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Ecosystem services in the floodplains: Socio-cultural services associated with ecosystem unpredictability in the Pantanal wetland, Brazil

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Ecosystem services do not exist independently from human perceptions and recognition. They are socially, culturally, economically, and environmentally scale- and context-dependent. Socio-cultural services tend to be difficult to evaluate and invisible to policymakers and conservation practitioners. Based on six years' qualitative analysis of a floodplain fishery in the Pantanal wetland, Brazil, we bring an in-depth understanding of the socio-cultural ecosystem services in the region. We show that the inter- and intra-annual ecosystem dynamics variations in the flood pulse are closely associated with local people's governance structure, identity, and cosmological histories. All of them, to some extent, capture some of the unpredictable changes in the Pantanal. Our study uncovers part of the complex and rich social-cultural ecosystem service created from the interaction between local people and the ecosystem in which they are embedded. We also present the threats faced by these services in the face of current development projects in the Pantanal, such as the Waterway and Hydrometric Dams. We argue that the predicted outcome may jeopardize not only the social-cultural services in the Pantanal, but also the local people themselves and the environment that they are currently protecting.

Keywords: cultural ecosystem services, fisheries

Introduction

Initially, ecosystem services were conceptualized as the benefits human populations derive from ecosystem functions (Costanza et al., 1997). However, ecosystem services do not exist independently from human perceptions (Fischer

and Eastwood, 2016). They are socially, culturally, economically, and environmentally scale- and context-dependent (Spangenberg and Settele, 2016). Ecosystem services are a direct co-product of the continual negotiation of the social, political, and economic dynamics (Allison and Ellis, 2001). People constantly create new realities, and, to fully

capture all the benefits people extract from nature, we must broaden our understanding of ecosystem services, going beyond the frequently used monistic, utilitarian, and economic approaches with no room for other social scientific methods (Scholte et al., 2015). Quantifying or uncovering them using this more holistic perspective is critical to better understand the impact of humans on nature and also to support local adapted nature-based solutions (Scholte et al., 2015)

In this paper, we describe the social-cultural ecosystem of two groups Pantanal wetland in South America. The Pantanal is a rare example of a wetland that is still well-preserved, with over 84% of its native vegetation still standing (Souza et al., 2020). Globally, since 1900, between 69 and 75% of all inland wetlands of the world have been lost (Davidson, 2014). Currently, wetlands are disappearing three times faster than forests (Gardner and Finlayson, 2018). Given the level of nature protection, the Pantanal may provide billions of dollars in ecosystem services to both local and global human populations. Recent estimations of potential monetary value showed that the Pantanal floodplain alone provides over US\$ 59 billion or US\$ 3,932.05 per hectare in ecosystem services per year (Bolzan et al., in press). However, the socio-cultural services presented in the Pantanal wetland have received little attention (Chiaravalloti, 2016). On the contrary, local communities' cultural aspects have been, for many years, deliberately ignored by some practitioners and policymakers in the region (Chiaravalloti, 2019). In this paper, considering that socio-cultural services are a product of the interaction between behavior, history and social networks and the ecological dynamics—in other words, they do not exist independently from humans—we uncover some of the socio-cultural ecosystem services recognized by two communities of fishers in the Pantanal, named here as Settlement 1 and Settlement 2. We also explore the connections between Pantanal environmental dynamics, community organization, and cosmological histories in the construction of the socio-cultural services. Finally, we discuss some of the potential impacts of climate and land use changes in the region on the socio-cultural services.

Material and methods

The Pantanal

The Pantanal stands out as the one of the largest, lying in three countries: Brazil (78%), Bolivia (18%), and Paraguay (4%) (Keddy et al., 2009). In the floodplain area alone, there are 1,863 species of phanerogams, 269 species of fish, 141 species of amphibians and reptiles, roughly 460 species of birds, and 236 species of mammals, and most of these species are considered to have viable populations and not to be under threat, especially due to the low deforestation rate of native vegetation (Souza et al., 2020).

Local people

Fishery communities in the Pantanal had their origin during the 18th and 19th centuries, yet through different processes in each region of the Pantanal (Chiaravalloti, 2019). We focused our research on two communities living in the Western Border of the Pantanal, named here Settlement 1, with 23 families and about 150 people, and Settlement 2, with 40 families and about 250 people (Botelho et al., 2008). Both settlements originated through intermarriage and adoption of the indigenous Guató with Paraguayans who came to the region after the War of the Triple Alliance, 1864–1865, as well as former slaves previously working in gold mines in the Cuiabá (Bortolotto, 2006). In both settlements, about 80% of the community members depend on fishing or gathering bait as their main source of income (Chiaravalloti, 2019). They fish for self-consumption and to sell in small markets in cities (especially Corumbá). Bait on the other hand is sold to tourists who come to fish in the Pantanal. People constantly switch between gathering bait and fishing depending on the demand for either one (Chiaravalloti, 2019).

