Local communities and conservation in the Pantanal wetland, Brazil

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Declaration

‘I, Rafael Morais Chiaravalloti, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.'

Rafael Morais Chiaravalloti

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Abstract

This thesis aims to develop the understanding of inland floodplain fisheries. It focuses on the Western Border of the 160,000Km^2 Pantanal wetland in Brazil, using participant observation, semi-structured interviews, participatory mapping, and a critical exploration of Systematic Conservation Planning meant to optimize land use planning for biodiversity conservation. Following the introduction, study site and methods chapters, the first data chapter presents a description of fishing communities' social structure, livelihood and history of resource use and occupation. New information on this hitherto unstudied group explores their mobile way of life and their physical displacement during the creation of Protected Areas. The second data chapter analyzes the current management of inland fisheries, examining evidence for claims around overfishing by local communities. The results do not support narratives of overfishing. Instead, fishers' customary use is characterized by mobile patch use, territory, and reciprocity. These map onto features of this dynamic ecosystem, such as the flood pulse and the presence naturally unexploitable reserves, in ways likely to create sustainable use. The discussion explores why these features may play equally important roles in other floodplain fisheries. The third data chapter discusses tenure and property in floodplains, using as case in point the conflict among Pantanal Protected Areas managers, fishers and state prosecutors over floodplain ownership. A multidisciplinary approach to resource use, access and property, drawing on economics, anthropology and ecology, may help understand tenure in floodplains so as to help management policies mesh better with local realities and resolve conflicts. The final data chapter critically examines prioritization solutions seeking to promote socio-ecological development. Applying Systematic Conservation Planning in the Pantanal case study shows the assumption of fixed set-aside areas is incompatible with the ever-changing nature of the Pantanal and the needs of local fishers. Dynamic socio-ecological systems, such as floodplain fisheries, demand continual adaptation.

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Chapter 1 Literature Review: Governance of Common property regimes and sustainability

1.1 Thesis structure

This thesis aims to uncover socio-ecological features of floodplain fisheries. It intends to present different tools and understandings that may shape management policies better. Floodplain fisheries are among the least studied socio-ecological systems in the world, and management practices are mostly based on case studies brought from quite different ecosystems and realities, such as industrial fishing and coastal areas. This thesis uses the 160,000km^2 Pantanal wetland in Brazil to explore different research question on governance of floodplain fisheries that are risen in the chapter hereafter.

The first chapter recapitulates debates around the ways common property regimes interact with sustainability, focusing on Hardin's "tragedy of the commons" and Ostrom's governance of common pool resources. It goes on to compare how these views have structured the management of inland fisheries, unpacking the complex interaction among flexible livelihoods, environmental changes and property regimes. The practice of Systematic Conservation Planning is outlined to introduce the interaction between management tools and local realities of socio-ecological systems in inland fisheries. The chapter describes the conflict among conservation practitioners, tourism trade and local fishers in the Pantanal wetland as a high-profile case study, highlighting the need for scientific research in order to test prevalent narratives and to uncover the local workings of socio-ecological governance in a 160,000 km^2 wetland. The chapter finishes with the research questions and thesis structure.

Following the introduction, the second chapter describes environmental features of the Pantanal. It starts with a short description of local biodiversity. Then it explains the flood pulse and the changes this causes for access to natural resources within and between years.

The third chapter starts by justifying my decision to study the Western Border of the Pantanal. Then it goes on to describe the necessary steps taken before the start of the fieldwork, such as securing ethics consent from the Brazilian Government, from UCL and local people. The chapter then, explains, in detail the four main methods used throughout data collection: participative observation, semi-structure interviews, participatory mapping and Extreme Citizen Science (ExCites). The chapter gives some emphasis to ExCites and the challenges faced while applying this approach on the ground, because this thesis is one of the first scientific publications that used ExCites to generate and collect data.

The fourth chapter constitutes the first data chapter of the thesis. It gives an in-depth detailed description of fishers living in the Western Border of the Pantanal. It details their spatial distribution and historical occupation. Then, it describes local people's livelihoods, documenting their historical relations with caiman poaching and with the different types of fishers now using the Pantanal.

The fifth chapter is centred on the question of overfishing in inland fisheries. It gives a brief discussion on the lack of accurate methods focusing on inland fisheries management, pointing out the frequent use of poorly substantiated environmental narratives to justify severe enforcement over small-scale fishers' resource use practices. The chapter illustrates the discussion with the case of the Pantanal, in which policymakers accuse local small-scale fishers of jeopardizing the tourism economy due to overfishing. Time series regression analysis and qualitative data are used, first, to deconstruct such postulated links, and then, to show that local people enact a complex system of governance over natural resource use that is likely to result in sustainable fisheries. These findings are used to re-visit inland fisheries management in general.

The sixth chapter starts with an in-depth analysis of different disciplines' views on property. The main goal is to build a solid background to better evaluate the solution sought by prosecutors of giving land title and access to local people in the Western Border of the Pantanal. The chapter explains the conflict that unfolded due to this state action and shows that, currently, local fishers are in no better position than prior

to state intervention. It explains that this same negative outcome is frequently seen elsewhere around the global south, whereby land titles are given with no consideration of the different perspectives on property and ownership in the systems they seek to appropriate. This is especially true in floodplain systems, in which seasonal and inter-annual long term changes in landscape and livelihood are common.

The seventh chapter discusses the possibility of creating a systematic conservation plan for the region, in which, based on in-depth consideration of environmental and social needs, different areas would be set aside and zoned for use. The chapter gives a detailed critical analysis of the method used in order to explore its validity. After carrying out Systematic Conservation Planning procedures the results were shown to local people to elicit their perceptions of the planned solutions it proposed. However, the proposed solutions met with considerably criticism locally. The discussion is centred on explaining that local people's needs are dynamic and flexible, and fixed solutions are unlikely to be feasible in floodplains with high level of unpredictability.

The final chapter returns to the discussion on sustainable development frameworks presented in Chapter 1 to show how this thesis' findings further the state of knowledge on sustainability of socio-ecological systems.

1.2 From Hardin to Ostrom

1.2.1 Hardin's "tragedy of the commons"

In 1968 G. Hardin published what was to become one of the most influential papers on the use of natural resources, "The Tragedy of the Commons" (Hardin, 1968). The rationale set out in the paper was intended to justify population control and privatization, which he presented as inevitable measures in a world with finite resources:

> "To couple the concept of freedom to breed with the belief that everyone born has an equal right to the commons is to lock the world into a tragic course of action" (Hardin 1968, p. 162).

Although the dimension of population control was not much remembered, the concern over the commons which he articulated became known worldwide. For many years, the same logic was adopted by international agencies, conservation NGOs and scientists to justify different kinds of regulation enforcement over use of natural resources in common property regimes (Ostrom et al., 1999; Robbins, 2012). Hardin's argument used the following logic and example: In a pasture open to all comers, where livestock but not land is the property of individuals, it is expected that each herdsman will try to maximize his or her individual profit. Such a system may work well for centuries because of the low population of herdsmen and livestock. However, each individual will always see the personal benefit of adding one more animal to their herd. The consequence is that each animal added will increase the income to the herdsman alone, but it will decrease the quantity of pasture for all individuals. The conclusion is that:

> "the only sensible course for him to pursue is to add another animal to his herd. And another; and another.... But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit-in a world that is limited." (Hardin 1969, p. 162)

The measures Hardin proposed to avoid the tragedy were through privatization or state ownership, whereby rules of private properties or government control regulating use would avoid the collapse of the resource.

Soon after Hardin's publication, other authors tried to challenge his rationale, pointing out that the tragedy of the commons was not a simple direct consequence of common property regimes. Stillman, (1975) observed that there are three assumptions in the commons paradigm that must be fulfilled for the tragedy to occurs: (a) The users must be selfish and they must be able to pursue private gain even against the best interests of the community as a whole. (b) The environment must be limited, and there must be a resource use-pattern in which the rate of exploitation exceeds the natural rate of replenishment of the resource. (c) The resource must be collectively owned by society (common-property) and freely open to any user (open-access).

However, Hardin's link between common-property regimes and tragedy influenced international agencies and national government's policies in areas where use of natural resources was shared (Berkes, 1985; Homewood, 2008). In particular, it dominated environmental protection for the second half of the 20th century and it is still seen by some conservationist groups as central (Sanderson and Redford, 2003; Soulé, 2013). It played into the narrative that local people's resource use in common property regimes would always tend to destroy the environment, and that to guarantee sustainable use of natural resources, there must be external measures imposing restrictions on use (Miller et al., 2014; Soulé, 2013). This framework supported and heightened the use of conservation tools that were in line with this thinking, whereby biodiversity should be kept strictly protected from human use and impacts (Sanderson and Redford, 2003). The most widespread tool became the creation of National Parks and other similar Protected Areas based on the concept of strict protection of natural resources (Neumann, 2004). From this period onwards, the number of Protected Areas in the world has grown exponentially (Figure 1-1).

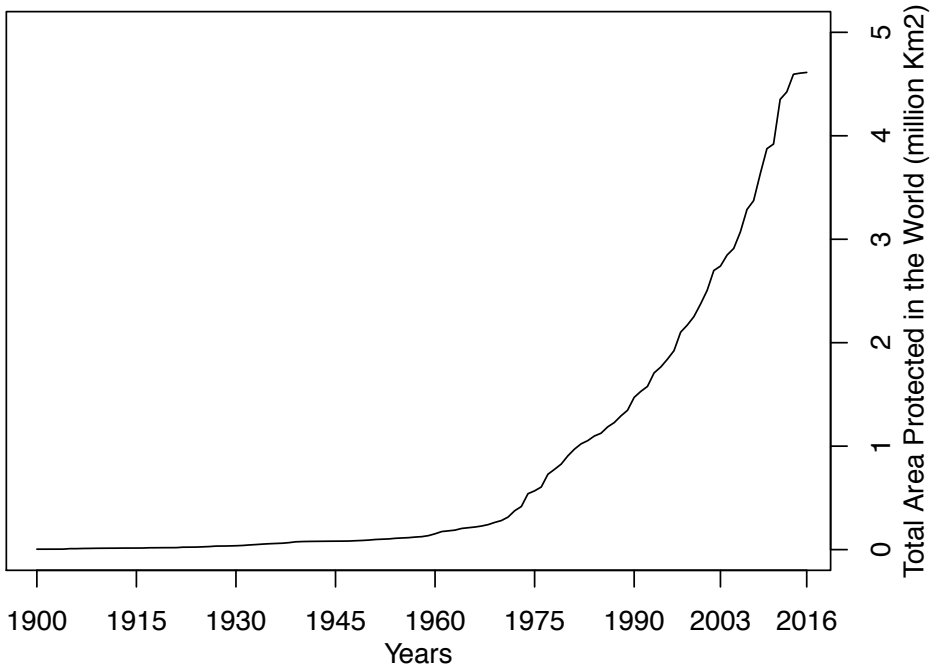

Figure 1-1: The total area protected around the world 1900-2016. Source: https://www.protectedplanet.net

1.2.1.1 Protected Areas

The first Protected Areas' based on the idea that nature is something pristine and should be physically separated from humans, were founded as National Parks in the middle of the 19th century in the USA (Yosemite and Yellowstone, 1864 and 1872 respectively) (Adams and Hutton, 2007). After the popularization of this tool in the 1970s and 1980s, today worldwide, 15.4% of terrestrial and inland water areas and 3.4% of oceans are protected, covering a total of 20.6 million km^2; 60% of this are managed as strict protected areas (Juffe-Bignoli et al., 2014). Moreover, this percentage is likely to increase due to the Nagoya Protocol, with most countries agreeing to the Aichi Targets, whereby they pledge to increase the percentage of Protected Areas to 17% of the Earth surface by 2020 (Machado et al., 2012).

The outcome for local people's wellbeing and livelihood of this management practice has been drastic. Already in the first USA's National Parks evidences of physical displacement and the loss of access to land and resources were reported (Lubick, 2001; Neumann, 2004), and still today similar negative impacts are described on local people's livelihood due to strict protected areas (e.g. Rantala et al. 2013). Widely reported outcomes due to physical and economic displacement imposed by the creation of Strict Protected Areas include: joblessness, homelessness, marginalization, food insecurity, an increase of morbidity and mortality, and social disarticulation (Adams and Hutton, 2007; Cernea and Schmidt-Soltau, 2003; West and Brockington, 2006). Moreover, such impacts are still present even when local people are in principle compensated (Brockington and Wilkie, 2015). For instance, Rantala et al., (2013) showed that the economic effects on local people in Tanzania associated with the creation of several Strict Protected Areas increased the marginalization and poverty of some groups that were already excluded, such as women and the poorest farmers. Contravention of legal or human rights through violent eviction or enforcement are other negative impacts seen in some cases (Sikor and Lund, 2009). Nevertheless, not all Protected Areas necessarily have negative impacts on local communities (Holmes & Brockington 2013). Such impacts may be less frequent than we tend to believe, though the scale of loss and displacement remains hotly debated (Brockington and Igoe, 2006; Curran et al., 2009). The evidence suggests that Protected Areas often have undesirable effects on thousands of people who live in or around them and these effects tend to multiply as the new proposed Aichi targets are approached (Büscher, Sullivan, & Neves, 2012; Fairhead, Leach, & Scoones, 2012; Redford & Adams, 2009).

1.2.2 Ostrom's common property regime governance

However, between mid-1980s and 1990s, a group of researchers using empirical evidence had already started to deconstruct Hardin's logic and, therefore, the idea that natural resources would only be protected through external enforcement over local use (Berkes, 1985; Ostrom, 2000; Schlager and Ostrom, 1992).

Hardin (1968)'s "Tragedy of the Commons" is underpinned on the idea that communities whose livelihood are based on common pool resources [1] have no internal (*de facto*) rules governing access. Such unregulated cases would now usually be termed "open access". Ostrom et al., (1999), agreed that if that was the case, the tragedy would be a natural endpoint; however, they argue that many, if not most of the "commons" to which Hardin referred are, in fact, governed by collective common property resource management regimes[2] and are not open access:

> The proposition that resource users cannot themselves change from no property rights (open access) to group or individual property, however, can be strongly rejected on the basis of evidence [….] Both group-property and individual-property regimes are used to manage resources that grant individuals varying rights to access and use of a resource. (Ostrom et al., 1999)

Analysing different case studies, scholars started to show that in reality there were few situations where no *de facto* rules were present (Gibbs and Bromley 1989). Embedded social sanctions normally guard against excessive individual gain from communal resource and against the accumulation of surplus (Ostrom, 2009). In other words, if communities have embedded *de facto* rules that lead to sustainable use of natural resources, no privatization or state control is needed (Vollan and Ostrom, 2010). In fact, they showed that state control and private properties were frequently associated with resource degradation (Berkes, 1985; Ostrom et al., 1999). Sustainable management depends rather on *de jure* rights for communities to promote their *de fact* customary use and customary systems of regulation.

Ostrom (2011, 2000) emphasises that governance of common property regimes is made up of sets of different rules for each given case which, combined, can lead to sustainable use of natural resources (Ostrom, 2000; Schlager and Ostrom, 1992). Based on that assumption, mismanagement of some other rule could lead to environmental damage.

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[1] For a more detailed definition: Common-pool resources (CPoRs) are natural or human-made resources where one person's use subtracts from another's use and where it is often necessary, but difficult and costly, to exclude other users outside the group from using the resource (Berkes, 1985)

[2] The term common property regime (CPR) refers to a particular social arrangement regulating the preservation, maintenance, and consumption of a common-pool resource (Dietz et al., 2003)

In an attempt to establish the conditions essential for guaranteeing the sustainability of common pool resources, different authors started to identify from case studies around the globe a generalised set of institutional arrangements which commonly appear in functioning Common Property Regime (CPR) systems (Campbell et al., 2001; Schlager and Ostrom, 1992; Steudel et al., 2005). Agrawal (2001), reviewing the most influential publications on common property institutional arrangements, outlined a group of 24 facilitating and 33 critical enabling conditions for sustainability. Some characteristics proposed by these authors as essential to sustainability in common property regimes were: small size, well-defined boundaries, low levels of mobility, predictability, low level of user demand, long established mutual interaction, low-cost exclusion technology, nested level of appropriation, etc. (Table 1-1). Therefore, where these conditions were met people would weigh up the pros and cons of maximizing the use of natural resources and reach sustainability (Ostrom 1999; Vollan and Ostrom 2010):

> In all cases, individuals must overcome their tendency to evaluate their own benefits and costs more intensely than the total benefits and costs for a group. Collective choice rules affect who is involved in deciding about future rules and how preferences will be aggregated. Thus, these rules affect the breadth of interests represented and involved in making institutional changes, and they affect decisions about which policy instruments are adopted (Ostrom et al., 1999, p. 281)

Table 1-1: Critical enabling conditions for sustainability in the commons (based on Agrawal 2001)

Group	Conditions
Resource System Characteristics	Small size
	Well-defined boundaries
	Low levels of mobility
	Possibilities of stores of benefits from the resource
	Predictability
Group Characteristics	Small size
	Clearly defined boundaries
	Shared norms
	Past successful experience – social capital
	Appropriate leadership
	Interdependence among group members
	Heterogeneity of endowments, homogeneity of identities and interests

Group	Conditions
Resource System Characteristics	Small size
	Well-defined boundaries
	Low levels of mobility
	Possibilities of stores of benefits from the resource
	Predictability
	Low levels of poverty
Relationship between resource system and characteristics and group characteristic	Overlap between user group residential location and resource location
	High levels of dependence by group members on resource system
	Fairness in allocation of benefits from common resources
	Low levels of user demand
	Gradual change in levels of demand
Institutional arrangements	Rules are simple and easy to understand
	Locally devised access and management rules
	Ease in enforcement of rules
	Graduated sanctions
	Availability of low cost adjudication
	Accountability of monitors and other officials to users
Relationship between resource system and institutional arrangements	Match restrictions on harvest to regeneration of resources
External environment	Low cost exclusion technology
	Time for adaptation to new technologies related to the commons
	Low levels of articulation with external markets
	Gradual change in articulation with external markets
	Central governments should not undermine local authority
	Supportive external sanctioning institutions
	Appropriate levels of external aid to compensate local users for conservation activities
	Nested levels of appropriation, provision, enforcement, governance

This debate on common property and institutional arrangements has led to important conclusions. The empirical evidence showing different cases of successful governance of common property regimes highlighted the possibility of sustainable development by promoting the regulation of common pool resource use by local rules (Agrawal, 2001; Johnson and Johnson, 2004; Ostrom, 2011). The external control of resource use was no longer the only solution to the problem of the tragedy of the commons. Hence, contrary to Hardin's argument, state governance and private ownership were not the only types of property regime that could lead to sustainable use of natural resources. Rather, guaranteeing common property resource management regimes for the commons could have better outcomes for the environment as well as for local development (Ostrom, 2009). Two different yet complementary approaches stood out as the most important tools to address this

topic: Community-based conservation and Formalization of common property regimes.

1.2.2.1 Community-based conservation

The growing empirical evidence showing that natural resources would only be conserved or managed sustainably if local people and interests are motivated to do so for both ethical and utilitarian purposes (Rodríguez et al., 2007), deeply affect the conservation agenda. The underlying idea was that biological conservation is not just about direct linkages between biodiversity and local people's livelihoods, but about how people perceive and give value to such linkages (Salafsky and Wollenberg, 2000). Therefore, restrictions and negative impacts imposed on local peoples' livelihoods could trigger opposition to conservation initiatives and, sometimes, actively exacerbate impacts on the environment (Adams and Hutton, 2007).

