may seem obvious, but this is not currently mirrored in conservation efforts across Indonesia (Chua *et al.*, 2020), as is reflected in the paucity of information available on fish species, populations and conservation threats (Duncan and Lockwood, 2001; Ormerod *et al.*, 2010; Posa *et al.*, 2011; Reid *et al.*, 2013; Lees *et al.*, 2020). Our results support the suggestion of Seele *et al.* (2019) that fish should be seen and treated by the conservation community as a cultural keystone species. They also are in agreement with Sule *et al.* (2016) who write that one of the strongest justifications for conservation of PSF is to support the persistence of the resident ichthyofauna: maintaining fish populations requires maintaining the natural water tables of the swamps, and so the conservation of one directly supports the other. In accordance with this, we illustrate how fish conservation has the potential to support important biocultural and livelihood relationships between human and nonhuman communities living around peatland areas. This is not to say that species-focused conservation, such as orangutan conservation, is not important and necessary, but that, once again, a shift towards multi-level, multi-perspective and multi-species approaches to conservation are still needed and would be expected to provide additional complementary conservation benefits. We thus suggest that the links between fish (and other 'natural resources' of importance to local communities), the forest and the conservation of other species can and should be made more evident in conservation messaging and strategy development: e.g. demonstrating how conservation of apes (as umbrella species) can benefit fish and vice versa, and how this can benefit local communities. We expect that this approach would lead to better conservation success. As Chua *et al.* (2020) write, conservation programs can use proxies, such as fish, to align different agendas (e.g. between conservation organisations and local communities) to achieve similar goals through a process of commensuration. This allows not only a 'destabilisation' of the species-centrism of orangutan

conservation, but also centers the multiplicity of international to local (and in between) scales and the diversity of values between local and international actors (Chua *et al.*, 2020). For this reason, and as informed by this research and the larger interdisciplinary project (Thornton, 2017), Borneo Nature Foundation has increasingly incorporated fish research within its activities to seek to mitigate local villagers' concerns about the impact of canal damming, while also using concerns about fish and fishing as a bridge between local and non local conservation concerns (see Chua *et al.*, 2020). Data collection on these initiatives is ongoing and will allow future evaluation of the approach proposed here.

Bridgewater and Rotherham (2019) define biocultural diversity as: "*a dynamic, place-based, aspect of nature arising from links and feedbacks between human cultural diversity and biological diversity. These core concepts are placed jointly within a culture on the one hand, and a landscape with its ecology, on the other*." With our:

a. rejection of nature-culture and object-subject dualities,
b. acceptance of other worldviews, and
c. integration of the definition of livelihoods as presented by Miller (2019) and illustrated in our analysis of fishing livelihoods in Sebangau,

we present an alternative definition of biocultural diversity as: 'the dynamic, place-based multiplicity of human and nonhuman beings, their livelihoods and their constituting relations'. We propose that, using this definition, biocultural diversity can be assessed through exploring various human-nonhuman relationships with a focus on trends over time: are these relationships weakening or strengthening, are they disappearing or are new relationships being formed? In this way, researchers can also evaluate biocultural approaches to conservation, explore livelihoods and livelihood options, while avoiding the ecosystem service paradigm and its problematic assumptions.

It is through a recognition and a promotion of diverse views, values and knowledge systems that socially just approaches to conservation must be found. This is required to benefit the communities involved in this research and are also fundamental features of a biocultural approach to conservation (Gavin et al., 2015). The information presented herein, including the spiritual human-nonhuman relationships negotiated in Sebangau, provides a starting point for this locally. With the importance of fishing for many rural communities in developing countries across the globe, these conclusions extend far beyond our case study area and include other significant tropical peatland and wetland areas.

Box 1: Key findings and suggestions:

1. We propose a definition of biocultural diversity as: the dynamic, place-based multiplicity of human and nonhuman beings, their livelihoods and their constituting relations.
2. Using this definition, biocultural diversity can be assessed by exploring various human-nonhuman relationships with a focus on trends over time: are these relationships weakening or strengthening, are they disappearing or are new relationships being formed?
3. This allows researchers to evaluate biocultural approaches to conservation, explore livelihoods and livelihood options, while avoiding the ecosystem service paradigm and its problematic assumptions.
4. Using our Sebangau case study, we illustrate how a focus of resources/efforts on fish conservation has the potential to support important biocultural and livelihood relationships between human and nonhuman communities living in peatland areas. This will be relevant to peatland and wetland areas beyond Indonesia.

Notes

1. The term 'Dayak' that is used within this paper is a blanket term for many indigenous ethnic groups found in Central Kalimantan, including the Ot Danum, Ma'anyan and the Ngaju Dayaks. The Ngaju Dayaks are the largest of the Dayak tribes in Central Kalimantan. Histories, languages, beliefs and practices vary significantly between various Dayak tribes.

2. *Adat* is the traditional Dayak law, knowledge, wisdom or way of life. We use this term cautiously as it tends to have a vague meaning and can have various definitions depending on context and person. It can refer to knowledge and wisdom that is passed through generations and dating back and evolving from the earliest Dayak settlements, but everyday politeness can also be seen by some as 'hukum adat' (Christel, 2015; Schreers, 2016). It can also be closely linked to religion (Schreers, 2016).

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