Climatic and ecological dynamics

The Pantanal is a semi-arid region. In the rainy season, the quantity of rain in the floodplain per month varies from 100 to 300mm, and in the dry season from 0 to 100 mm (Marengo et al., 2016). However, the Pantanal is a large intracontinental depression area, and receives most of the rain that

falls in the surrounding region. Therefore, despite the low quantity of rain in the floodplain, the flood pulse in the Pantanal can cover from 11,000 km² to 110,000 km² of the region, varying according to the quantity of rain outside the Pantanal (Hamilton et al., 1996).

The Pantanal also sees intra-annual variation in the flood pulse. Once the water reaches the border of the floodplain, it moves slowly from east to west towards the main rivers in the region. In the northern region, however, this process is more intense due to geomorphological barriers and the presence of big lakes in the area, creating a flood wave traveling from north to south (Alho and Sabino, 2012). Due to the slight gradient of the terrain in the Pantanal (2–3 cm/kilometer north to south, and 5–25 cm/kilometer in the east to west) this process, or flood pulse, takes 3–4 months to pass through (Junk et al., 2006).

For resource-dependent communities, the inter-annual and intra-annual variation play a critical role in their lives, since all local biodiversity will adapt according to the specific time-location features of the flood pulse.

For fishers, specifically, another driver of unpredictability in the Pantanal is the presence of floating aquatic vegetation, which can occupy more than 90% of the area in years of high floods (Sousa et al., 2011) and can move freely throughout the floodplain, constantly changing position according to wind direction and river flow (Tur, 1972). Frequently the vegetation gets stuck in river channels or bay mouths, closing these off for fishers. This is a very common process locally called clogging (“*entupido*”).

Data collection

We have been studying Pantaneiro communities for over six years. Eight one-month field trips were held between 2013 and 2014 as part of an ethnographic study in Settlements 1 and 2. Also, between 2015 and 2019, 10 two-week field trips to the communities were held as part of a long-term project focused on livelihood changes and adaptation. During this period, we used two methods: semi-structured interviews and citizen science. First, semi-interviews were held using printed maps to gain a better understanding of the patterns of access and cooperation, and how

people see control of resources and sharing. Citizen science was performed using software called Sapelli that can be installed in any android smartphone, which allows people to collect precise locations of natural resource use through icons developed by themselves (Vitos et al., 2013). The project was approved by both a federal and a local ethics committee from the study region (acceptance number CAE 828,070).

Results

Socio-cultural ecosystem services: Reciprocity and territories

Qualitative and quantitative data showed that fishers or bait gatherers follow the flood pulse drawdown throughout the year, creating a continual turnover of fishing or gathering sites. People continually try new spots to verify whether they are worth going to. The length of stay in each spot varies from two days to two weeks, depending on the characteristics of the flood pulse each year, the site-specific consequences, and the presence of aquatic vegetation.

To optimize the search for the best spot each time, people constantly share information with other community members about good fishing or gathering spots. The fishing and gathering bait system work in the following way: A group of fishers or bait gatherers go to a site while a few others try new areas. If someone manages to find a better place, s/he will inform the others, and everyone moves there. The information sharing is related to both bait spots and fishing grounds. The method is constantly repeated throughout the year.

The information about good fishing or gathering spots is shared during several “iced mate drinking sessions” held each day (“*tereré*”). People from the same community tend to not hide such information, establishing a sense of reciprocity. During this study, some families received visitors for more than five iced mate sessions a day, primarily to discuss good fishing spots. Moreover, visiting other people’s houses is a way to verify their catch and establish trust regarding the information they have given and how many fish or how much bait they have stored.