Actions based on these ideas, started to be framed as community-based conservation or "the New Conservation" (Mace, 2014). Again, using Protected Areas as an illustration, it is possible to point out some important changes brought about by this movement. Beginning with the Third World Parks Congress in 1982. The Congress is organized by International Union for Conservation of Nature (IUCN) every 10 years. Their main goal is to define the most important strategies concerning Protected Areas Management. The Third Congress was important because its participants voted to replace the way they saw Protected Areas. Since then, Protected Areas have as their main goal to protect the natural resources **for** the people; very different from the old one, which stated that Protected Areas were intended to protect natural resources **from** the people (Padua and Chiaravalloti, 2012). Of specific regional importance was the creation of the concept and establishment of Protected Areas with Sustainable Use of Natural Resources that emerged in the Brazilian Amazon from rubber tappers movement during the 1980s (Cunha and Almeida, 2000). In the mid 1970s, in the Military Period, the Brazilian Government financed an "occupation of the Amazon" through National Integration Programs, such as construction of highways, loans for the establishment of cattle ranchers and logging companies in the region (Moran, 1993). However, the wave of migrants intending to

cut down the forest clashed with those who had migrated in the 1940s to work with rubber tapping and underpinned their livelihoods on the forest remaining standing (Calegare et al., 2014). The local rubber tappers group, led by Chico Mendes, became internationally known and started to claim territory to be protected against cattle ranchers and logging companies (Mittermeier et al., 2005). Their argument was that they were undertaking sustainable use of natural resources and, thus, actually, safeguarding the forest. To protect the region as well as the livelihoods of local dwellers living in the Amazon forest, in 1990, the Brazilian government created the first Protected Area of Sustainable Use of Natural Resources in the world (Calegare et al., 2014). The idea of protecting sustainable livelihoods of communities living in rural areas was one of the greatest innovations on the original USA's framework of modern protected areas (Kothari et al., 2013). It allowed the protection of larger regions encompassing both local peoples' territories and strict conservation (Mittermeier et al., 2005). Similar protected areas were replicated all over the world, and today 40% of all Protected Areas hitherto established share the same underlying idea that biodiversity conservation and use of natural resources can exist in balance within the same enclosure (Juffe-Bignoli et al., 2014; Kothari et al., 2013).

It is important to point out that, in many places, community-based conservation (CBC) or the "New Conservation", has been used to endorse and label as 'community-based' a whole range of conservation projects differing only very slightly from a strictly environmental approach (Dressler et al., 2010). Thus, rhetoric around embedding local development as a goal became widespread in conservation publicity and discourse (Berkes, 2007, 2004; Hackel, 1999). Therefore, even where labelled as community-based, some conservation efforts still displaced local communities and restricted access to land and resources, leading to the outcomes already highlighted: joblessness, homelessness, marginalization, food insecurity, etc. (Adams and Hutton, 2007; Dressler et al., 2010; Noe, 2013; Noe and Kangalawe, 2015). As presented:

> "the "win–win" approaches portrayed by conservation enterprises (good for wildlife, good for people, good for the economy, participatory, empowering and liberating)" did not produce the benefits they claimed" (Homewood et al., 2009, p. 247)

However, at the same time, there is no doubt that community-based conservation is a profound conceptual (paradigm) shift (Berkes, 2007, 2004). The idea that local livelihoods could be protected alongside biodiversity meant an enormous change on the way conservation interventions were carried out. Therefore, the current approach must be focused on ways to improve the effectiveness of those actions, otherwise, community-based conservation is unlikely to become a successful tool (Dressler et al., 2010).

1.2.2.2 Formalization of common property regimes

Another important movement that appeared since the 1990s, equally based on the same idea of local governance, was the basis for a great international effort into programs focused on securing access to land and guaranteed property rights through formalizing customary regimes (Zoomers and Haar, 2000). This approach is assumed to be a key element in tackling poverty alleviation and environmental conservation by international development agencies (FAO, 2012, pp.3). For instance, insecurity of land or resource tenure and lack of established property rights are singled out as the main causes of deforestation in the Amazon (Nolte et al., 2013), of failures to reduce poverty in Africa (Peters, 2004) and of the collapse of marine fisheries (Pauly et al., 2003).

The main approach to deal with these challenges has been to grant property titles and to set up modern land registries (Zoomers and Haar, 2000). It is claimed that the conversion of collective and customary land rights into formal, individual rights, and the creation of free land markets, in principle, gives poor people the ability to, on the one hand, formalize their customary governance and harmonise it with dominant western concepts of property regimes, and, on the other, allow them to sell or rent land to third parties or to use land as a collateral for credit (De Soto, 2001). Moreover, security of tenure is presented as a prerequisite for the establishment of protected areas, payment for ecosystem services projects and for most biodiversity protection schemes focused on specific sites (van der Ploeg et al., 2016). In Afghanistan alone the US international development agency USAID, invested USD 56.3 millions between 2004 and 2009 on a program focused on Land titling (Manila,

2009). The Brazilian Government plans a similar investment, claiming that deforestation in the Amazon will only end when ownership is established across the area (MMA, 2013).

However, such approaches have precipitated outcomes rather different from their stated purpose. The liberalisation of land markets led to land grabbing, with foreign investors buying land to expand forestry, mineral extraction and commercial plantation projects in and around the global south (Borras et al., 2011). In 2007, USD 500 billion was invested in developing countries; most of this went to those industries (Zoomers, 2010). Locally, the consequences involve replacement of small scale economies and natural areas by intensive resource exploitation (Nayar, 2012). Empirical evidence shows that in many cases far from improving local people's wellbeing, land titling has increased environment impact (Mittermeier et al., 1990; Sjaastad and Cousins, 2009; van der Ploeg et al., 2016).

1.2.3 "From Hardin to Ostrom": conclusion

The idea of governance in common property regimes became one of the most important findings of the late 20th century; in 2009, E. Ostrom became the first women to receive a Nobel Prize for Economics due to her work on governing the commons (Forsyth and Johnson, 2014). Her compilation of empirical evidence was fundamental to deconstruct Hardin's claim that common property regimes must be regulates through external interventions in order to avoid their collapse. In other words, Ostrom, building on Berkes and others, it brought to light possibilities of sustainable use of natural resources based on internal and customary governance.

However, Ostrom's new institutional economics and 'economically rational man' theory of common property is unlikely to fully operate on the ground given the social and historical particularities shaping any one case in reality (Johnson and Johnson, 2004). Few real situations can be manipulated or constructed to fit with the several sustainability conditions proposed by the theoretically ideal institutional arrangements. The notion that common property resource management is based just on the idea that individuals overcome their tendency to evaluate their own benefits and costs more intensely than the total benefits and costs for a group (Ostrom, 2011)

is an instrumental and historically de-contextualized understanding of common property relations (Campbell et al. 2001). Therefore, it is important to take into account socio-historical factors and environmental complexity in understanding successes and failures of common property regimes. The simple formalization of customary governance and its re-formulation within western concepts of governance, especially through land titling or embedding local people inside Protected Areas, is likely to have limited success in establishing sustainability.

1.3 Small-scale inland fisheries management

The complex interaction among property regimes, customary governance and sustainability and the failure of management policies to tackle sustainability is seen globally. However, such interaction in enhanced in some socio-ecological, such as small-scale inland fisheries. Hardin coined the term "Tragedy of the Commons" partly exemplifying his theory using fisheries, and even earlier, fisheries were used in economic evaluations in order to define the concept of common property regimes and the possible outcome of it on resource use (Gordon, 1954). Hence, since this debate was embedded into the conservation/development agenda, and give the evidence for catastrophic overfishing in marine commons, fisheries stood out as one of the most important sectors needing external sanctions to avoid collapse (Berkes, 1985). However, although fishing has been part of the global conservation agenda since the beginning of the 20th century, with much effort put into developing tools and techniques for accurate evaluation of the status, economic significance and best conservation practices, they have been mainly focused on industrial fishing (Pauly et al. 2003; Norse et al. 2012; Watts et al. 2009; Costello et al. 2016). Small-scale fisheries have been largely overlooked, and management approaches transposed from marine systems to focus on inland fisheries have had limited if any success (La Valley and Feeney, 2013).

Small-scale inland fishing plays a fundamental role in nutrition, livelihoods and poverty alleviation in the global south (Béné et al., 2016). For example, in Southeast Asia, the Mekong River encompasses six countries, maintains the world's largest inland fisheries, and supplies 50-80% animal protein for 65 million people regionally (Dugan et al. 2010). In the Brazilian Amazon floodplain, among the 6 million people

living in the forest, 84% households engage in fishing, representing 40% of local people's income (Almeida et al. 2002). For instance, the simple definition of land tenure in the north-eastern region of the state of Pará of roughly 105,000 ha, has led to the legalization and social inclusion of 9,309 riverine families (Pinedo-Vasquez et al., 2011). Even in the drylands of sub-Saharan Africa, fish represent a fundamental part of local people's livelihoods and diets. In Senegal alone the estimated annual value of fish from two of the three main rivers was between USD 19 - 26 million (FAO 2016). Across the Lake Chad basin, fisheries provide 45% of regional household income, amounting to USD 45.1 million per year (Young et al. 2012). Similarly, Lake Victoria produces about 1 million tonnes of fish per year (Kolding et al. 2014). Moreover, small-scale fisheries play a remarkable role in poverty alleviation through their capacity to absorb surplus labour and as an alternative protein supply when other sources fail (Béné, 2009). It is important to note that the Pantanal faces a different reality from most floodplain fisheries. 95% of the region is privately owned and the majority of riverine areas are occupied by cattle ranches (Mittermeier et al., 1990). The most populated area is the Western Border of the Pantanal, in which it is estimated that roughly 1000 people live throughout the Paraguay riverbank (Amâncio et al., 2010; Neuburger and Silva, 2011).

However, catch statistics used to assess species stocks in small-scale inland fisheries are based on industrial practices. For instance, most catch evaluations used to estimate socio-ecological parameters do not take into account the fact that inland fisheries landings are essentially dispersed among different ports (Cowx et al., 2004). As a consequence, small-scale inland fisheries catches, fish population trends, fishers effort, spatial use, and other measures of fishing activity are thought to be greatly underreported (Welcomme et al. 2010; Cooke et al. 2016). Management practices are similarly based on approaches developed for industrial fisheries, largely predicated on models disconnected from the complex realities of artisanal fisheries and inadequate to predict changes in fish species assemblages and local livelihoods (Welcomme 1999). An interesting example of this disjunct between small scale inland fisheries realities and the management practices applied to them is seen in Systematic Conservation Planning (SCP).

1.3.1 Systematic Conservation Planning and socio-environmental complexity of inland fisheries

The prioritization of conservation actions through a multi-stakeholder process, or simply Systematic Conservation Planning (SCP), is considered one of the most important steps towards sustainable development (Brooks et al., 2006; Margules and Pressey, 2000; Smith et al., 2006). The approach is underpinned by the idea of community-based conservation, in which the needs of local people are weighted equally with the conservation goals (Mazor et al., 2014). The possible outcomes of such an approach could, indeed, be outstanding. For instance, Protected Areas, the most common tool for conservation biology, constantly face claims that they lead to a rather different outcome than that which planners intended. The scientific literature documents cases of physical and economic displacement (West et al., 2006). Moreover, the effectiveness of those protected areas is constantly challenged. There are several concerns, such as the negative shifts in conservation status due to downsizing, downgrading and degazettement in recent years (Bernard et al., 2014), reduction in game populations inside National Parks (Ogutu et al., 2011), and overuse of natural resources of Sustainable Use Protected Areas (Peres et al., 2003). In that regard, multi-stakeholder prioritization has the potential to be used in forecasting local conflicts to anticipate and minimize them before they arise. Moreover, the participatory nature of the process is equally promising. Partnerships are crucial in an equitable conservation approach. For instance, the effectiveness of protected areas is strongly linked with the presence of partnerships with local communities and other stakeholders (Adams & Hutton, 2007; Chiaravalloti et al., 2015; Reed, 2008).

In spite of the wide use of SCP, few places have seen the proposed solutions implemented. A systematic review indicates that only 5.7% of peer-reviewed papers describing SCP documented the implementation of some kind of conservation action (Knight et al., 2008). The reasons for this gap between research and implementation of SCP are manifold (Toomey et al., 2016). Knight et al. (2011) point out that the challenges of implementing SCP are mostly related to human, social and institutional factors rather than technical issues. However, others argue that it is not a simple matter of incorporating more local participation into the SCP (Linke et al., 2011).

There are methodological challenges inherent in the understanding of socio-ecological systems that need to be overcome (Sowa et al., 2007).

SCP for freshwater ecosystems stands out as a field still requiring a lot of development (Abell et al., 2007; Linke et al., 2011; Runge et al., 2014). Freshwater systems are characterized by longitudinal and lateral connectivity; therefore, any effective conservation measure needs to consider the connectivity between upstream and downstream areas, catchment ecosystems and land use and between different water bodies (Linke et al., 2011). However, most SCP algorithms are not able to encompass such complexity (Sowa et al., 2007). Environmental variability, as well as species migration and dispersion, challenge the underlying assumption of SCP that species or ecosystems are static in space and time (Runge et al., 2014). In fact, although SCP has been applied in most ecosystems, it was developed for Marine ecosystems, in which such parameters may be only partially relevant (Abell et al., 2007). Recently, there have been improvements in that regard. There are case studies considering the probability of species presence making it possible to deal with species mobility (Carvalho et al., 2011) and new algorithms, such as neighbourhood quality penalty, used to force the software to consider connectivity of river systems (Moilanen et al., 2008). Additionally, for wetlands, scholars have started to consider the historical frequency of floods in SCP (Lourival et al., 2011, 2009).

On the other hand, although there are similar challenges to deal with the social aspects of freshwater SCP, there have been few improvements. In freshwater SCP, social needs are mostly represented by economic gains, such as total income or fish catch (Esfandeh et al., 2015; Whitehead et al., 2014). Equally, in industrial marine fisheries, for which SCP tools were developed, such parameters are, in general, the most important. However, freshwater fisheries involve a different reality. They are mostly carried out by small-scale communities for subsistence and local trade using artisanal techniques. For instance, although inland fishing represents only 13% of wild fish capture worldwide (FAO, 2014), it is estimated that 56 million people are directly involved in inland fisheries across the developing world, surpassing the estimated 50 million people who depend on fishing in coastal areas (Welcomme et al. 2010). Moreover, due to the dynamic features of freshwater systems, fishers living in freshwater systems perform complex adaptations, such as flexible

livelihoods, different intensity of use throughout the year and flexible spatial use (Allison and Ellis, 2001). However, most of these parameters have been ignored in the application of SCP to freshwater systems (Stephanson and Mascia, 2014).

1.4 Case studies and new perspectives of inland fisheries management

Abbott and Campbell (2009) document a telling example of the complexity involved in socio-ecological systems of inland fisheries. In the Upper Zambezi River Floodplains, local people started to use government-issued mosquito nets for fishing. This method, used mostly to catch small fish, was widely seen as driving the area's fish stocks into decline. However, researchers uncovered a more complex situation. While the Zambian Government accused local fishers of using damaging fishing methods, local Zambian communities accused foreign Namibian fishers of overfishing, and Zambian fishing lodge owners accused all non-tourist fishers of unsustainable practices. However, ecological research revealed that changes in fish stocks were overwhelmingly driven by the biophysical effects of (variable) flooding events, not by local fishing practices, which were not leading to overuse, despite the mosquito nets.

The case of the Upper Zambezi River Floodplain highlights a central issue common to many wetlands. Continual transitions between flood and drawdown states create a highly unpredictable system with unique features (Junk et al. 1989). It has been argued that socio-ecological systems constantly facing environmental changes, such as floodplain fisheries, challenge established ideas of property regimes and sustainability (Moritz et al., 2013). According to Moritz et al., (2015, 2014, 2013), in some systems, common pool resources in such systems are shared through an "ethos of open access" with no customary restriction on use, leading, nonetheless, these authors suggest, to sustainability. For example, in the Logone Floodplain, Cameroon,

> "open access does not have to lead to a tragedy of the commons […]. In a sense, management of open access is not an oxymoron because there are clear rules about who has access to the common-pool grazing resources (all pastoralists) and who can be excluded (no one)." (Moritz et al., 2013, pp. 356),

> "Management of open access is not limited to pastoral systems. There is evidence that other resource systems with open access to common-pool resources may also work as self-organizing systems" (Moritz et al., 2015; pp. 62).

> "in many cases these systems are best described as open access because there are de facto no restrictions on access and use, but that researchers may have been searching for some regulation as evidence of common property regimes where there is none, and afraid to use the label open access because of all its negative connotations." (Moritz et al. 2013, p. 352)

These concepts remain poorly understood. For instance, whether Moritiz's postulated "Management of Open Access" is a valid new category of property regime and a more accurate understanding of reality is yet to be proved (Behnke et al., 2016; Thébaud, 1995). However, regardless of the debate around the theoretical concept of property regimes and their potential outcomes for sustainaing, managers and policymakers worldwide commonly assume the same narrative of local overuse of resources that Abbott and Campbell (2009) challenged for the Zambezi River floodplain. Indeed, such narratives are often strategically deployed to argue vested interests (Abbott and Campbell, 2009; Homewood, 1994). Claims of overfishing, bushmeat overhunting or desertification may be less evidence-based, than power plays by different interest groups (Robbins, 2012; Sullivan and Rohde, 2002). Scientific evidence to support or reject specific claims offers one set of tools to deconstruct these narratives (Gray and Campbell, 2009), in a fundamental step towards better local natural resources management and development (Neumann, 2011). This is especially important for floodplain fisheries, on which millions of people depend but for which there is limited understanding of customary regimes, ecological drivers and impacts of use.

1.5 The conflict over use of natural resources in the Pantanal wetland

This thesis focuses on a salient but little studied example. The Pantanal, a 160,000 km^2 wetland covering three countries in South America (Brazil, Bolivia, and Paraguay), is also seen in terms of this same environmental narrative of overuse by small-scale fishers. Conflicts between conservation agencies, private ranchers, tourism industry, government and small-scale fishers undermine sustainability and

also local development opportunities. Currently the mix of private, state, and customary property tenure, alongside the effects of seasonal inundation creates ambiguities and overlaps, which allow unsubstantiated narratives to gain tractions in the absence of strong evidence.

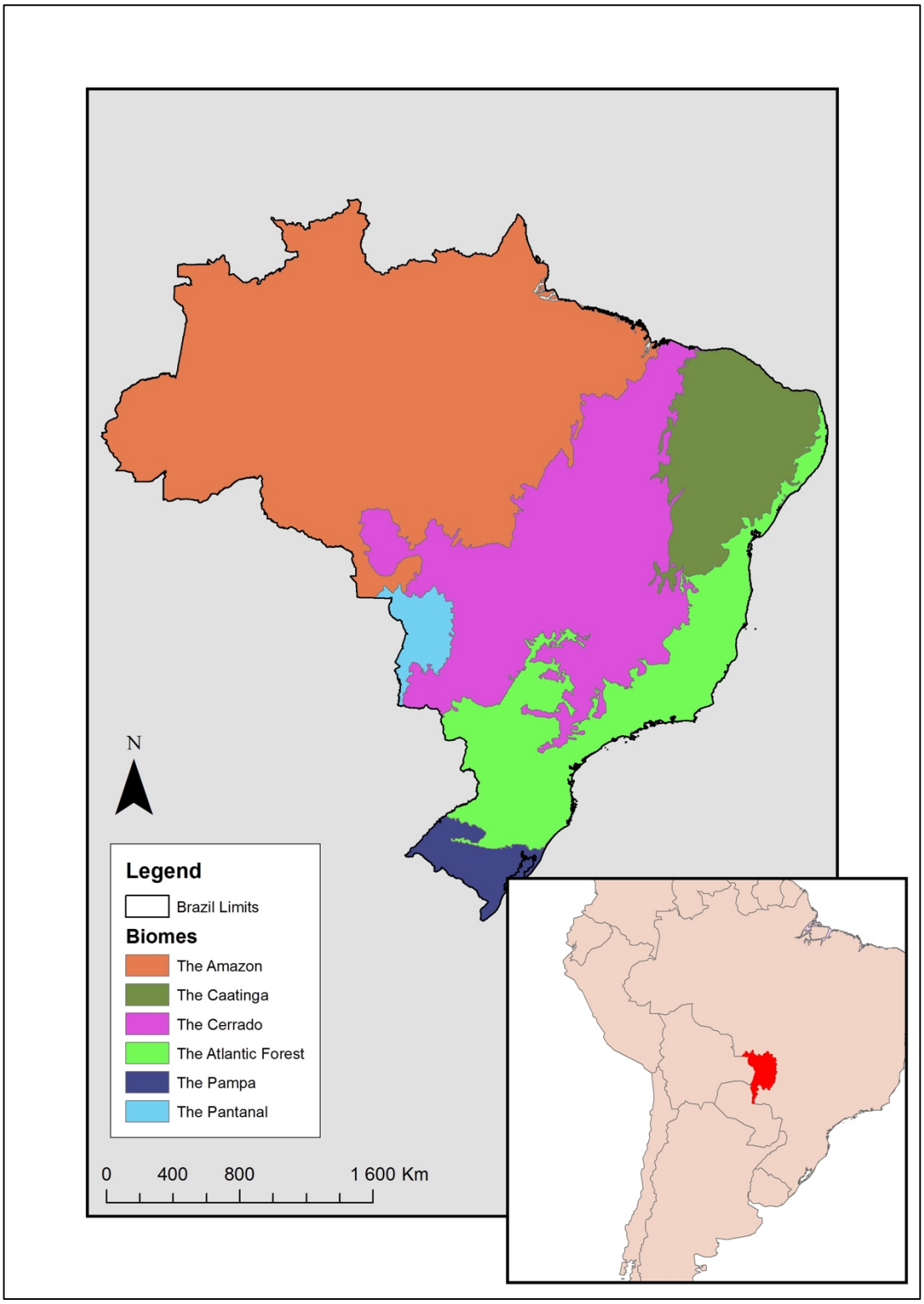

Figure 1-2: Brazilian biomes colour-coded according to their limits. Inset: location of the Pantanal in South America.

1.5.1 Colonization, land titling Protected Areas in the Pantanal

The Spanish were the first to colonise the region of the Pantanal in the 16th (Oliveira, 2003). Due to the presence of a vast inundated area, they initially thought the region was an inland sea, calling it Xaraés Sea (Costa, 1999). Following the exploration of the region and, consequently, a better understanding of the ecosystem, the name was replaced by "Laguna de Xaraés" (Lake Xaraés) (Figure 1-3). The Portuguese Empire conquered that region from the Spanish in the 18th century; after initial military occupation they started to give land to people willing to settle in the area (Costa, 1999). The first land was given in 1727 (Silva and Silva, 1995), and soon the first cattle ranches were established, with accounts of cattle already emerging in 1737 (Abreu et al., 2010). Nonetheless land title was only ratified in 1850 through the "Law of Land" in an attempt to formalize the occupation promoted during the 18th century (Silva and Silva, 1995).

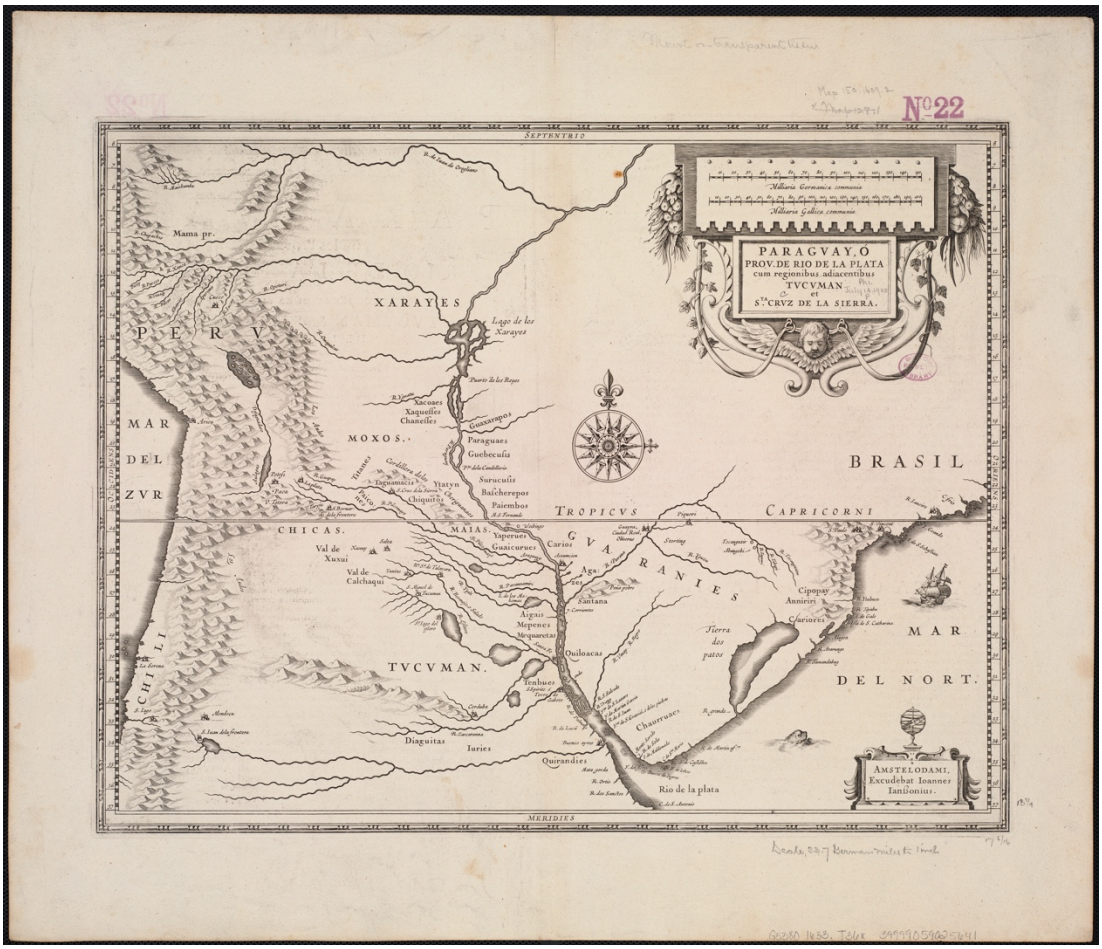

Figure 1-3: Map from 1633 produced by Spanish Explorers showing the Pantanal at the centre of the map with the name "Laguna de Xaraés". Source: Boston Public Library/Maps of the world.

Although formally occupied, it took another three centuries for the Pantanal region to be integrated into the national economy. It was only in the 1960s and 1970s during the Brazilian Military Period, that the Government started to promote the local economy through national plans of integration, such as: National Rural Credit, Development Council of Beef Cattle and construction of highways connecting Brazil's north and south, west and east (Franco et al., 2013; Silva and Silva, 1995). In the Pantanal, after these plans were put into action the production of cattle went from an offtake of 700,000 to 5,000,000 animals annually in the beginning of the 1970s (Abreu et al., 2010). The expansion of cattle ranches was favoured by a coincidental sequence of dry years in the Pantanal. From the early 1960s till the middle 1970s was the driest period ever recorded; low flood levels exposed and maintained a great abundance of natural grassland (Mourão et al., 2010). In the 1970s, following international pressure on the Brazilian Government to better protect

its natural ecosystems, made salient by an increase in deforestation of the Amazon, many Protected Areas were created (Silva, 2005). The Pantanal saw its first Strict Protected Area in 1971, the Biological Reserve of Caracará (Reserva Biológica do Caracará), located in its Western Border (Bello, 2014).

In 1974, however, the region faced major changes. A large flood inundated most of the grasslands and reportedly killed half of the Pantanal's cattle population (Junk et al., 2011). The extent of annual floods and permanent flooding has remained high in the three decades since then and in the western region, where water is retained as large lakes (Padovani, 2010), many farmers went bankrupt (Tocantins, 2011). In the face of economic collapse in the region and increasing international pressure from high-profile environmentalists (Schaller and Vasconcelos, 1978), the Brazilian Institute of Forest Development (Instituto Brasileiro do Desenvolvimento Florestal – IBDF) established a project, in 1975, buying these farms to expand the Biological Reserve of Caracará (Couto et al., 1975). In 1981, the Federal Government replaced the Biological Reserve for the Federal National Park of the Pantanal (Parque Nacional do Pantanal), expanding the area protected from 80,000 ha to 130,000 ha (IBAMA, 2003). 10 years later, in the early 1990s, with support from the NGO The Nature Conservancy, three other large farms were bought and converted into Private Protected Areas (Reserva Particular do Patrimonio Nacional – RPPN) (Bello, 2014; Tocantins, 2011). In 2005 and, then in 2006, two other Private Protected Areas were aggregated, leading to the establishment of the environment group "Protection and Conservation Network for the Amolar Region" (Rede de Proteção e Conservação da Serra do Amolar – PCNAR). This is a partnership among all Protected Area managers, including the federal agency of Protected Areas, NGOs and local Forest Policy agents, aiming to monitor resource use across 310 km linear river distance and adjacent channels, securing strict conservation of 262,000 ha of Protected Areas in the Western Border of the Pantanal (Bertassoni et al., 2012) (Figure 1-4)

However, although the creation of PCNAR increased biodiversity protection across the region, it also at the same time enhanced a conflict with fishers living in the Western Border of the Pantanal (Chiaravalloti, 2016). Local fishers claim that during the creation of Protected Areas, they were physically and economically displaced

from their original settlements and, currently, with the creation of the protection group, they are restricted from using fishing sites of fundamental importance for their livelihood (ECOA, 2013). There are around 600 dwellers divided into 3 settlements in the Western Border of the Pantanal. However, it has been argued that fisher population was until recently much bigger, but it has been have drastically reduced in the last few years, partly due to the displacements (Amâncio et al., 2010).

On the other hand, Protected Area Managers and local supporters argue that these so-called fishers are, in fact, squatters. For instance, Franco et al., (2013) claim that there have never been fisher communities in the Western Border of the Pantanal. According to their view, the current dwellers appeared in the region after 1974, when the great flood covered part of the region leading some ranch workers to move to the riverside and switch their livelihood to fishing. Therefore, it is suggested that fishers were neither displaced nor is fishing is part of their traditional customs. Moreover, it is claimed that fishers have no system of local governance that might otherwise ensure a sustainable use of natural resources. However, hitherto, there is no empirical information supporting or deconstructing any of these claims, as to whether fishers have a historical presence in the region and/or carry out customary governance of natural resource use, nor whether they have migrated to the region after losing their jobs in nearby farms.

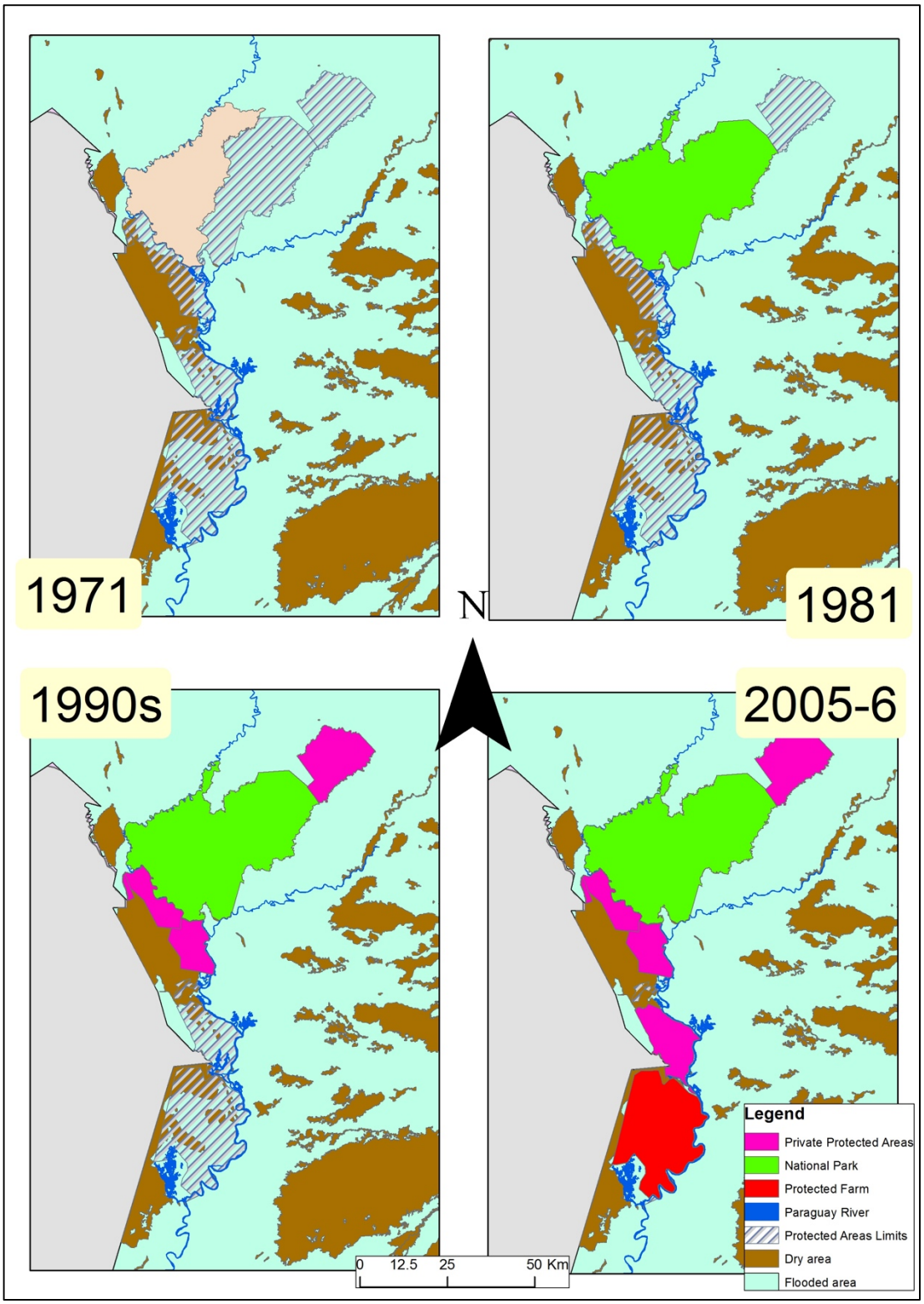

Figure 1-4: a) top left (1971), the first Protected Area created in the Pantanal in 1971 - The Biological Reserve of Caracará. b) top right (1981), the National of the Pantanal that expanded the previous Biological Reserve; c) bottom left (1990s), the first Private Protected Areas created extending the areas protected in the Western Border of the Pantanal; d) bottom right (2005-6), all Protected areas, the Protected Farm is shown in red.

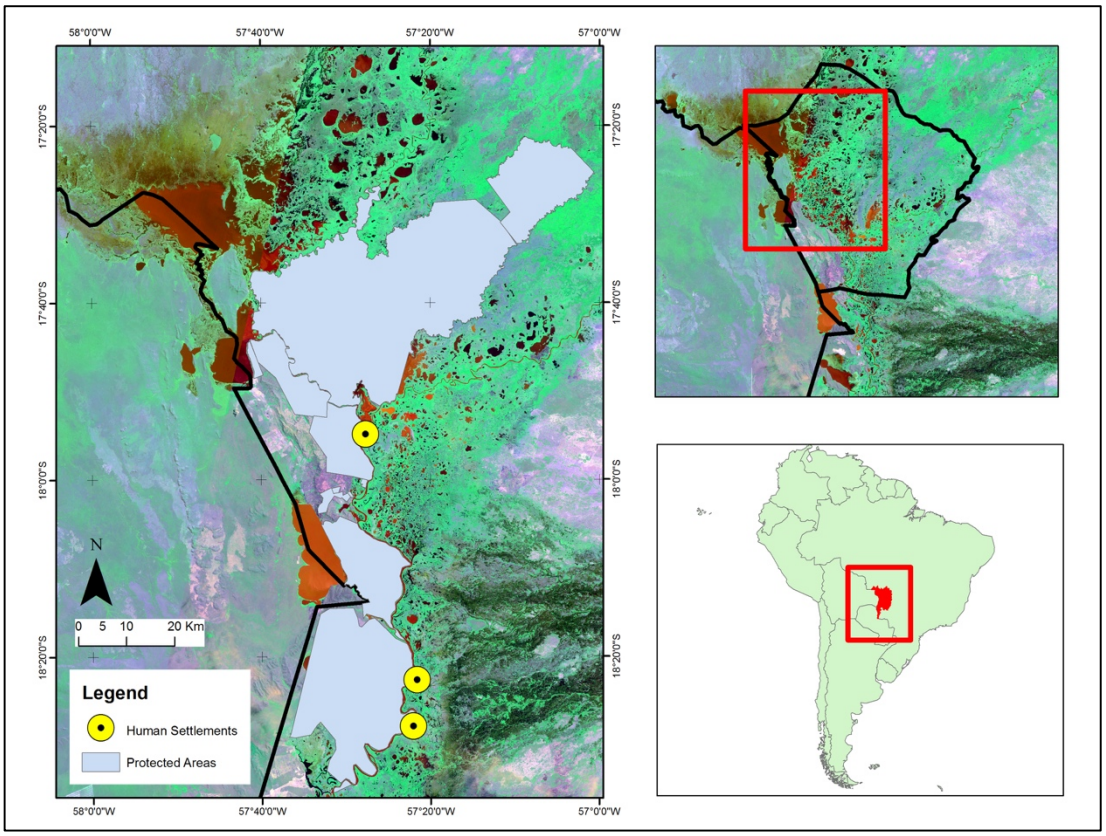

Figure 1-5: The current location and extent of Protected Areas and Human Settlements. Numbered 1, 2, and 3 from North to South. Inset: location of the Pantanal in South America (bottom right) and location of the Protected Areas in the Study Area (top right).

1.5.2 Claims of overfishing

Apart from being accused of invading the Protected Areas region, for roughly the last 40 years, local fishers have been under constant pressure to stop fishing. Decision makers, environmentalists and local businessmen have accused them of overfishing (Silva, 1986), as a consequence restrictive laws have been imposed to reduce their assumed impact on the fish stock (Figure 1-6). The first regulations rose in the state of Mato Grosso do Sul (MS), Southern Pantanal (Catella, 2003). There, between 1983 and 1994 three different laws were established to forbid the use of any kind of fishing net. In the Northern Pantanal, the state of Mato Grosso (MT) followed the same approach banning fishing nets in 1987. At the same time a new tourism fishing business emerged in the region. In a short period this became one of the most important drivers of the local economy (Girard and Vargas, 2008). For instance, in 1999, in the state of MS (the only one where they record annual data), 59,000 tourists were coming every year to fish in the region (Albuquerque et al., 2011).

After 2000 the tourism industry started to collapse, and already by 2006 the numbers of tourists coming decreased to roughly 15,000 people / year (Albuquerque et al., 2012). Local companies started to argue that there were no tourists because there were no fish and revived the same narrative of local, small-scale commercial fishers overfishing (Alho and Sabino, 2012; Franco et al., 2013). As a consequence, in 2006, the state of MT prohibited the use of "anzol de galho" [set hooks] (the most important fishing technique in the region allowing fishers to set several fishing gears at the same time) and banned local people from gathering live bait (Catella, 2003), a major livelihood activity. In 2014, MS's prosecutors also called for a legal ban on the use of set hooks invoking the great damage it causes in a "*fishing stock already overused*"[3]. The Brazilian Federal Supreme Court accepted their arguments and forbade the use of this technique all over the Pantanal. Although there is still a long way to go in putting this new law into practice in MS, legally, today, local small-scale commercial fishers in the Pantanal can only use line and hook to sustain their livelihood; and those who decided to continue gather bait may only do so in the southern region of the biome. Some authors claim that local fishers were driven to migrate to nearby cities (Amâncio et al. 2010) or to seek alternative livelihoods locally, with many starting to work for the tourism trade, as guides to fishing spots (piloteiros) or bait suppliers (Catella et al. 2014).