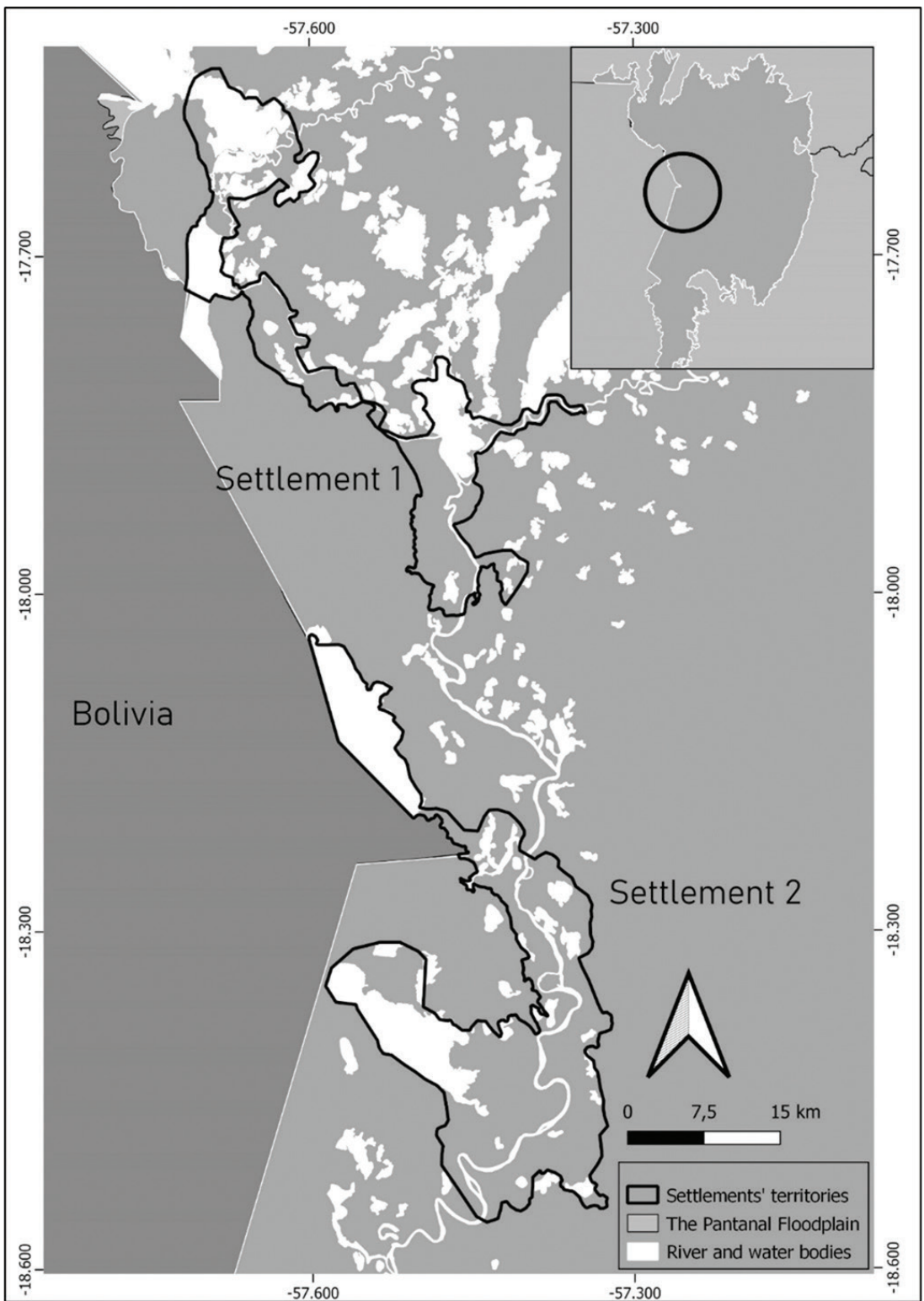


Figure 1. Limits of Settlement 1 and Settlement 2 territories located in the Western Border of the Pantanal wetland, as highlighted on the top left of the figure.

However, the openness and reciprocity shown by people from the same community do not extend to people from outside their area. People from the two settlements studied were very clear about boundaries that groups from other settlements need to respect, as presented by Informant 1: “*My uncles from the North Pantanal came to the Settlement 1 to gather *tuvira*, .. however... people started to come and say they should leave. There was no way to argue against it, they had to leave.*” The same sense of territory was conveyed by Informant 21 from Settlement 2 talking about Settlement 1: “*When I go there to play football I feel like I am in the United States, they speak differently, behave differently, as soon as I finish I run back home*” (Figure 1).