[3] http://www.correiodoestado.com.br/cidades/stf-considera-inconstitucional-lei-que-permitia-abusos-nos-rios-do/245405/ (accessed on 18/11/2016)

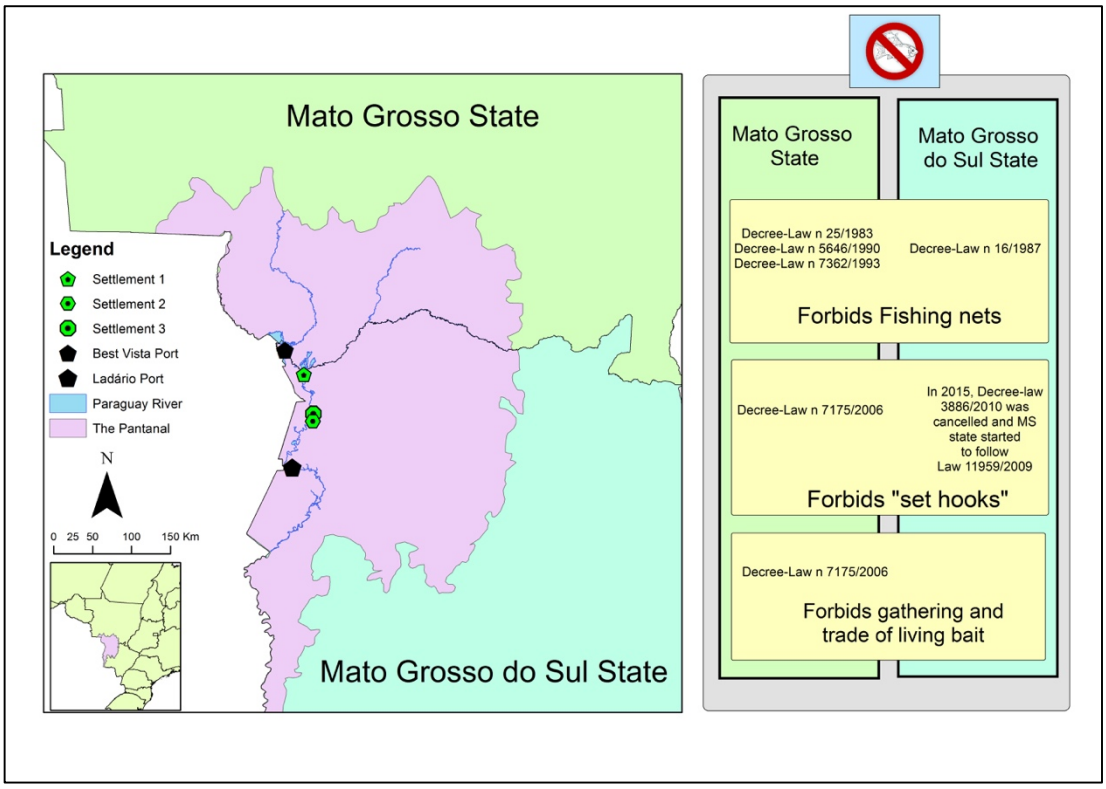

Figure 1-6: Location of the Pantanal and the states of Mato Grosso (MT) and Mato Grosso do Sul. The table on the right shows the different legislations for each state imposing restrictions on small-scale commercial fishing.

1.5.3 Pantanal case study: conclusion

The Western Border of the Pantanal has been part of the conservation agenda of NGOs, government, private sectors, and conservation practitioners since the early 1970s. Conservation there has intensified in the last few years through both the expansion of the Protected Areas and tougher legislation on fishing. At the same time, local fishers claim that, as a consequence of these interventions, their livelihood have been jeopardized. However, hitherto, no empirical research has been carried out in the region to support of deconstruct any of these claims.

This thesis thus addresses the following research questions arising from the literature review:

1.6 Research questions

Who are the fishers living in the Western Border of the Pantanal?

- Are local people recent in-migrants?
- Is fishing a new activity in the region?
- What are the different types of livelihoods in the Western Border of the Pantanal?
- Should local fishers in the Western Border of the Pantanal be labelled as part of the Pantanal's Local Communities?

To what extent do current management practices in floodplain fisheries, focused on regulating overfishing, map onto local realities?

- Is the claimed link between decline in tourist numbers and overfishing is backed by evidence?
- What evidence is there for overfishing in the Pantanal?
- How is small-scale local commercial fishing adapted to the flood pulse?
- Are there customary rules to control overfishing and what are the likely effects?

What is the relation between sustainability and land tenure in floodplains?

- How do Pantanal property systems map onto the region's unpredictable, dynamic ecosystem?
- Is the conflict in the Pantanal will be resolved through setting defined ownership and rights to exclude through land titling?
- How can the integration of economic, anthropological and ecological approaches help to address land conflict in Brazil's Pantanal?

To what extent are local people's needs captured in prioritization models? Systematic conservation planning in freshwater floodplain systems

- What is the relative importance of data on local people's territory and economics for systematic conservation planning in floodplains?
- To what extent do local people concur with the zoning models produced by Systematic Conservation Planning in the Pantanal?
- Is Systematic Conservation Prioritization a promising solution for management of resource conflict in floodplains?

Chapter 2 The Pantanal environmental features

2.1 Abstract

This chapter describes some important environmental features of the Pantanal. First it presents some characteristics of local biodiversity. It goes on to describe the flood pulse and the differences of extent of the inundation within and among years. It proposes a simple model to forecast the location of the flood pulse in each given time and to calculate the flood pulse speed. It explains how some species of fish that play an important role on local people's livelihood react to the inundation. and how access to those resources changes. The chapter finishes by explaining changes through time in the Pantanal landscape and how this may affect local people's access to fishing sites.

2.2 The Pantanal

The Pantanal is considered one of the biggest wetlands in the world, shedding three countries and emcompassing over 160 000 km^2 (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 (Junk et al., 2011). 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, with is less than 17% have been lost (IBAMA, 2012). It is a fact that the Pantanal hosts healthy populations of locally threatened and endangered species such as Jaguar (*Panthera onca*) (Cavalcanti et al., 2012), Marsh Deer (*Blastocerus dichotomus*) (Mourão et al., 2000), and Jabiru Stork (*Jabiru mycteria*) (Mourão et al., 2010).

2.3 The flood pulse in the Pantanal

The flood pulse is the main environmental feature of the Pantanal, all species and local people with natural resources dependent livelihoods are directly or indirectly affected by it. The flood pulse is a direct consequence of the rainfall on the surrounding highlands (the Maracaju, Guimarães, other mountain ranges) between

October and April (Padovani 2010). Once the waters reach the border of the floodplain they move slowly from East to West towards the main rivers in the region, The Paraguay, Taquari, and Negro rivers. In the northern region, however, this process is more intense: due to the geomorphological barriers and presence of big lakes in the area, there is a larger concentration of water, which creates a flood wave travelling from North to South (Alho and Sabino, 2012). As the water drains from East to West across the region, the flood wave starts its movement throughout the Paraguay River basin, inundating huge areas and merging with other localized waters all over the floodplain. The overall wave keeps moving south draining away from the areas it has passed over, eventually flowing out and away from the floodplain area, yet not before inundating hundreds of km^2 in the Southern Pantanal. Due to the slight gradient of the terrain in the Pantanal (2–3 cm/kilometre north to south, and 5–25 cm/Km in east to west) this process, or flood pulse, takes between 3–4 months to pass through (Junk et al., 2006) (Figure 2-1).

Figure 2-1: Child on a canoe over a football pitch during the inundation period in the Pantanal. (Photo A. Siqueira).

2.4 Time flow of the flood pulse in the Western Border of the Pantanal

The time of year that the flood pulse reaches each site varies a lot (Cunha and Junk 2011; Junk et al. 2011). It is not uncommon to see a difference of more than one month on in any site in the time of the flood and dry periods between successive years. In other words, the exact days of the beginning and end of the flood period and, therefore, its duration differ from year to year. Flood level data are recorded every day by the Brazilian Navy and are available to download from their website[4]. These data are measured in several locations throughout the Paraguay River. Figure 2-2 shows the level of the Paraguay River measured in the most important Port in the region, Ladário Port, for: 2012, 2013 and 2014. Looking at the flood pulse peak data marked by a coloured line in each curve, it is possible to see, for instance, that in 2014 the flood reached its peak 42 days before 2012 at this location, and was bigger than the 2013 and 2012 floods. Therefore, it is, only possible to evaluate the specific time/location of the flood pulse on a year-by-year base.

[4] https://www.mar.mil.br/cfpn/

In order to clarify this aspect, a simple model of the movement and speed of the flood pulse was created for the year 2014. The analysis focused only on the Western Border of the Pantanal in the region of the three human settlements and Protected Areas.

In this region, there are two different sites where river level data are recorded daily. One is located in the northern region (Bela Vista Port), and the second one in the southern region (Ladário Port). The first step was to estimate the river distance between them using satellite images with a 5-metre pixel resolution. The total distance was 265.01 Km. Secondly, using the river level data, the exact day of 2014 that the water started to drop steadily in both Ports was established, that is the day that the flood-pulse peak started to move south. For Bela Vista, this was 23rd of May (day 143 of the year) and for Ladário it was 24th of June (day 175 of the year). This information allowed estimation of the flood pulse time lag between Bela Vista in the north and Ladário in the south (32 days). Finally, dividing the distance by the difference of the flood pulse peak date between the two, it was possible to establish the average flow of the flood pulse in the Western Border of the Pantanal between Bela Vista Port and Ladário Port for 2014, which was 8.2 Km/day. In other words, in 2014, the flood pulse moved on average 8.2 km southwards every day. A similar approach was used by Valverde (1972), using data from 17 years between mid 1960s and 1970s, he showed that the average flow was 9 Km per day.

It is important to point out that the model created assumes the flood pulse as an isolated pathway between the two sites pushing the water on a constant speed on north-south direction. However, although the flood pulse in the Western Border of the Pantanal indeed starts in the northern region and finishes in the southern region, behaving like a flood wave (Alho and Sabino, 2012) and in the Paraguay River the drainage of different sites have a correlation higher than 80% (Padovani, 2010), there are other localized floods and/or natural changes that can speed up or slow down the flood flow. Therefore, the flood pulse speed is not constant as presented in this simplified model. The only way to achieve a more accurate analysis would be by evaluating water cover through satellite images of the year based on the changes of water cover month by month. To do so all images (or most of them) should not have

a cloud cover bigger than 40% (Jung et al., 2011). Unfortunately for the year 2014 only two images from the twelve-analysed met this assumption.

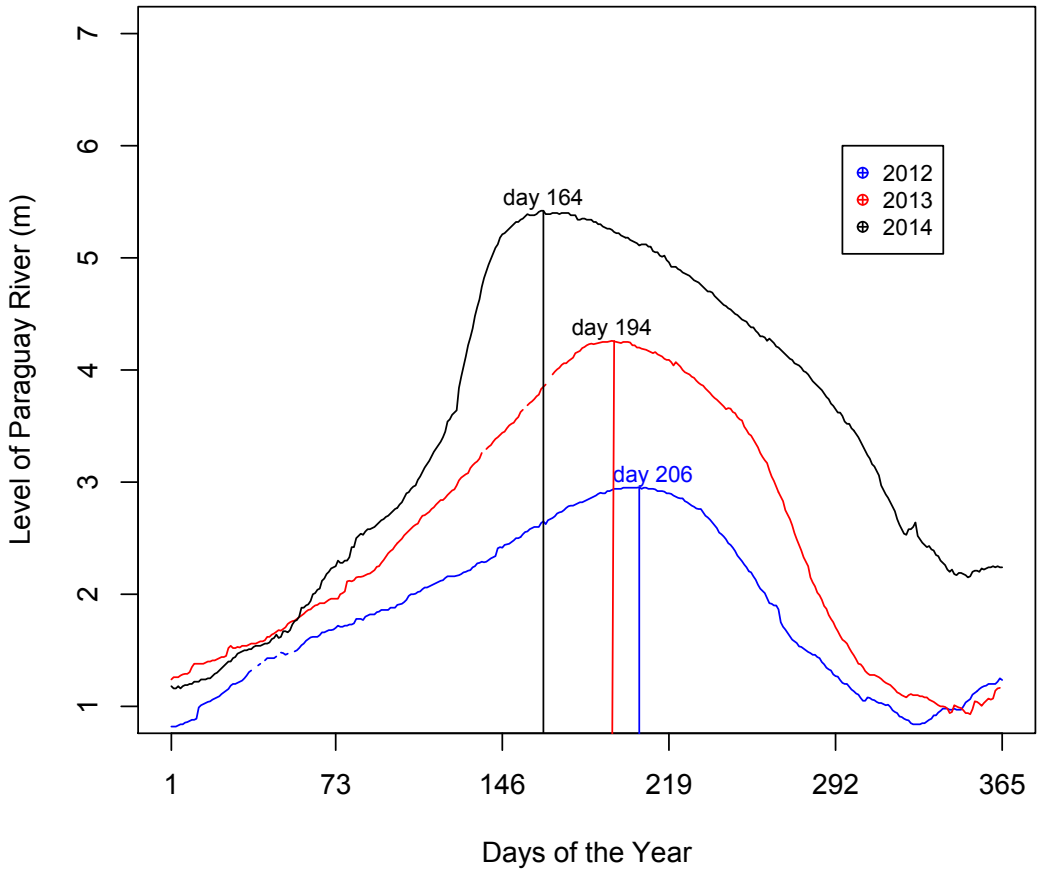

Figure 2-2: Paraguay River levels for 2012 (blue), 2013 (red) and 2014 (black). The lines highlight the day that the river reached its highest level, corresponding to the flood pulse peak. Gaps in the curves are missing values. All data were collected in Ladario Port. Source: www.mar.mil.br/cfpn.

2.5 Changes between years

Another feature of the flood pulse important in understanding natural resource distribution is the size of each year's inundation. The Pantanal catchment area is situated within a belt of very variable precipitation, and depending on the quantity of rain, the flood size and the extent and distribution of areas that will be covered by water differ from year to year (Junk et al., 2011). One useful way to look at this variation is through the hydrologic index, which can give a measure of both the

intensity of flooding and the severity of dry periods (Poff and Zimmerman, 2010). For the Pantanal, a combined index (dry and flood periods) was created in order to make the outcomes more straightforward to analyse and understand, as proposed by Mourão et al., (2010). It was calculated simply by summing up of all daily Paraguay River water levels (in meters) measured at Ladário Port, to produce the annual hydrologic index (AHI). AHI thus expresses the extent and duration of each year flood in the Pantanal. Figure 2-3 shows all AHI index from 1900 to 2014. From the graph, it is possible to visualize the great variation of the flood size among years. For instance, the Pantanal went from a dry run of years (mid 1960s-mid 1970s) to a period of big floods (mid 1970s to mid 1990s). Hamilton et al., (1996), did a similar analysis using remote sensing, and found that from 1900-1996 the inundated area at peak flood varied by an order of magnitude from approximately 11 000 km^2 to 110 000 km^2.

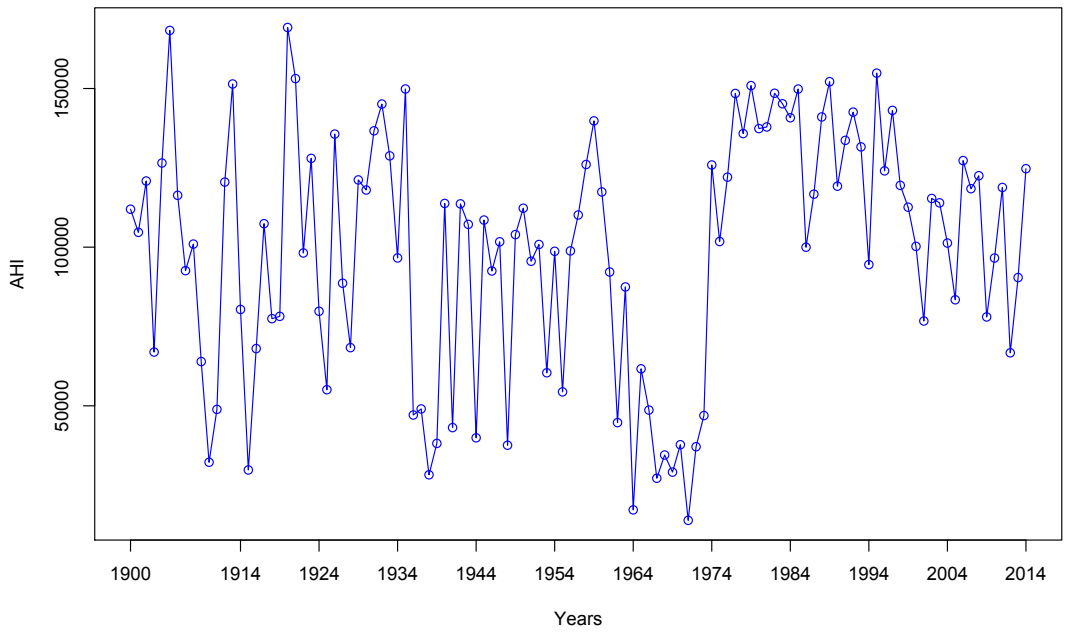

Figure 2-3: AHI index 1900 - 2014. The index is the sum of all daily river levels each year in Ladário Port

2.6 Fisheries in the South Pantanal

In the state of Mato Grosso do Sul (South Pantanal), local scientists have been recording fishing data since the 1990s, publishing every year detailed figures of fishing in the South Pantanal (Albuquerque et al., 2011; Catella et al., 2014, 2008). According to these authors, currently, there are roughly 2,000 people registered as professional fishers and approximately 10,000 sport fishers come to the region every year. The amount of fish caught by each group is similar. In 2013, professional fishers captured 165 tons and sport fishers 168 tons. Therefore, in 2013, 333 tons of fish were taken from the South Pantanal.

Another important source of income is bait. People sell live bait to tourists who come to fish in the Pantanal. However, there are no robust data about how many people take part in this activity and how many baits are caught. The only estimation is from 1996, which researchers estimated that 15 million units are captured every year.

2.6.1 Flood pulse and reproduction of fish with economic value

The flood pulse leads to major changes in the socio-ecological systems in the Pantanal. Therefore, it is important to clarify how local economically important fish populations behave in face of the flood pulse in order to better understand fishers' adaptive strategies.

The most important species in terms of economic value are Pintando (*Pseudoplatystoma corruscans*), Cachara (*Pseudoplatystoma reticulatum*), Pacu (*Piaractus mesopotamicus*), and Jau (*Zungaro jahu*), representing 84.73% of small-scale commercial fisher's total catch (Catella et al., 2014). All of them belong to the category of long distance migrators with external fertilization, moving upstream from further downstream (Resende, 2011). They start their reproductive process during the flood pulse drawdown period. After the flood passes through and the water starts to recede, they move from the floodplain to the rivers, the "lateral migration" (Agostinho et al., 2004). The fish then gather in river channels, creating big shoals. Together, and now in the dry period, they start to migrate towards the upper river, the "longitudinal migration". Once in the upper river basin they wait until the start of the rainy season, between October and April, and then begin to lay and fertilize their eggs. Finally, using the flood pulse flow created by the rainy season, adults, eggs and larvae are passively borne down to the floodplain where they will find food and protection from predators. A fifth fish important to local people's livelihoods is the small gymnotid fish Tuvira (*Gymnotus* sp.) [2-42cm], which undertakes a short migration with external fertilization followed by a parental care period (Polaz, 2013). When the water is rising again, adults, larvae and eggs drift back to water bodies. They represented 50.1% of all bait gathered in the Pantanal, an estimated 7.8 million units or 500 tons are caught every year (Moraes and Espinoza 2001).

Another important species is the Pantanal crab (*Dilocarcinus pagei*) [5-10cm], representing 34.2% of the total catch for bait gatherers during the same period, an estimated 5.3 million units are caught every year (Moraes and Espinoza 2001). During the dry season females hatch their eggs in holes in the banks of water bodies to protect them from predators. When the water starts to rise, they leave the holes

with the offspring guarded in the female's abdominal plate, returning to the aquatic environment and using macrophytes as their new habitat. From all these species, the main goal is to grow rapidly and accumulate large amounts of fat during the flood period, as a strategy to survive during the dry season that follows (Resende et al., 1996).

It is important to note that the flood pulse occurs at a different time of the year in each region of the Pantanal. As explained, there is time lag between different areas, especially between North and South Pantanal. For local biodiversity, this is crucial. The time lag leads species to migrate or hatch at different times of the year according to their location. Hence, different populations of the same species of crabs and fish migrate and reach their peak abundance at different periods (Resende, 2011). Moreover, the change in flood size between years further modifies the distribution of natural resources. The main point is that a specific site that was inundated in a previous year will not necessarily be under water in the following year, and this will dictate where the fish and crab populations will be found. Equally, changes in river distributions can connect or divide different populations, allowing or precluding dispersion and intermixing between one another. Therefore, the fish and crab migration, population sizes and their distribution are a direct consequence of the features of each year's flood (Welcomme, 1999).

2.7 Changes in access

The unpredictable nature of the Pantanal floods and of the ever-changing river drainage network leads to profound fluctuations in access to fish stocks (Assine et al., 2015). First, as pointed out, depending on the characteristics of each year's flood pulse, water bodies can gain or lose their connection with the main river, which dictates people's access to individual sites. Moreover, the continual changes in flood patterns, together with the very slight gradient across the Pantanal and the high production of aquatic vegetation, all contribute to changing access to different parts of the water bodies. In the Paraguay River Basin, aquatic vegetation can occupy more than 90% of the area in years of high floods (Souza et al., 2011). This vegetation can come to dominate lakes and bays due to the component species' rapid propagation (Villamagna and Murphy, 2010). For instance, it has been estimated that

the annual floating mats ("camalote") production may reach anywhere from 0.8 to 2.4 x 10^7 tons (Mg) of dry biomass, which represents nearly 60% of the riverine carbon export of the floodplain (Bergier et al., 2012). The floating mats can mix with other types of vegetation creating what is called floating meadows ("baceiro" or "batume"). This special type of floating mat is supported by a sort of organic soil made of decomposing plants called histosol (Pott and Pott, 2012), which can build to up to a depth of more than 1 m (Pott and Pott, 2011). Old meadows look like floating islands and can carry more than 35 different species of plants (Pivari et al., 2008). The main point about these floating mats or meadows is that they move freely throughout the floodplain, constantly changing their position according to wind direction and river flow (Tur, 1972). Sometimes however they get stuck in river channels or bay mouths closing these off, a very common process locally called clogging ("entupido"). Although powerful tourist motorboats may force a channel through such blockages, local people's outboard powered canoes cannot do so. In other words, each year either through the changes in river connections or through blocking of channel or river mouths by floating vegetation, a different group of bays, lakes and river channels will be available to be used.

Chapter 3 General Methods

3.1 Abstract

This chapter sets out the reasons why I chose to study the Pantanal wetland. It goes on to outline the ethics consents sought and my position as a researcher in the region. The second part gives a detailed description of all data collection methods used, with particular emphasis on Extreme Citizen Science methodology. Specific methods that are related to individual data chapters are described in more details later the relevant chapters.

3.2 Research in the Pantanal and design of the PhD proposal

My work in the environmental field in Brazil began in 2006 while I was still an undergraduate at Federal University of Mato Grosso do Sul. For three years, supervised by Walfrido Moraes Tomás, I worked as an intern at "Embrapa – The Brazilian Agricultural Research Corporation", which is a governmental enterprise seeking scientifically validated solutions for environment and development challenges in Brazil. Embrapa's organizational structure is composed by 46 offices. My internship was in the Pantanal unit. Since then my focus has been mainly on this region.

In 2010, I became a collaborating researcher for the project "Community Based Tourism Actions for Conservation of the Pantanal", funded by the Brazilian Government through the Foundation for Diffuse Rights (Fundo do Direito Difuso), coordinated by the NGO Ecology and Action (ECOA), and held in the Western Border of the Pantanal. The project was an effort to build a link between Biodiversity Conservation and Traditional Community Development in the Western Border of the Pantanal through innovative ways of developing local tourism.

After working few months with local fishers, the complexity of people's lives started to fascinate me. I started to realize that all the time fishers have to make new decisions on where to fish, which gear they should use and most importantly, whether it is worth going out fishing or not. Moreover, all this was embedded in a complex society, in which people's behaviour was influenced by other people's

actions. I found myself intrigued by all this complexity. Furthermore, during this period, I became aware of the conflict between fishers and conservation initiatives. In order to establish better understanding of land tenure, customary governance, access and natural resource use in the region I decided to undertake a PhD in Anthropology.

First, I contacted Dr. Jerome Lewis from University College London, Anthropology Department, who introduced me to Professor Katherine Homewood. After a first interview in January 2012, she accepted to further discuss the idea and support me to design a research proposal focused on that topic. In January, 2013, I started my PhD in the Anthropology Department, UCL, supervised by Professor Katherine Homewood and Co-supervised by Dr. Marc Brightman.

3.3 Selection of the study site

The project was first proposed with the idea of studying all three main human settlements present in the Western Border of the Pantanal. However, during my pilot-study (July-August 2014) it started to become clear that it would be very complicated to apply all methods proposed and collect accurate information on land tenure and resource use studying all three sites during a single year of fieldwork. Moreover, all three settlements are very remote and the cost of a return trip from the nearest city (Corumbá - MS) to each one is no less than USD 300, while moving between the three sites is equally expensive. As a result, an in-depth study was carried out only in "Settlement 1", although all the other settlements were visited during the fieldwork.

The reasons for choosing Settlement 1 to carry out an in-depth study instead of the other two, even though this is the most remote one, are manifold. First, even though all settlements face some kind of conflict with the Protected Areas around, only Settlement 1 is entirely surrounded by restrictions on resource use, while the other settlements are less restricted. Secondly, fishers from Settlement 1 clearly claim that they have been displaced during the establishment of the Protected Areas. Hence, the conflict over land use in Settlement 1 is greater compared to the other settlements, which makes it more intriguing from a research perspective. Thirdly, the settlement is located on a single island, which makes it easier to visit the different families for

interviews without the need of taking a boat. The other settlements are dispersed and spread throughout the riverbank and floodplain, which makes visiting them difficult and costly. Finally, I had previously gained some rapport with local people in Settlement 1 due to my participation in the research project focused on community-based tourism.

3.4 Time spent in the field

The fieldwork was, firstly, carried out between April 2014 and March 2015 and was divided between collecting data in the field and producing maps and inputs for formal process of the Systematic Conservation Planning. A further period of fieldwork between April and June 2016 was carried out by a field assistant, who was undertaking a master's degree and decided write her dissertation about the conflict in the region. Under my co-supervision, she collected data that enriched the results with a recently up-dated view of the conflict and local stakeholders' view.

The data collection was focused in three different periods of year related to local people livelihoods: the dry period, flood period and closed fishing season. Thus, I lived in the Settlement 1 during 3 periods of 15-20 days during the dry season (April-June, 2014), 3 periods of 15-20 days during the flood season (August – October, 2014), and revisited the area for 2 periods of 15 days during the closed fishing season (November / 2014 – March / 2015) to check with local people their perception of the Systematic Conservation Planning model outputs. (Figure 3-1). The fieldwork in 2016 carried by the field assistant, was mostly held in the nearest city. She stayed in Settlement 1 only 3 days.

Figure 3-1: Hammock protected with a mosquito net where I slept most of the time during the field work.

3.5 Ethics

To avoid causing any kind of offence or misunderstanding and to follow the ethics procedure rules, before any activity of the project several ethical consents were sought. First, University College London Anthropology Department Ethics Committee approved my Risk Assessment and Ethics Methods Procedure and authorized me to proceed with the fieldwork. Then following the Brazilian Rules of Projects for research that involves human beings (Resolution number 466 from 2012), the project was translated into Portuguese and submitted to the National Research Ethics Committee. It was approved firstly by a federal and secondly by a local ethics committee from the study region (acceptance number 828,070). Then local NGOs and research Institutes located near the study site (such as ECOA, Embrapa Pantanal, UFMS, Acaia and Instituto Homem Pantaneiro), were contacted and the project was explained to make them aware of the purpose of the research and of the form the data collection was going to take, as well as possible outcomes of the project. The same approach was carried out with community leaders. This process was followed by individual informed consent for any participant interviewed (Appendix 1).

3.6 Research Position

The position of the researcher in a study and the way they engage with people during their fieldwork both have a strong influence on the information being collected. Strong links with specific biophysical or socio-ecological research institutions and with NGOs focusing on biodiversity conservation or community development shape researcher attitudes can bring bias to the data, obscuring the understanding of local people's perceptions (Bernard, 2006). On the other hand, it is important to have backing from institutions that support local people in order to gain their trust. In the Western Border of the Pantanal fishers accuse some NGOs and Protected Area managers of displacing them, therefore, their feeling of suspicion towards foreigners is very high. In fact, the presence of people who act as gate-keepers mediating access for new researchers are normally key in social in-depth analysis (Bernard 2006 p. 357). Therefore, on the first trip to the community I was accompanied with a colleague from a NGO who has been working there on communities' issues for more than 10 years (A. Siqueira, ECOA). He introduced me to the local people and explained my project. However, during interviews and informal conversations, I emphasised that I was an independent researcher with no link with any other institution apart from University College London. On the following trips, whenever possible, I tried to avoid reaching the communities using boats belonging to established organizations, such as NGOs, which could cause the impression that I was part of any specific interest group. That was not always possible and sometimes I had to use such boats in attempt to optimize the financial resources spent in the fieldwork (as presented, each boat trip cost at least USD 300, including hire of a motorboat, a boat pilot and fuel). Moreover, I was there mostly by myself. This because, in face of the difficulties of establishing rapport with local people and the sensitivity of the themes discussed during the interviews and informal conversations, I decided to not take interns or field assistants, in order to avoid any kind of misunderstanding. The only time I was not alone in the community was at the very end of the fieldwork when I invited a photographer friend to take pictures of all people willing to participate. I did this to give the photos back as a gift, a gesture much appreciated locally. In the second part of the fieldwork, between April and June 2016, the master student who assisted on my research was there by herself too for 3 days.

As a native speaker, my command of Portuguese language and my familiarity with local idiom were essential during the fieldwork. However, in an attempt to embed myself in the local culture in order to capture with more accuracy their perceptions of natural resource use and land tenure, I set out to understand and use local words, specific behaviours, body language, and other elements of communication. All these were learned and used during the interviews and informal conservations. For instance, local people mostly never look at other peoples' eyes, they tend to talk with their head bent, and phrases tend to be expressed in the passive voice.

During all fieldtrips, I stayed in the house of a particular local family who provided food and lodging for the time I was in the field. Staying in someone's house was an important step in order to gain local rapport. After few weeks in the Settlement, I was told that I was the only researcher that ever slept more than one night in the community. They said that outsiders never stay there because they think is dirty or not safe. According to local people, even NGO practitioners never sleep there. Thus, every time I came back and ask if I could "stay for while", they were always happy to host me.

This particular family took me on several fishing trips. In the beginning my time was spent mostly with them. However, I managed to talk with most settlement's members several times and get close to most families.

3.7 Research Gifts

In the beginning of the fieldwork, the majority of the interviews were carried out with women because most men were out fishing. In order to gain their trust and rapport, at the end of each interview, I asked all interviewers if I could bring anything that they needed from the city because I would come back soon. Most women suggested "nail polishes". Thus, in the local shop in the nearest city I bought dozens of nail polishes and brought back to them. In fact, all women laughed at me when I said I myself bought it. Perhaps they were simply testing my will to get their trust, because, indeed, it is a very embarrassing situation to buy them in a city where

most men would never walk into a nail polish shop. Many other gifts were brought, such as tea bags, guitar strings and ice cubes. The last set of gifts were the photos that a friend photographer took in a previous trip.

For the family who hosted me and cooked for me during each fieldtrip, I paid them around USD 40 per week a sum the NGO who works locally suggested was appropriate.

3.8 Research Methods

3.8.1 Participant Observation

Participant observation was used throughout my fieldwork in order to understand the patterns of land tenure, access, and natural resource use that characterize local people's daily lives and to cross-check the validity of findings from other research methods such as interviews and participatory mapping. Participant observation involves getting close to people and making them feel comfortable with the presence of the researcher's, who becomes a "fly on the wall", allowing observation about their lives unbiased by prejudice prestige or other effects (Bernard, 2006).

In the case of this project, the method consisted of, first, helping in all daily activities that local people commonly engage in, for instance gathering bait, fishing, logging, collecting manioc, cooking, cleaning fish; secondly, attending meetings such as religious meetings, birthday celebrations, NGO meetings; and lastly, participating in leisure activities which consisted mainly of football matches' and of sitting in small groups to drink ice tea ("tereré") and exchange news (Figure 3-2).

Figure 3-2: Participant observation: fishing in Settlement 1.

Through participant observation I was able to build social relationships with local fishers and then gradually pick up their local perspectives on natural resource use and land tenure. I kept a field diary of various notes and thoughts gathered each day from this method. These notes were essential to reflect back on when later consolidating and analysing data.

3.8.2 Semi structured interviews

The semi-structured interviews (SSIs) were focused on resource use from both historical and current perspectives, the main goal being to get an understanding of how people see tenure and control of resources and their perspective on the conflict between resource use and protection.

As already outlined, all interviews were built upon free, prior and informed consent. Moreover, strict data anonymity and confidentiality were observed. Participants' names and identifiable characteristics were not written down on the field notes, and the information collected was kept securely by me – avoiding clues to identifying

participants. No information that might cause any kind of harm to the participants was written down or used in other dialogues. All quotes are referred to in this thesis as Informant + number (e.g. Informant 1), Nuclear Family + number (NF1), Extended Family + number (e.g. EF1). Some quotes in the data chapters are followed by general information about the person who said it in order to better put them in the context of the discussion and illustrate its meaning (for instance Informant 1, fisherman, 30 years).

3.8.3 Key informant (KI) and Group Semi structured interviews (GSSI)

Group and individual semi structured interviews were carried out with local people, tourism companies, and protected area managers, which together represent the main stakeholders in the Western Border of the Pantanal. They were all held in specific sites, where the respondent(s) could feel comfortable and more confident with the interviewer. For instance, group interviews with local people were held during the ice tea sessions, in which people just sit together in one other's homes to discuss all matters of subjects. On the other hand, individual interviews were held in places far away from interruptions by anyone around, for instance during some fishing sessions in a boat in the middle of the river.

The questions were focused strictly on people's perspectives and knowledge of land, water and natural resource use, following the interview guide outlined below, with a few adaptations depending on the individual stakeholder being interviewed.

1. Which places do you use most?
2. Is there anyone who controls the use of these places?
3. Are there any types of discussions / agreement among the community members about the use of places and resources and when to use them?
4. Do you happen to use places used by other settlement dwellers?
5. Is there any place around here that you are not allowed to use for any reason?

In total, I interviewed 40 people from Settlement 1, 3 people from Settlement 2 and 3 people from Settlement 3, 10 from the tourism trade group, and finally 8 people from protected area group. Moreover, some 10 scientists, NGOs and government institutions that are in some degree involved with the conflict in the Western Border of the Pantanal were consulted.

The field assistant carried out more 18 interviews in 2016, including 5 federal prosecutors, 6 fishers from Settlement 1, 3 scientists, and 4 conservation practitioners. Her interviews were mainly focused on the proposed relocation of Settlement 1 that will be explained in Chapter 6. Therefore, her guidelines were different, as presented below. Again, depending on the individual being interviewed in each case, few adaptations were made.

1. Do you agree with the proposed relocation?
2. What is the reason to move the community to a new settlement?
3. Why was this new location chosen?
4. Do you think it will bring positive or negative changes?

3.8.4 Participatory Mapping

The use of participatory mapping appeared as part of the participatory approach that became embedded in the conservation and development agenda, especially from the 1980s on, triggered by Robert Chambers' work on Participatory Rural Appraisal (PRA) (Chambers, 1981). The main idea, as with other participatory tools, was that poor and exploited people can and should be enabled to conduct and present their own analysis of their own reality. However, participatory mapping stands out from all other participatory techniques as the most used method (Chambers, 2006), partly because of the spread and development of Geographic Information System and tools related to it, such as accurate GPS units, and partly because of its range of different uses, from cultural representations to monitoring forest carbon and biodiversity (Danielsen et al., 2013, 2005; Funder et al., 2013).

The main goal in using this method was to display use of natural resource, local knowledge, customary governance and historical occupation on geographical maps of the region in ways that could be managed and understood by local fishers and protected area managers alike. In order to meet this goal, two different yet complementary techniques were used: Scale Maps and Extreme Citizen Science.

3.8.4.1 Scale maps

This first technique was based on asking people to draw on a satellite image the answers to four questions:

1) Where did you go fishing today?
2) How many days did you stay there?
3) Where are the most used places?
4) When did you go to each of these places?
5) Are there man-made mounds around? Cemeteries?
6) Where you were born? When?
7) Have you lived in any other place apart from Settlement 1? Where?

After a first interview following these seven questions was carried out, the first two questions were repeated every three or four days for each of the interviewers during each field trip. The answers made it possible to understand fishers' resource use characteristics in the Western Border of the Pantanal.

All maps were printed using the new Brazilian collection of satellite images "Rapid Eye" with 5 meters of resolution in a 1:20 000 scale (Figure 3-3). In total 8 different maps were printed that taken together covered the whole Western Border of the Pantanal region. They were printed on laminated paper, which people could draw on, easily erase, and then draw again. Hence, after all interviews pictures were taken of the locally created maps and all the information on the maps was then erased. The main objective to do this was, first, to observe strict data anonymity; second, to avoid any previous information biasing the next interview, and last, to facilitate the drawing.

3.8.4.2 Local People's interpretation of maps

During the pilot study of this research project local people's interpretation of geographical maps was tested. After a few interviews, it was acknowledged that most people could visualise the physical world with the scale maps, easily pointing out fishing areas, livings sites and former settlements. However, it is important to present the caveats of the method. Representing local knowledge on a physical map may fail to explore domains that are intrinsically complex (Brightman, 2012), such as

adaptation, emotions, conflicts and relationships of local communities (Drury et al., 2011). Moreover, in the Pantanal, people's lives are driven by the river flow; therefore, depending on each year's flood, landscape changes, and the resulting fish distribution means some places may be newly included within or excluded from their use area. Also, external and internal social changes can similarly add more complexity to the dynamics of local use. Therefore, the information collected through scale maps are only a snapshot of a fluid reality.

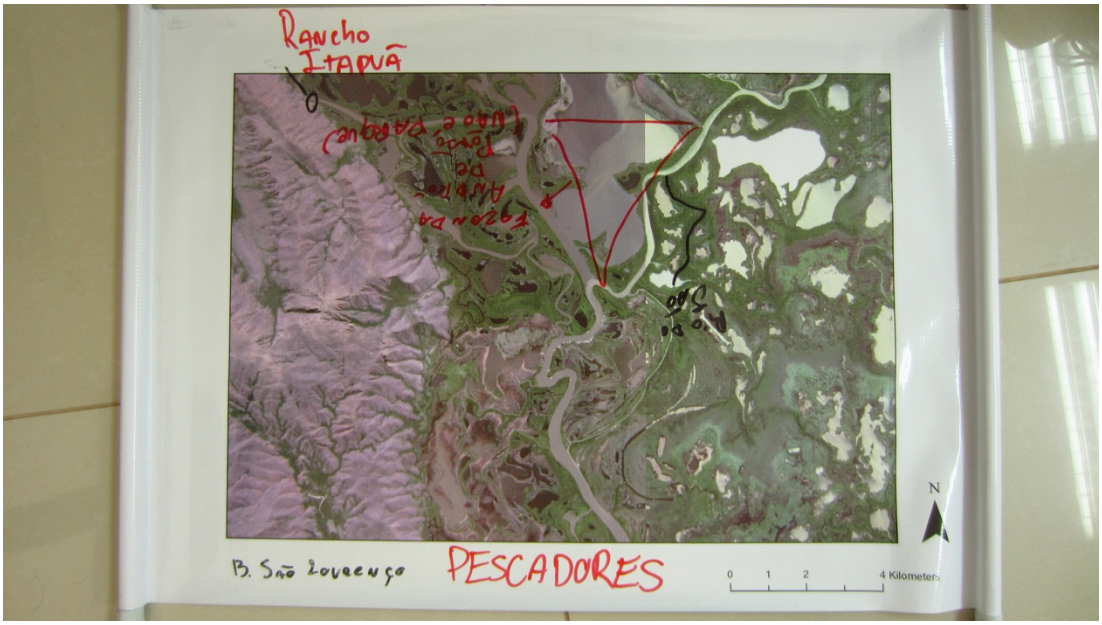

Figure 3-3: Example of a scale map used during the fieldwork

3.8.4.3 Extreme Citizen Science

Extreme Citizen Science (ExCiteS) is increasingly used within participatory mapping approaches. This widely acclaimed tool uses the concept of "Citizen Science", in which the goal is to integrate public outreach and scientific data collection protocols, adapted for rural populations in the context of conservation and development agendas (Lewis 2012). The tool enables local users (regardless of literacy levels, if this is an otherwise limiting factor) to collect and display geo-referenced data such as boundaries of territories and sites of importance for specific resource uses into scientifically robust and locally legible presentational forms, using handheld GPS units and icon-driven software whose interface is made locally specific (Conquest, 2013). In principle, ExCites makes it possible to record qualitative data such as

human well-being, customary governance, and/or natural resource use in scientifically robust way and as locally legible presentational forms, which make it possible to weight the environmental and social information equally to better address conflicts over land use (Milner-Gulland et al., 2014; Vitos et al., 2013).