During the interviews carried out with printed versions of satellite images from the region, it became clear that people tend to not recognize river channels and water bodies on the map from regions other than their own. For instance, when Informant 19, from Settlement 2 saw a satellite image of his territory, he identified dozens of places of use; however, when shown a second map on the same scale but from Settlement 1, he drew a line with his finger and said: “*This is another group’s area, I do not go there, I do not know the names.*” There are two possible explanations: Either he does not know these places, or he professed a lack of knowledge to show respect for the local rules. Either way, it illustrates that these boundaries, invisible to outsiders, are very real and important for local people.

On the maps used to facilitate the interviews, people from Settlements 1 and 2 were able to draw what they call “their” area, or demarcate the limit beyond which someone from another settlement cannot fish. People included areas of man-made mounds, cemeteries, river shortcuts, and clean water sources. Settlement 1’s territory covered an area of 35,652.29 hectares and Settlement 2 an area of 57,995.13 hectares. Nonetheless, the idea of fixed boundaries is not part of their understanding. Thus, depending on each year’s flood, some places may be newly included within or excluded from their territory.

The combination of high level of information exchange between community members and clear boundaries towards outsiders create a governance system named Limited Open Access,

which guarantees communities’ survivorship and sustainability of natural resource use (Chiaravalloti and Dyble, 2019). However, the governance system is factored into people’s livelihood adaptations. As pointed out by Informant 10: “*Observing the nature you can see that it builds and destroys itself. The forest appears and disappears. It is how the Pantanal works.*” In other words, it is built through their understanding and experience of the natural dynamics. From that perspective, reciprocity and territories, or Limited Open Access, are socio-cultural services originating from the interaction between Pantanal communities and the environment in which they are embedded (Figure 1).

Cultural ecosystem services: Identity and cosmological histories

Albeit having indigenous roots, during the interviews it was clear that fishers see themselves differently from any other group, calling themselves “*riberinhos*” which are those who fish and live by the river. As one of the informants put it, “*There are different communities, but it is the same ribeirinho tradition.*” For instance, a few years ago when local NGOs tried to introduce wild rice to grow close to all human settlements as an alternative livelihood, they declined the offer. People claimed that wild rice was “*an Indigenous food, and they were no Indians,*” as had been suggested by an NGO practitioner. They equally put themselves differently from “*pantaneiros*” [people of the swamp], who, according to them, work and live in ranches. As a young fisher pointed out “*Pantaneiros follow order, wake up early in the morning, go after the cows; we [riberinhos] can wake up whenever we want; we are free.*” Finally, they equally put themselves as very different from people living in the cities, pointing out that the main difference is the trust they have in one another.

Pantaneiro fishers have strong beliefs about the “*cobra grande*” (a giant snake), locally known as “*minhocão*” (giant worm). According to local fishers, *minhocão* exists throughout the rivers and live in giant holes in the riverbank. Many times, the riverbanks in the Pantanal collapse, especially in the beginning of the flood season, and often, local people blame the *minhocão* for it. Also, some people pointed out the presence of an underwater

world, which works as a mirror of the outside world, as illustrated by a fisherman: “*There are more eyes in the water than hair on land,*” referring to the number of people living in the underwater world. During the interviews, people frequently reported seeing little boys playing on the riverbanks far from the settlements, who, according to them, are unruly children who have escaped from the underwater world. In both cases, *minhocão* and the underwater world guard the river against abuse of its resources, carrying a mix of “evil” and “good.”

Discussion

Natural resource-dependent communities have been interacting with the environment they are embedded in for thousands of years, evolving to keep the use of their resources within the ecosystem’s carrying capacity (Fa et al., 2020). This long process of physical and cognitive exchange has led to the production of uncountable ecological services processes. However, historically, most of the evaluations have been focused on ecological services, such as pollination, climate regulation, clean water, and others. Socio-cultural values associated with nature have been overlooked by conservationists and practitioners (Scholte et al., 2015). Uncovering these socio-cultural aspects is key to fully put people’s values of nature central to the ecosystem service debate, encompassing living from, in and with the environment (Kenter, 2018), and to better design conservation practices that promote both local development and environment protection.

Our results show that the socio-cultural ecosystem services in the Pantanal are a product of the interaction between people and the environment. On the one hand, people’s own experience in the region and the long cultural evolution of the communities made them aware of the fact that the distribution of the resource is continually shifting, and that securing a specific fishing or bait-gathering ground does not guarantee a long-term income. As part of their resilience and cultural evolution to deal with these dynamics, people from the same settlement tend to not secure individual areas of use. Instead, fishers uphold the idea that the floodplain is a public good and should have no boundaries, expressed through their constantly

sharing fishing information in tea drinking sessions between community members. However, while within groups we see a system of open access, between groups we see a classical common property regime with the display of clear territories (Dietz et al., 2003; Ostrom, 1990). Chiaravalloti and Dyble (2019) point out that the presence of territories and group identities in the region is probably a cultural tool to deal with free-riders who may come to the region and benefit from the information exchange but do not share information themselves. Should we consider the territories as areas of *de facto* protection where communities’ safeguard local biodiversity from other uses, and considering the value of US\$ 3,932.05/ha/year for the Pantanal (de Groot et al., 2012), the monetary value provided by these territories can potentially reach US\$ 140,186,586.89 and US\$228,039,750.91 for Settlements 1 and 2, respectively.

Identity and cosmological histories are also important aspects of the socio-cultural ecosystem services in the Pantanal, which was highlighted in our data collection. Similarly to the governance structure, people’s identity and cosmological histories are built through their daily interaction with the environment, incorporating the ecological dynamics in their own understanding of themselves and in their understanding of the Pantanal. Likewise, this perception changes how they manage and interact with the natural resources (e.g., governance structure), changing the environmental dynamics themselves. The socio-cultural ecosystem services in the Pantanal are a product of this ongoing interaction. These findings contradict the local narrative that the Pantanal fishers have no particular “culture or tradition,” and do not fit what has been described as a traditional group for other areas of the country (Franco et al., 2013). However, their habits, governance structure, and identity is a unique product of their own understanding of their interaction with the environment. Therefore, although they do not resemble any other traditional group that has been studied in Brazil, it does not mean they do not have an identity or tradition. The search for an ideal identity will always create a type of indigenous fundamentalism, used many times to exclude and deny access to powerless communities (Siqueira et al., 2019). Uncovering these aspects is pivotal to create a better scientific understanding of the socio-ecological dynamics, and also to avoid

negative consequences of conservation initiatives, such as physical and economic displacement of traditional communities (Scholte et al., 2015).

Another important aspect to be highlighted is the threat faced by the Pantanal, and therefore, its socio-cultural services. Predictive land use and land cover scenarios show a rapid and threatening change (Roque et al., 2021). First, the surrounding region of the Pantanal is seen as a potential source of hydropower energy, and several small hydroelectric dams are planned to be built in the region (Jardim et al., 2020). Second, policymakers are planning to build the Paraguay River Waterway, which aims to facilitate the navigation of large boats and use the region to export soya. The construction of the Waterway and the small hydroelectric dams are predicted to disrupt the nutrient cycle and create fragmentation of the river network (Ely et al., 2020). Finally, climate change is expected to decrease the quantity of rain in the biome by 30%, which will inevitably affect the ecological dynamics in the region (Thielen et al., 2020). For instance, the 2020 forest fires that consumed 30% of the Pantanal and affected biodiversity and the local people that depended on it were partly a result of an extremely dry year (Marengo et al., 2021). For communities that depend on natural resources and who have culturally and socially adapted to certain environmental conditions, the possible environmental changes represent major challenges. For instance, if the location of fish become more predictable in the Pantanal (e.g., due to the construction of the Paraguay River Waterway or the dams), people would have a better chance of sustaining their livelihood if they reduce their mobility, as predicted by the economic defendability theory (Monk et al., 2018). Also, an increase in forest fires can have a drastic impact on people's territories and governance systems, since some of the areas of use would be inaccessible or destroyed. The impact may be scaled up due to the use of some unsustainable practices, such as illegal, unregulated, and unreported (IUU) fishing already identified in the region (Shirley and Gore, 2019). However, given the complex social and ecological dynamics within which each community is embedded, alongside historical and personal ties, alternative livelihoods and new property regimes or new networks of social support are not easily modified with rapid environmental changes.

Societies seem to not quickly adapt their resource use strategies to different ecosystem dynamics (Lenton, 2020). Abrupt environmental changes may lead to the collapse of not only the cultural services in the Pantanal, but also the sustainability of local people's strategies of resource use.

Conclusions

Our research has shown that socio-cultural ecosystem services depend not only on the protection of nature, e.g. low rate of land cover change, but also on the persistence of the ecological dynamics. The socio-cultural services in the Pantanal are a product of how communities interact with the unpredictable flood cycle in the region. Uncovering them is pivotal for a better understanding of the ecosystem services, but also to better evaluate the impact of environmental changes on people.

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