In present study, this tool was used to assist the understanding of spatial and temporal dynamics of natural resource use and fishers' governance of the common property regime in Settlement 1, complementing the information collected during the interviews and participant observation.

To apply this method steps outlined by Lewis (2007) were adapted for the Pantanal situation. However, many challenges were faced during the development and applying the method, explained below.

1. **Step 1 – development of ExCites' Pantanal version**

A Pantanal version of the icon-driven software Sapeli 2.0 (the software that underpins ExCites) was created before the start of the fieldwork. The software is based on decision tree logic, in which people make a sequence of several choices until reaching the final answer (Figure 3-4). Sapeli has an ".apk" extension that runs in gadgets with android platform (such as android phones or tablets) (Conquest, 2013). The development of the decision tree was supported by PhD candidate G. Conquest, who is carrying out a specific project analysing ExCites efficacy in multiple resource use contexts and ecosystems. All possible uses were added into the decision tree: fish, wood, straw, bait, hunting, fruits, honey, drinking water and wild rice; and the following choices added: "using the place" or "preparing the place", "how many people?" and "name of the place?". After reaching the final step of the decision tree, people are invited to select an icon (representing e.g fish, bait, wood, etc.) and take a picture and the software switch on a tool in the gadget to search for the GPS location. In principle, the data collected would be sent directly to a secure website via satellite link, however, there is no mobile phone signal in the Pantanal region. Therefore, it was established that the data being collected by fishers going about their activities in my absence would be stored in the mobile phones and that I would harvest the stored data during each fieldtrip.

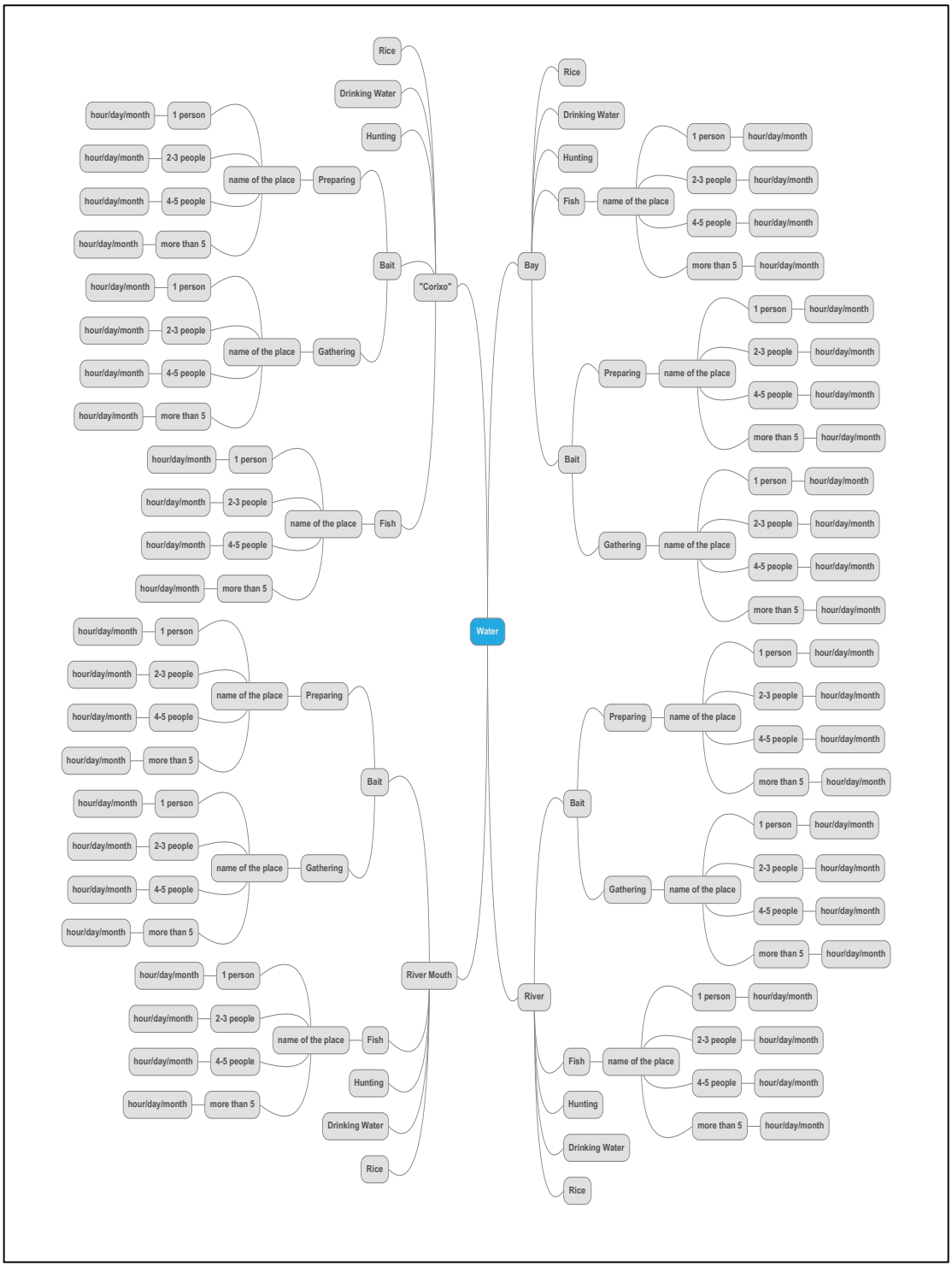

Figure 3-4: The figure shows part of the first decision tree built for the present project. It shows decisions made regarding resources from the "water". Another half of the decision tree (not shown) dealt with resources related to "Land", such as wood and honey.

2. Step 2 – Testing the software in the field and adaptations

Three different families tested the mobile phones with the software developed for the Pantanal for a period of five consecutive days. The first feedback that local people gave was about the complexity of the decision tree. Every one found it extremely complex and pointed out that it would take too long to record anything. Hence, a new decision tree was built, in which only the most used items were present: fish and bait (this last being divided into crabs and tuvira) (Figure 3-5).

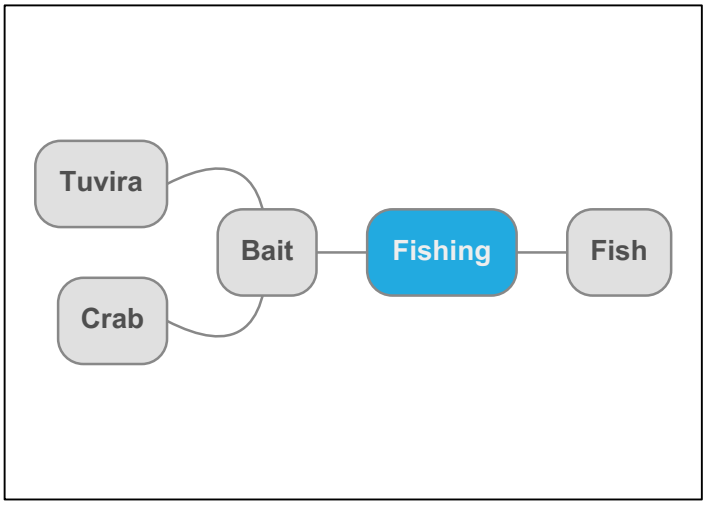

Figure 3-5: The final decision tree used for the ExCities Method.

The last concern was about the icons used. Fishers and bait gatherers did not like the carton-like figures initially used in the software. They argued that these were misleading and did not look like a fish or bait. Thus, the icons initially used were replaced by scientific illustrations of fish and bait (Figure 3-6; Figure 3-7).

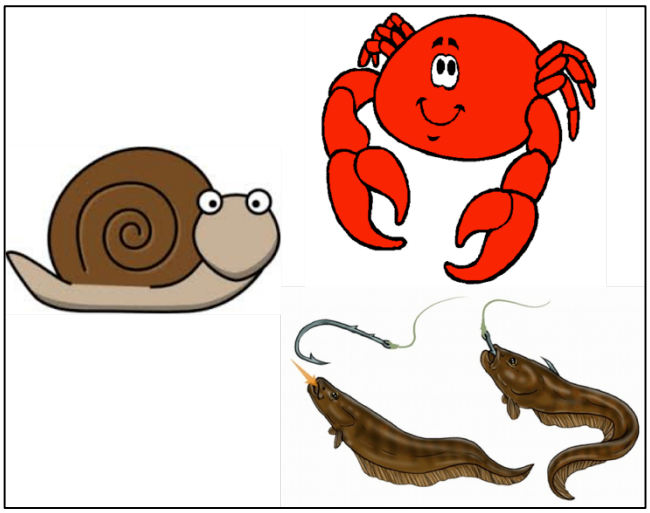

Figure 3-6: Figures initially used to represent the icon "baits" in the software.

Figure 3-7: The final figure used to represent the "crab" icon in the ExCites software. The image is a scientific illustration of *Dilocarcinus pagei* (from Magalhões, 2003), exactly the same species that local people collect as bait.

3. Step 3 – Use of the mobile phones in the field

From the total of 40 household families interviewed and asked about the use of the handheld GPS, only two accepted to use it. The first family was a typical Bait Gatherer household for which fishing is more related to home consumption and the second was a family of fishers, for whom fishing is related to small-scale economic activity.

It took approximately four months for local people to start to collect data, therefore, the data generated from ExCites runs from August 2014 till November 2014 (end of the fishing season). The challenges faced were technical issues mostly unforeseen before the start of data collection. For instance, one of the mobile phones broke, even

though it is sold as shock resistant; the memory card stopped working because one of the fishers used a sim card from another country, with no electricity in the Settlement people had difficulties to charge the mobile phone, etc. However, the data collected were very important and indeed assisted to uncover important features of resource use and common property regime governance (Figure 3-8).

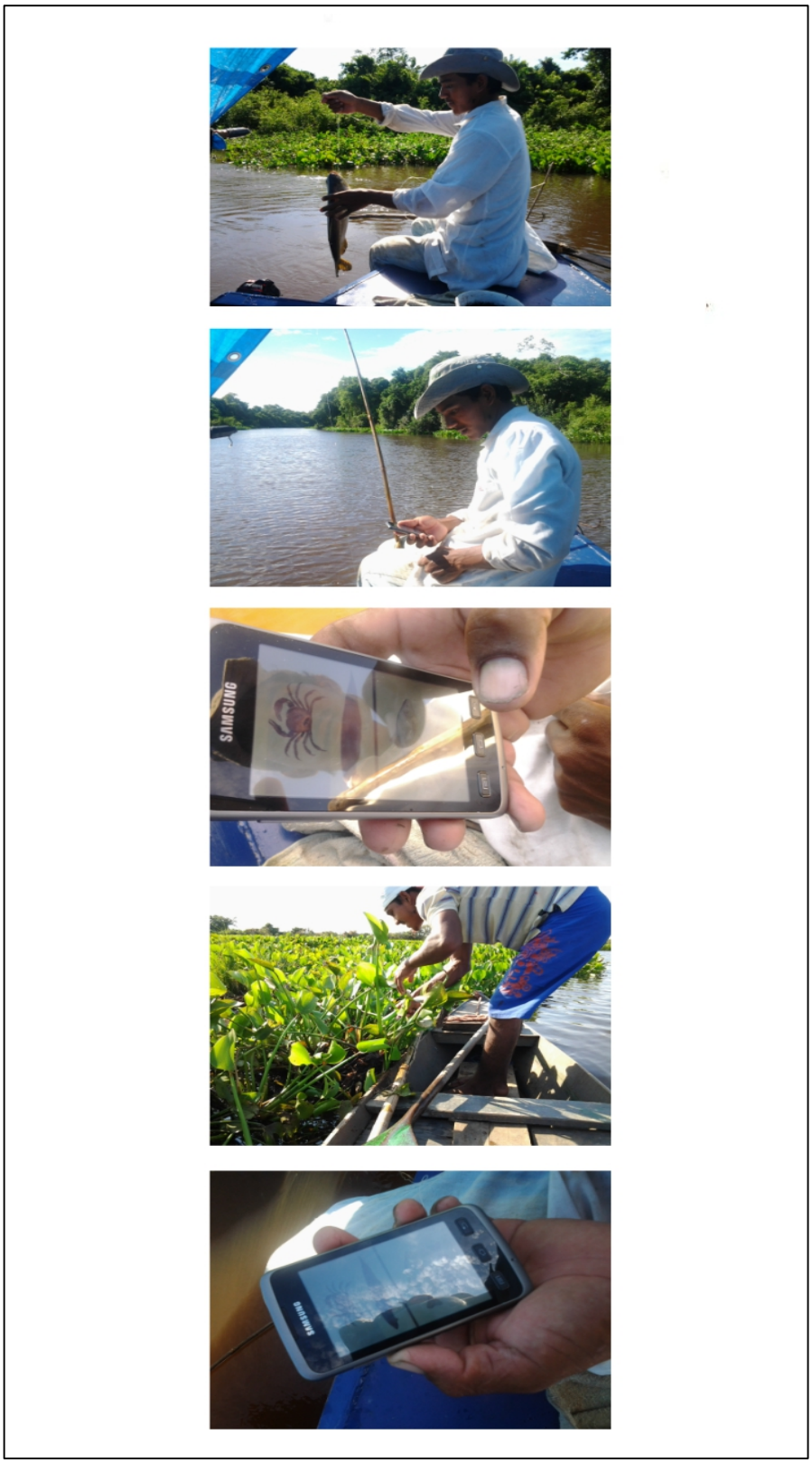

Figure 3-8: The sequence of photos shows the same fisherman recording his natural resource use in the Western Border of the Pantanal. In the first two frames, he is fishing and in the second sequence he is gathering bait.

3.8.5 Systematic Conservation Planning

A Systematic Conservation Planning exercise was carried out for the Western Border of the Pantanal in order to test the validity of zoning tools for these floodplain fisheries. The main goal was to understand the validity of adding social needs as explanatory variables in the software and to then verify with local people the quality and feasibility of the answers given. All steps taken to build the models, including the construction of new variables, as well as the interviews to test the output and the feedback produced are explained in Chapter 7, section 7.3.1, in detail.

3.8.6 Secondary Data

Different secondary data are used in all three data chapters. They were an important component of the thesis to better explain patterns and deconstruct narratives. All data used are credited and referenced in the text as they arise. They range from shapefiles of vegetation types of the Pantanal to quantity of tourists coming to the South Pantanal every year and dates and details of fishing policy changes. In each chapter the secondary data used and its source is explained in detail.

3.9 Research questions and Methods

Table 3-1: Research questions and methods

Research Questions	Specific Research Questions	Methods
Who are the fishers living in the Western Border of the Pantanal?	Are local people recent in-migrants?	Ethnographic (participant observant and semi structured interviews around resource use) historical approaches (resource use histories of key informants), participatory mapping, and Extreme Citizen Science
	Is fishing a new activity in the region?	
	What are the different types of livelihoods in the Western Border of the Pantanal?	
	Should local fishers in the Western Border of the Pantanal be labelled as part of the Pantanal's Local Communities?	

To what extent do current management practices in floodplain fisheries, focused on regulating overfishing, map onto local realities?	Is the claimed link between decline in tourist numbers and overfishing is backed by evidence?	Ethnographic (participant observant and semi structured interviews around resource use) historical approaches (resource use histories of key informants), participatory mapping, and Extreme Citizen Science
	What evidence is there for overfishing in the Pantanal?	
	How is small-scale local commercial fishing adapted to the flood pulse?	
	Are there customary rules to control overfishing and what are the likely effects?	
What is the relation between sustainability and land tenure in floodplains?	How do Pantanal property systems map onto the region's unpredictable, dynamic ecosystem?	Ethnographic (participant observant and semi structured interviews around resource use) and historical approaches (resource use histories of key informants).
	Is the conflict in the Pantanal will be resolved through setting defined ownership and rights to exclude through land titling?	
	How can the integration of economic, anthropological and ecological approaches help to address land conflict in Brazil's Pantanal?	
To what extent are local people's needs captured in prioritization models? Systematic conservation planning in freshwater floodplain systems	What is the relative importance of data on local people's territory and economics for systematic conservation planning in floodplains?	Extreme Citizen Science, Systematic Conservation Planning and ethnographic (participant observant and semi structured interviews around resource use)
	To what extent do local people concur with the zoning models produced by Systematic Conservation Planning in the Pantanal?	

	Is Systematic Conservation Prioritization a promising solution for management of resource conflict in floodplains?	

Chapter 4 Fishers of the Western Border of the Pantanal[5]

4.1 Abstract

This chapter describes the fishes from the Western Border of the Pantanal. It discusses, first, the idea of "Local Community" in Brazil and the attempts to exclude fishers of the Western Border of the Pantanal from this category. It goes on to describe local people's spatial organization, which for many years has been on continual migration among unflooded locations. The Chapter goes on to present how the creation of Protected Areas may have affect their customary mobility, showing several claims of historical physical displacement. The Chapter then gives a historical account of the intense conflict between caiman poachers and forest police during the 1970s and 1980s, with several quotes describing this violent period. The last part focus on fishing practices, outlining the different types of fishers and the complexity of their activities and livelihoods. For instance, tourism companies put fishers into a precarious situation but, at the same time, represent an important source of income. The chapter concludes by showing that fishers from the Western Border of the Pantanal have characteristics very distinct from other communities in the Pantanal. However, this does mean they do not have a historical presence in the region and a complex social and economic organization.

4.2 Introduction

As was presented in Chapter 1, community-based conservation (CBC) came to bring a paradigm shift in the conservation and development agenda worldwide (Berkes, 2004; Campbell and Vainio-Mattila, 2003; Nelson and Agrawal, 2008). It is based on the idea that biological conservation will only be effective if local people's values and livelihoods are deeply rooted in its actions (Adams and Hutton, 2007). However, many CBC initiatives and tools have led to no real change and, many times, exacerbate the impact on local people (Homewood et al., 2012; Nelson and Agrawal, 2008). Dressler et al., (2010), for instance, point out that in Philippines, CBC arose in

[5] This chapter has been in part published in "Chiaravalloti, R.M., 2016. Is the Pantanal a Pristine Place? Conflicts Related to the Conservation of the Pantanal. **Ambiente e Sociedade** 19, 305–310"

response to colonial conservation policy and has led to a process of criminalization of former peasants and replacement of earlier land use. They document the failures of CBC with cases in Madagascar, South Africa, Nepal, Nicaragua and in North America. Despite such failures, rhetoric around embedding local development as a goal became widespread in conservation publicity and discourse (Berkes, 2007, 2004; Hackel, 1999).

Of particular interest is the recognition of the rights of traditional populations living in rural areas. Already in 1972, during the second World Congress of National Parks, it was acknowledged the presence of peoples inhabiting surrounding regions of protected areas "*that practice forms of agriculture specifically adapted to that ecosystem and whose cultural heritage warrants conservation and protection*" (Barreto Filho, 2009: 99). Further international agreements better defined and recognized the importance of traditional populations for conservation. In particular, the Convention 169 from International Labour Organization (ILO), elaborated in 1989, which intends to empower tribal and indigenous peoples, stands out. Hitherto, only 22 countries ratified this convention, most of them from South America. Led by the ratification of the ILO 169 in 2002, the Brazilian government created the National Policy on Traditional Peoples and Communities (Política Nacional de Povos e Comunidades Tradicionais – PNPCT - decree number 6040, 2007). PCPCT recognised the rights of groups identified as "Traditional peoples and communities" (in Portuguese "*Povos e Communidades Tradicionais*") offering the legal means to secure their livelihoods, social cohesion, and to claim territory (Calegare et al., 2014; Creado et al., 2008). This policy, however, was not focused on autochthone indigenous groups or ex-slaves communities living in rural areas (they were already covered by other legislations, such as The Indian Statute, Law number 6001, 1973, and Brazilian Constitution of 1988, articles 68, 231 and 232) (Shiraishi-Neto, 2007). Rather, the main goal was to create rights for rural populations who have migrated to forested areas in Brazil in the 18^{th},19^{th} or 20^{th} century (such as rubber tappers), whose livelihood was dependent on sustainable use of natural resources and who were, for many years, invisible to the state, once they were neither Indigenous groups nor modern societies (Calegare et al., 2014; Little, 2002; Silva, 2007).

The reference to a specific group of local people cause great confusion on the identification of who were the "traditional peoples and communities" the policy was referring to (Castro et al., 2006). The policy itself use the concept of auto-identification, stating that traditional peoples are those groups who identify themselves as such. Scholars tried to define them in many ways (Diegues, 1993; Little, 2002, 1999). Some link the term with populations who inhabit a specific area for more than three or four generations (Cunha and Almeida, 2000), others use a more flexible approach and argue that traditional populations are any group who undertake a sustainable use of natural resources (Barreto Filho, 2009). Academic debate over the definition of the term continues (Creado et al., 2008) and in order to put the PNPCT into practice, a list of known traditional peoples who were carrying out sustainable use of natural resources in Brazil was created. Although this list gave some groups the possibility to claim access to their territory being considered a milestone event in the Brazilian conservation agenda (Shiraishi-Neto, 2007; Silva, 2007), those left off the list, supposedly "the non-traditional ones", faced increasing pressure from groups against their presence; many times, regardless of these local people's customary and sustainable use of natural resources (Castro et al., 2006).

A telling case study is seen in the Pantanal. As presented in Chapter 1, fishers living in the Western Border of this region argue that they were displaced from their original region and their area of use have been restricted during the creation of seven strict Protected Areas near by their settlements (Chiaravalloti, 2016). Protected Area managers, on the other hand, accuse the contrary, claiming that local families appeared in this region only after 1974, when a great flood covered part of the region leading some ranch workers to move to the riverside and switch to fishing their livelihoods, without customary management of natural resources in ways that would protect local biodiversity. In order to undermine possible "traditional communities rights" of local people over the region, Protected Area managers made concerted effort to deny Western Border fishers the legal status of "Traditional communities" (Franco et al., 2013), claiming that they neither have historical links with the region, nor undertake customary management of natural resources in ways that would protect local biodiversity (Franco et al., 2013). For instance, they argue that the Western Border of the Pantanal has always been focused on cattle ranching, and that

it does not make sense to grant access to small-scale fishers. Moreover, they state that local people are characterized by "*their weak ability to organize themselves*" (p. 91) and "*Within their environmental impacts can be counted overfishing*" (p. 91) (Franco et al., 2013).

In fact, fishers from the Western Border of the Pantanal are not listed as part of Pantanal's former traditional communities (Neuburger and Silva, 2011: 680). The current understanding is that there are two traditional groups in the Pantanal: "pantaneiros [people from swamp]" and "ribeirinhos" [riverine people] (Neuburger and Silva, 2011; Silva and Silva, 1995; Silva and Sato, 2012). The first one refers to farmers and ranchers that since the 19th century have been raising cattle in the Pantanal through rotational and extensive grazing, known as traditional cattle farming (Abreu et al., 2010). The other group are the riverine communities. The appearance of this group in the Pantanal is related to the Portuguese occupation of the region in the 18th century (Neuburger and Silva, 2011). After the discovery of gold mines in the westernmost region of Brazil, explorers established a route through the Pantanal to reach the region and bring the gold back to the east coast. Along the way, sugar mills were installed and families were settled on unflooded sites to provision explorers. Therefore, the established concept of a riverine community of "Traditional People" in the Pantanal is a group of families permanently settled on a unflooded area clustered around a small sugar cane mill (Silva and Silva, 1995). From that perspective, fishers from the Western Border of the Pantanal should not be labelled as traditional community because apart from their not figuring on the list of Pantanal's local communities, there are no sugar mills nor have there ever been permanent settlements in the region. However, equally, there have been no in-depth studies trying to uncover who these fishers are. These people are invisible to most researchers in the region. This chapter intends to give the first description of local fishers in the Western Border of the Pantanal, outlying their historical presence in the region, social cohesion, complex structure of livelihoods and discuss whether the classification of traditional community is worth giving.

This chapter intends to answer the following research questions:

Who are the fishers living in the Western Border of the Pantanal?

- Are local people recent in-migrants?
- Is fishing a new activity in the region?
- What are the different types of livelihoods in the Western Border of the Pantanal?
- Should local fishers in the Western Border of the Pantanal be labelled as part of the Pantanal's Traditional Communities?

4.3 Methods

The methods used to collect data for this chapter included participant observation, semi-structured interviews and participatory mapping, all described in detail in Chapter 3, section 3.8.

4.4 Results

The data collected showed that although currently there are around 600 people living in the Western Border of the Pantanal separated into three main settlements (Figure 1), extended families with between 15-20 people used to live on man-made or natural mounds over the floodplain moving their settlements according to changes in the landscape. Using Extended Family 1 (EF1) as a case study, it was found that in the last 60 years, people reported having lived in many different sites, falling into two distinct phases. During the first phase, between 1960s and 1974, at least four different sites were counted, for which local people were able to give the exact date of occupation. Moreover, six other sites were pointed out on the maps as historical settlements, though with no defined date of use. In this first phase the recorded movements between these sites were related mainly to changes in environment and natural resources. For instance, informant 12 (fisherman, 72 years old, EFN1) described the case of a river branch called "Old River". His family used to live by the main channel that linked the São Lourenço River with the Paraguay River in the Western Border of the Pantanal. However, in 1962 a new channel became the major link between the two rivers, leading the family to move to another site. According to him there were several families living nearby, and even a cemetery, which today is under the water. The name "Old River" is a reference to the role the channel used to play in the past. Informant 2 (92 years) presented another location for the years that followed. According to her, in 1969 they were living in Caracará site, pointing out that her first husband died and was buried there in that year. Then, in 1972, another

location was pointed out: The Three mouths site; where informant 4 reported to have been born. Another important moment was in 1974, when a big flood permanently inundated several sites that were formerly used as living areas. EF1 members reported that they moved to Porto Brazil searching for dry land, almost 30 km away from where they were previously living. Although only four living sites were precisely identified during the first phase and six more were pointed out as historical settlements; it is likely that between 1960s and 1974, EF1 lived in more than that number of locations. The ones recorded are just those which are still lodged in local people's memory through milestone events. As suggested by informant 15 (fisherman, 65 years) who is part of the EF1: "*when I was young we used to keep moving trying to find a better place to live, we eventually moved three or four times in one year*" (Figure 4-1).

Another factor that gives a sense of how the changes in the landscape drive their mobile lives is the way they explain the length of the time they stayed in each site. People use the number of floods or "waters" they went through as a time mark, as described by Informant 13 (male, 57 years) "*we went through four waters in Porto Brazil*".

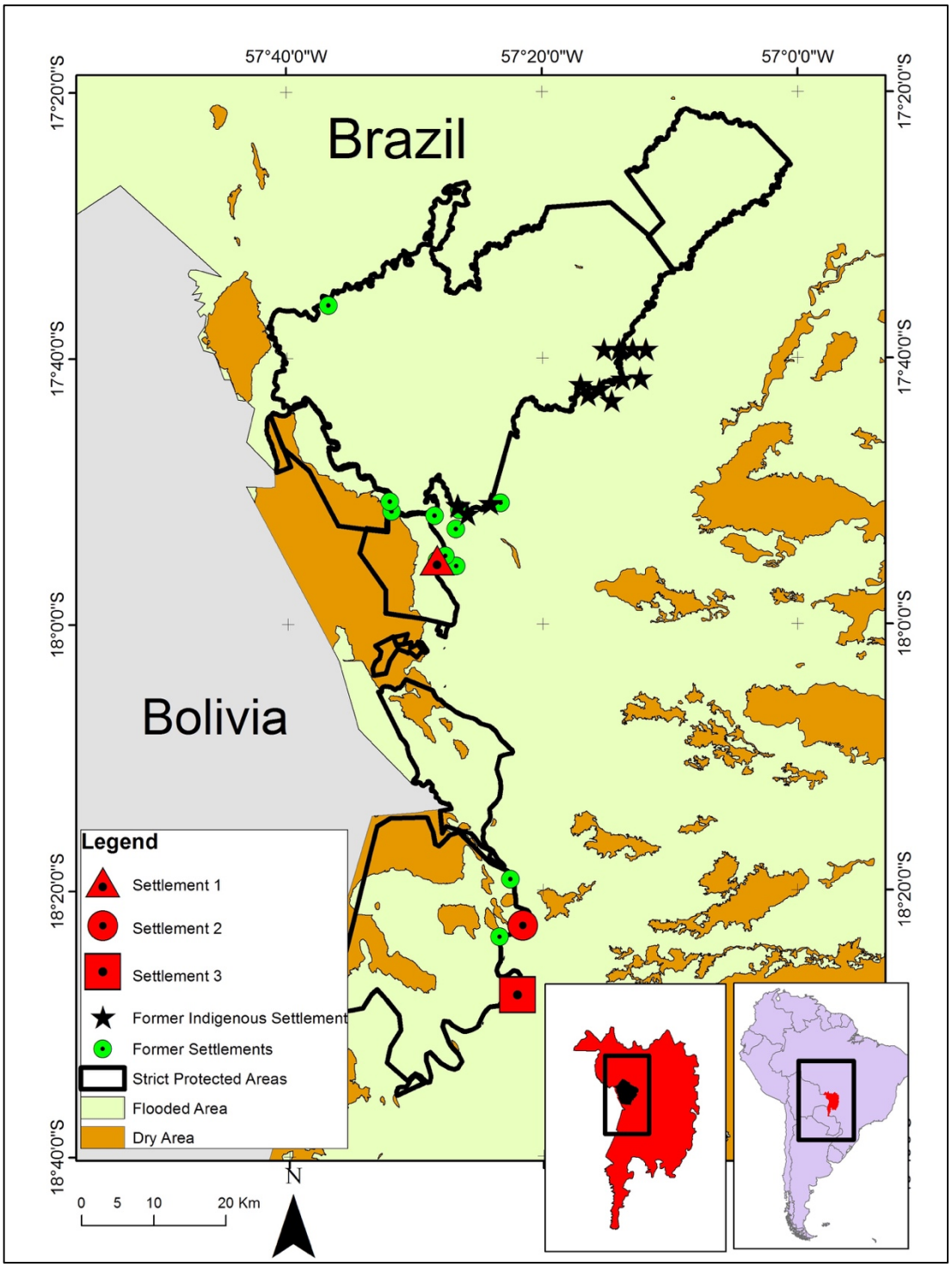

Figure 4-1: Former and current Human Settlements in the Western Border of the Pantanal and Indigenous settlements recorded by Oliveiros (2007). In black, the seven strictly protected areas in the region. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

After 1980, two other movements were identified during the second phase. In this case movements were related to the local conservation agenda and, according to informants were not voluntary:

> "When we were living in the region of the National Park [Porto Brasil], they came and tied Informant 13 hands and feet and beat him until he fainted." (informant 6 – male, fisherman, EF1, 55 years)

> "when they created the National Park [in 1981] we were living in Porto Brazil, they gave us 3 days to leave the place, we put all our belongings in two canoes and sailed for two days trying to find a dry land to settle on." (Informant 4 – 44 years, fisher, female, EFN1).

The second alleged displacement occurred in the 1990s, when the first Private Protected Areas were created. In the area where some families used to live there are still remnants of their former houses.

Although currently there are only three extended families in Settlement 1, there were likely to have been more living in the region when the Protected Areas were created. The area has seen a great exodus from rural areas in the last few decades, and local people from Settlement 1 remember as many as 10 other extended families living in the region. According to local people, Settlement 1's current location was used by one of the extended families in the region from roughly 1960s-1980s, and then abandoned because the matriarch of the family died from snakebite. Settlement 1 is surrounded by rivers, and all families are clustered in to a single area of roughly 20.5 ha. The region is referred to as "the island". No information was collected about claimed displacements in the other settlements.

The places used as homesteads were non-flooded areas that could accommodate the whole Extended Family, and can be divided into three different types:

1) Palaeo-levees: areas that are covered by forest and are only briefly inundated during the year. These are natural raised banks that can be easily occupied once the forest is cleared. However, they normally do not last long because big flood periods can completely submerge and erode them (Cunha and Junk, 2011: 135).

2) Old indigenous mounds. It is possible to see this continuity comparing the EF1's historical living sites and Guató archaeological living sites recorded by Oliveira (2007). At least two sites have been occupied by both groups. They call it "aterro de bugre" (referring to indigenous [bugre] mound [atterro]). These sites are very similar to Black Earth or "Terra Preta" found in the Amazon (Pinedo-Vasquez et al., 2011). Local fishers see these areas as very good spots to settle. Due to the long term accumulation of organic material the soil is very fertile (Kawa et al., 2015). Informant 23 (female, 46 years, hotel keeper, EF4) described the importance of finding an "aterro de bugre" to live:

> "We used to live in Palmital, an aterro de bugre. There we could plant whatever we wanted that it would grow fast and strong. We had things that no one had here, fruits, vegetables, beans, rice, and manioc. We had so much that we could sell and trade with other families."

Figure 4-2: Rock engravings dated from roughly 2600 years B.P (Oliveira, 2007, 2003), located on one of the living sites used by local people from Settlement 1. These engravings suggest the overlap and continuities in spatial use between current local communities and Guatós (Picture V. Chiaravalloti).

3) **Family-built mounds**. For instance, according to informant 17 (43 years, fishers) his family used shells, wood, animal bones and all of things they could find to build up a mound with all materials being carried to the site in wheelbarrows made of caiman lather.

Given the need for frequent moves, local people's dwellings used to be very simple and made of bamboo and palm leaves, very similar to the Guató's houses (Oliveira, 2007) (Figure 4-3). Today, however, few families in the settlements follow this type of construction. In Settlement 1, of the 23 nuclear families living there, two live in houses of bamboo and palm leaves. Most houses are made of "taipa" (packed earth) or wooden planks. It is interesting to note that some families are replacing the wooden sheets with plastic sheets arguing that these are lighter and more modern. There is just one house made of bricks. The family who built it is from one of a

typical “Pantanal Local Community”. They used to live in a dry area near a small sugar cane mill in the northern region of the Pantanal.

To conclude, local fishes in the Western Border of the Pantanal are indeed very different from other communities in the Pantanal. However, the accusation that these people moved to the region after 1974 is unfounded and untrue. The evidence shows a long history of occupation in the area, probably of at least 150 years. Moreover, although researchers classify pantaneiros as local farmers, all interviewees claimed to be “pantaneiros” [people from swamp].

Figure 4-3: House made of bamboo and palm leaves, very similar to the Guató’s houses

4.5 Extended Families

The extended families occupying the different sites throughout the floodplain were mostly comprised of couples with their aunts, uncles, and cousins living clustered together yet in separate small houses. To live within the extended family people had to have some kind of kinship. Thus, outsiders could become part of it by marriage or adoption.

Sometimes, joining these extended families was used as an option for poor people from the nearest cities, as described by informant 6 (fishers, 55 years, EF1):

> "I was born in Caceres and when I was 10 years old I left my adopted parents and started to travel around here, one day I met the daughter of informant 2 (female, 92 years); we got married and I started to follow them".

The groups living the Western Border of the Pantanal groups were probably constituted through such processes of marriage and adoption. From ethnographic and archaeological studies it is known that the Guató, Boróro, Paiaguá and Guaikuru indigenous groups used to live in the Western Border of the Pantanal (Ribeiro 2005, Oliveira 2003). First the Spanish in the 16th century and then the Portuguese in the early 18th came into contact with them during the European colonization process in South America (Costa 1999). However, in contrast to other local groups, the Guató population did not collapse following contact. Their spatial organization was not centred on villages. Rather, extended families lived in isolated homesteads on man-made mounds[6] throughout the river floodplains and fringing the hills (Amolar Mountains). Perhaps, as a result, they were less severely affected by European diseases than other local Indian groups (Ribeiro 2005). Secondly, due to this dispersed pattern of settlement, there very few outright conflicts with Europeans. As a consequence, the Guatós were the main indigenous group remaining in this region at the end of 18th century.

It is likely that Guató extended families started to accept ex-slaves, foreigners, and other outsiders to join them through marriage. It is possible to identify this looking at personal histories of the elderly. For instance, Informant 44 (60 years old) pointed out that his mother was Guató and his father was from Paraguay. He claims to have been born in the Western Border of the Pantanal and that he and his family always lived on natural or man-made indigenous mounds. His wife, Informant 43, (92 years old), stated that her mother was an ex-slave who joined her father's family (Figure 4-1). Equally, she claims to have been born in the region. Sometimes relatives get

[6] In the Pantanal man-made mounds (locally known as "Indigenous Mound") are unflooded spots made by different materials such as pottery' shards and organic compounds, especially shells (Eremites de Oliveira 1995).

married, however, this is neither common nor seen as entirely acceptable. For instance, nuclear family 8 is composed of two cousins who got married. When asked about it, they promptly justified their marriage saying they did not know they were cousins before getting married.

Figure 4-4: Elderly couple in the Western Border of the Pantanal, Settlement 1.

Today a similar pattern of distribution and kinship is seen on the Settlements. For instance, in Settlement 1, even though everyone lives on the same island, there is a very clear physical separation of the extended and nuclear families. EF1 live on the southern side of the area and all EF1 nuclear families live side by side, they do not mix with EF2 who live in the central part of the "island" or EF3 who live on the northern side. Extended families do not accept outsiders moving in, apart from those who marry into the group or can establish some kind of kinship. The story of Informant 1 illustrates these restrictions very well. He and his family are from North Pantanal and were invited to move to Settlement 1 by Informant 16 (as described, she was not part of the original resident group but moved in when she married someone from EF1). Therefore, Informant 1 and his family were unrelated to any of the Extended families living there. Within a month of finishing their house, the family started to receive threats and had to leave the settlement. However, instead of

coming back to North Pantanal, they moved to the city of Corumbá. While there, Informant 1 met Informant 2, a single mother from Settlement 1 – EF1 who was in the city while her sick baby received treatment in the local hospital. After helping her and starting a relationship with her, they got married. This allowed him to come back to the Settlement 1 and live with her in the house his family had built. His mother and brothers never came back. After five years living there and already with children born in the Settlement 1, he tried to bring two relatives to live in the Settlement. Again, they were expelled.

Local people point out that nuclear families stay living together. The cases when nuclear families move away are mainly due to changes in livelihood. A typical case is when local farmers ask them if anyone could take care of the cattle for a season. The family accepting the job moves to the farmer's place and stay there. Tourism lodging is another source of jobs, and sometimes lodge owners ask nuclear families to work as housekeepers. After the season the family returns to their extended family. For instance, during 2014, Nuclear Family 5 (NF5) who is part of the EF1 was living in Bela Vista Ranch taking care of the cattle. After they finished their agreement with the farmer they came back to live in Settlement 1. Moreover, it is not unusual for a relative from the city to come to live in the settlement and start gathering bait or fishing. Moves in the other direction are equally likely, with people from the settlement going to live in the city and coming back after a while. Outsider perception is that there are always new people moving in and out. However, when local people are asked about the new dwellers they tend to answer that these individuals were already living there but were "away for a while". There is a sense that if someone is part of the family they will always be part of the settlement with a right to residence.

There are also out-migrants who do not come back. In the past, this would be a way to establish new extended families. EF4 is probably one of the most recent cases. The family is composed of eight people: a couple (informant 22 and informant 23) with two daughters, two sons in law and three grandsons. They do not identify themselves as part of Settlement 1, living further south between Settlement 1 and Settlement 2. They settled in their site around 10 years ago, after living in a few tourist lodges as

housekeepers. Today the man of the household reports that he is a farmer. Both informants 22 and 23 were born in the region, and as claimed by people from Settlement 1, their families were living throughout the floodplain moving according to environment and landscape changes. Today, however, the most common "definitive migration" is to the cities. The settlements have seen a marked rural exodus, with some authors believing that they will soon disappear altogether if current trends continue (Amâncio et al., 2010). Hence, even though, as described, there are three extended families living in Settlement 1, this, probably represents a very small subset of the people who used to live there. Nonetheless, any estimation of how many extended families were living, for instance, just where the region of Settlement 1 is today, is unlikely to be accurate. People claim to have been there at least for four generations (roughly 100 years). However, settlements of Guató families (the main founder influence in the formation of these groups) were only officially extinct from the region in the 1950s (Ribeiro, 2005). Therefore, both groups had lived side by side, or together, for at least 50 years. Hence, it is hard to identify whether an extended family was a Guató family or one that was already mixed race. The only thing for sure is that, the region was much more occupied in the past.

4.5.1.1 Religion and Extended Families

Another aspect of the extended families is the division between religions. In Settlement 1, although all people are Christians, each extended family has its own religion. Hence, EF1 is Evangelic, EF2 is Catholic and EF3 is Presbyterian. In 2015, Informant 12 and 13, a couple of pastors, built an evangelical Church in the Settlement and every Sunday they carry out a service (Figure 4-5). Sometimes Catholics may attend. There is no Catholic church in the Settlement, however, celebrations worshipping different Catholic Saints are quite often held. Equally, although the evangelicals argue that worshipping saints is against their religious principles, they may attend these festivities as a way to socialise with the group. Presbyterians do not attend most of the religions events.

4.5.1.2 Ethnicity

During the interviews people were asked about their ethnic identity. First, local people separate themselves very clearly from Indigenous Groups. 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 rice was "an Indigenous food, and they were no Indians", as suggested by an NGO practitioner. When I asked about how they see themselves, suggesting different possibilities, such as "sulmatogrossense (someone from the state of Mato Grosso do Sul), "matogrossense (someone from the state of Mato Grosso)" or "pantaneiros" (someone from the Pantanal), everyone interviewed pointed out "pantaneiro". During following conversations people made very clear that they have a strong identity with the Pantanal. However, when compared "pantaneiro" and "Brazilian", they chose the second option.

Some people claim that "*we are a traditional people, we can stay here*" (Informant 7, settlement 1, female, 46 years). However, most likely, this very emphatic claim is a consequence of the conflict between protected areas and fishers. As earlier presented, environmentalists tried deconstruct the possibility of labelling local people as a traditional people, and development NGOs warned local people to always say that they indeed are a traditional group.

Figure 4-5: Service being held in an Evangelical Church in Settlement 1.

4.6 Local people's livelihoods

4.6.1 Trade in wildlife and caiman poaching

Historically, trading of wildlife has been an activity in the Pantanal since the first colonizers reached the region. The great abundance of large and medium mammals, reptiles and birds makes it a hotspot for hunting. Thus, even though hunting was declared an illegal activity in Brazil from 1967 (law 5.197 from 3/01/1967), poaching has kept going in the Pantanal for many years. The main focus was Yacaré caiman (*Caiman yacare*). Other species such as jaguar (*Panthera onca*) and giant otter (*Pteronura brasilienses*) were, indeed, important, however, they soon approached commercial extinction in the 1970s, (Tomas et al., 2015). Moreover, caiman leather was a very popular product in Europe and America and, therefore, a profitable activity. During the 1960s Pantanal was already the biggest source of caiman leather in the world (Mourão, 1999).

Most of the caiman poaching was carried out in the Western Border of the Pantanal. Interviewers pointed out that the region was a hotspot for caiman hunters because it has a high concentration of water bodies (the most suitable habitat for *C. yacare*) and, compared to other Pantanal areas, there were more people living there who could help in poaching. Informant 24 (former poacher, 45 years) gave more details about the caiman latter business:

> "A group of poachers (coureiros– Brazilian Portuguese men who works or sell leather) was normally composed of 12 boats with 2 people in each (one as a pilot and the other as a hunter). All poachers were settled on the same place. Then, a leather dealer used to come and choose his poachers. He provided all equipment for us. Each excursion would take 20-30 days. After that we had to clear a landing area and a small plane would come and pick up the leather. After we finished the job, either you would come back home or to the poachers' settlement to be picked up again".

Informant 28 (former colonel of the forest police) pointed out that the leather was taken to Bolivia or Paraguay. In these neighbouring countries hunting was not illegal and they could effectively launder the skins and export them to USA or Europe. Based on the interviewees' information, it was estimated that each caiman skin was sold for approximately USD 5.00. Poachers had to be skilful merkmen, most caimans were killed with a shot in the eyes in order to not damage the leather. It is generally accepted that during the 1980s, about at least one million skins were exported from the Pantanal per year (David, 1989).

To restrain this activity, the Local Government set up in 1979 a specific branch of the forest police to fight against the poachers, in what is still called "the war against coureiros" ("*Guerra contra os coureiros*"). Little is known about this period in the Pantanal and the information available is unreliable. However, it is a fact that the Pantanal saw serious violence. For instance, informant 22 (EF4, farmer, 42 years, farmer) report that: "*for several times they tie the hands and feet of my father and pull him along in the water with a boat to make him tell where he was hiding the leather*", or by informant 12 (fishers, 72 years) "*They forced me to eat raw meat of a whole pecari, when they saw I had hunted it*". There are similar descriptions about the violence in the region from the police side, as described by informant 28 (male, former colonel of the forest police, 57 years), "*in the day I got shot on the shoulder,*

11 other colleagues died". In one notorious clash some local newspapers from that time reported 27 people died both from forest police group and *coureiros* (Ruiz, 2014). However, most deaths were not recorded, according Informant 32 (former forest police group member) "people's corpses were left to be picked clean by piranhas". As an attempt to finish the "war", between 1988-9, the federal government increased the numbers of policemen and their military armament. However, the new approach just led to "complete chaos", as described by informant 28 (male, former forest police coronel, 57 years), and caiman poaching did not stop. It only came to an end towards the end in the beginning of the 1990s after Yacaré caiman (the most poached species in the Pantanal) was listed on the US Endangered Species Act and banned from trade in America (Mourão et al., 2000). With no buyers in America or Europe, caiman dealers left the region or started to invest in other business ventures.

It is important to note that some authors (including IUCN's Crocodile Specialist Group) claim that listing Yacaré caiman as "endangered" was an instrument to promote USA's caiman leather production, and some authorities argue that this species in fact has never faced any real threat of extinction (Mourão et al., 2000, 1996; Ross, 1998).

Moreover, although caiman poaching came to an end, suspicious feelings and a great lack of trust between conservation practitioners and local people still persist in the Western Border of the Pantanal. Today ex-members of the forest police coordinate local environmental groups and military enforcement is used to support prohibitions on natural resource use. For instance, even though hunting for home consumption is not illegal, people tend to hide their wild meat even when it is intended to be consumed locally. It is interesting to compare the perception of some people from the environmental groups, who remember things differently; as presented by Informant 25 (female, 52 years, former forest policemen and currently protected area manager) "*I miss the time when people respected us; I remember one day that we put a gun on the head of someone here and pretended we pulled the trigger several times*".

4.6.2 Fishing

During the 1980s, fishing developed greater importance. Several federal and local government initiatives supported local fishers. For instance, in 1981 they funded the creation of the Fishing Cooperative of Corumbá alongside a fish processing plant that played a fundamental role in the local fishing economy, once they started to buy local people's fish and deliver it to outside markets (Silva, 1986). Moreover, local fishers pointed out that, it was during the 1980s that new fishing gear and techniques were brought to the region, in the form of Set Hooks ("anzol de galho"). Anzol de galho are individually set hooks whose lines fishers can set side by side, especially on the riverbank in the middle of the vegetation. This allowed fisherman to reach areas covered by forest where large valuable fish hide and, therefore, to increase their catch. Although, currently each fisher is allowed to set no more than eight individual "anzol de galhos", in the 1980s there were no legislation regulating this technique. As a consequence, even though some restrictions were established on fish size and permitted gears, local people's total catch doubled from 1070 tons in 1979 to 2136 tons in 1984 (Catella, 2003).

However, policies in support of local fishing in the Pantanal did not last long. Informant 33 (local researcher on fisheries) argues that agenda change started when tourism companies took 11 federal deputies to the Pantanal to show how their business could boost the local economy while arguing that local small-scale commercial fishing should be forbidden. As presented in Chapter 1, section 1.5.2, for some 40 years, fishers have been accused of overfishing, with some commentators maintaining that there is no customary management that could promote sustainable use (Franco et al. 2013). As a consequence, several laws were established to reduce this perceived fishing pressure.

4.6.3 Fishers in the Pantanal

Although local people have been facing severe restrictions over natural resource use in, fishing remains the main activity among local dwellers. In fact, fishing has always been part of local people's livelihoods, Silva (1986) recorded that local

dwellers started to sell salted fish in Corumbá city from the early nineteenth century. Fishers in the Western Border of the Pantanal

During the interviews with local people in the Western Border of the Pantanal, 95% of local dwellers identified themselves as fishers. The data collected during this study showed that of the 22 families living in Settlement 1, around half (44%) depend on gathering bait as their main livelihood, 23% on fishing and 33% on other sources such as short term jobs and pensions (for retired fishers). Moreover, it showed that fishing and gathering bait activities can be divided into four main categories: bait gatherer, bait gatherer middleman, fisher, and fisher owning a boat. Each category faces different difficulties in seeking to enter the fishing trade, described as entry barriers (Monnereau and McConney, 2015). Thus, each fisher needs to make some investment according to their category's entry barrier. Classes with higher entry barriers lead to higher profits.

It is important to note that in the Pantanal fishing is carried out through artisanal means. Powerful fishing gears that would allow professional fishermen to scale up their catch, are forbidden. Local fishers are only allowed to use line and hook, with some adaptations, such as set hooks. Therefore, although they are called professional fishermen because of their participation in the market, their impact on the system is small-scale, as it will be better explained in Chapter 5.

4.6.4 Bait

4.6.4.1 Bait gatherer

The first category, which yields only low income and has low entry barrier, is "gathering bait for a middleman". Both men and women can do it. The person gathers bait and delivers to someone else from the settlement, who sells to the tourist boats (Figure 4-6). The informal commitment between the bait gatherer and the middleman in Settlement 1, works two ways: either the person gathers bait and then seeks for a middleman to re-sell it or a middleman asks the person to gather bait. The middleman sells each crab for USD 0.18 and each tuvira for USD 0.30, and the profit established is always USD 0.01 of each unit. In Settlement 1 people tend to gather

more crabs than tuvira, however, local people keep switching between collecting one or the other depending on factors such as the time of the year, demand from tourist boats, and availability of crabs and tuvira in the system.

Local people that acts as middlemen do not provide loans to the gatherers as shown in other places with similar agreements (Pedroza, 2013; Russell, 1987). On the contrary, gatherers receive their money roughly a month after they sell their bait. Sometimes gasoline is provided up-front, borrowed from the middlemen to be used in the bait gatherers' boats when there is high abundance of bait during the high fishing season. Apart from this, the main role of the middleman is to link bait gatherers to external markets (Russell, 1987).

Figure 4-6: Bait gatherer collecting bait in the Western Border of the Pantanal

An important fact is that only people who are part of the extended families from Settlement 1 can become bait providers. In other words, other people from different extended families from the Western Border of the Pantanal cannot take part in this agreement. However, this does not exclude those families who are living abroad for a

while but who remain members of the extended families established locally. For instance, Informant 12 (male, 72 years) who is part of the EF1, was living during 2014 in the Best Vista farm far from the Settlement 1. For several weeks during the high season he provided bait for Informant 1 who is a bait middleman in Settlement 1. This is because, as already described, local people see relatives as remaining lifelong members of the settlement group even when they live elsewhere.

Some middlemen who have many providers tend to not take more than a certain amount of bait from each provider (for instance 150 baits per week). Nonetheless providers can find more than one middleman to resell their bait. The quantity of bait sold depends on the time of the year and the type of bait. At the beginning of the fishing season the quantity of bait sold is low. There are few tourists and a low availability of natural resources on the floodplain. However, from the middle till the end of the fishing season, the demand for and supply of bait is higher, once there are more tourists and more natural resources available on the floodplain. It was estimated that their monthly wage is, on average, USD 86.00 in the beginning and can reach USD 375.00 per month from the middle till the end of the fishing season (Table 4-1). However, it is important to note that due to the great variation in the quantity of baits gathered between weeks, the relatively small sample size, and the continually changing on livelihoods, this wage estimation is a very broad approximation of reality; of the 44% of the families gathering bait in Settlement 1, 50% are bait providers.

4.6.4.2 Bait gatherer middleman

The second type of job involves gathering bait for tourism companies. These individuals gather bait themselves or sometimes resell it from other members of the settlement as middlemen, as already described. These people have an informal contract with the companies to sell crabs and/or tuviras direct to tourist boats. Some have more than one contract, for instance, Informant 5 has six different boats that buy from him, but most have just one. The contract works such that the gatherer agrees to sell bait for the boat assuring that every week they will be able to buy a considerable quantity of bait (this is not defined and it depends on the time of the

year, but it means, for instance, no fewer than 300 crabs and 200 tuviras per week). Each week after the deal is done, someone from the boat crew gives an informal receipt to the gatherer, stating how many baits were bought. When gatherers want to collect their money, s/he must go to the city and exchange the receipts for cash in the tourism boat office. As already said, the number of bait sold, and therefore, the income varies depending on the time of the year and there are several caveats on this data. As an estimate, on average, it comes to around USD 106 per month in the beginning of the season and can reach USD 862 per month from the middle till the end (Table 4-1). This group represent 50% of all bait providers of the Settlement 1.

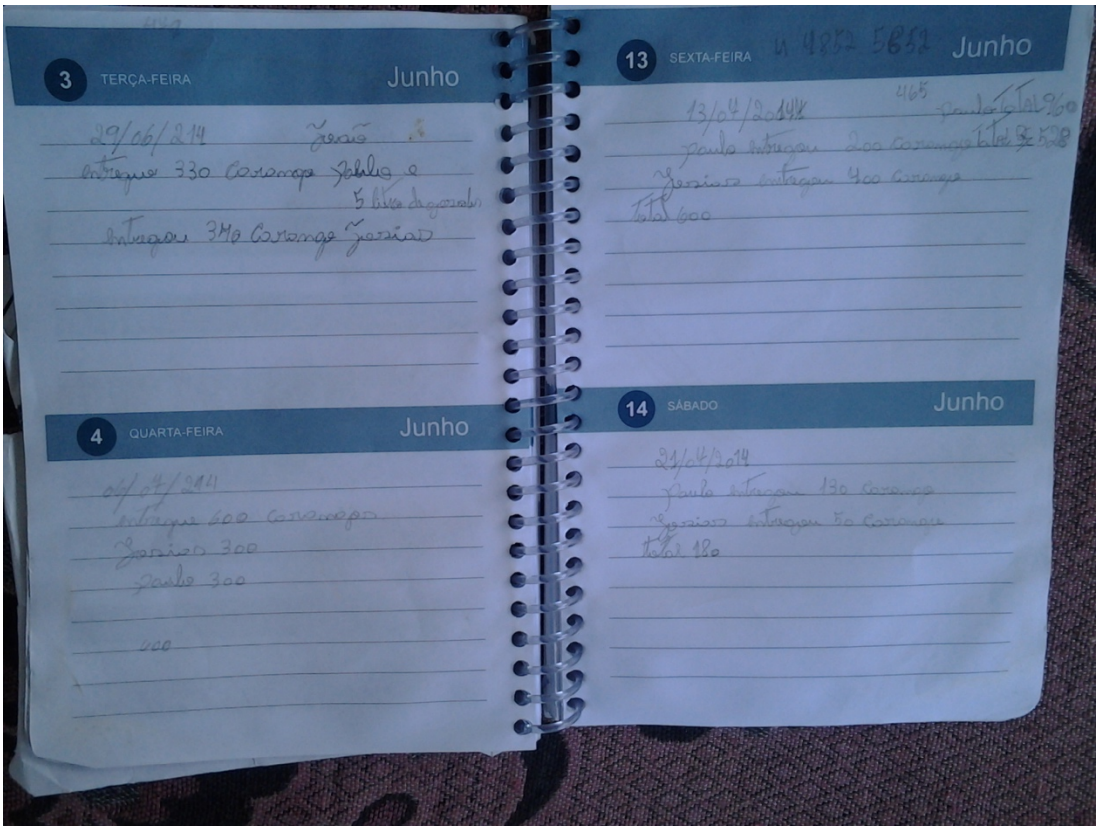

Figure 4-7: Bait gatherer middleman's notebook showing his daily notes on who gathered bait for him and how many. Settlement 1, Western Border of the Pantanal

4.6.4.3 The problems of the bait gatherer's contract with tourism companies

Due to the informal nature of the contract, local sellers are placed in a very vulnerable situation. First, there is no guarantee that the boat will come every week, and the tourism company have no obligation to warn their sellers when their boat is

not going to come, which would allow the sellers to find another boat to sell their bait outside the contract, or to a middleman. In this situation, given that tuvira and crabs are fragile species, the bait that has been collected will normally die. Moreover, for instance, the ideal price established by local authorities for each tuvira is USD 0.30 and crab USD 0.26, however, today, crabs are bought for no more than USD 0.18 each unit and tuvira USD 0.20. Finally, even though tourism companies already buy bait below the established official price, they are constantly pressing gatherers to bring the price down. When a company finds a nuclear family willing to sell below the usual price, they normally cancel the contract with the previous seller without giving them notice. This was seen twice during 2014, although, people usually tend to respect other folks' contracts. For instance, informant 1 had a contract with one boat since 2012 to sell crabs for USD 0.18, however, at the end of 2014 they cancelled it and started to buy from Informant 34, who offered crabs for USD 0.10. This can cause a lot of trouble and lead to fights between the settlement members.

Companies, differently from local middlemen, they lend money to local bait gatherers. Most local families do not have a bank account or a regular salary that could allow them to borrow money from a bank or any credit institution. Thus, some people who have a contract with the tourism companies use their "good relations" to borrow money from them. For instance, Informant 1 negotiated a loan of USD 1192.00 from the boat company to buy himself a bigger boat made of steel. He paid back during the year in two instalments of 3200 units of crabs. Moreover, every week they borrow gasoline from the tourist boat (roughly 20 litres at a time), which is used to reach the bait spots and to power the electric generator in the house. Any spare gasoline is sold to other members in the settlement. The gasoline is paid back when they go to the company office to exchange their receipts for cash. The price charged is USD 1.19 per litre.

Their economic dependence on the tourism companies creates a very fragile situation for the bait gatherers. These companies are their main source of income. Thus, if there were no companies baying bait in the region, they would be even under more pressure. Companies use this power to extract surplus labour from the gatherers (Béné, 2003). Thus, even in the face of under-pricing the bait purchase price, and the

lack of guarantees on the agreed contract, gatherers make no direct claim for a better deal. Local families fear that complaining about the arrangement, would lead the companies to cancel their contract and start to buy from somebody else. When asked about their deal with the companies, bait gatherers normally answer: "*the company has been very good to me*".

4.6.5 Fish

4.6.5.1 Working for a fisher

The third type of job, again, yields a low income and requires only low investment in fishing gears (low entry barrier). This consists of "working for a fisherman". Anyone who accepts this job needs to bring his own fishing gear and half of his catch is given back to the owner of the boat. Only men can carry out this work, each fishing trip last between seven and 12 days, depending on when they reach a good catch size. Each boat takes between six and eight people. Settlement members normally keep switching from gathering bait for somebody else to fishing for a fisherman, people's decisions normally depending on the quantity of bait and fish available in the river, personal interest, the possibility of investment in fishing gears, and the time any individual can stay away from home. On average, fishers, can earn around USD 90 monthly in the low season and USD 297 per month in the high season (Table 4-1).

4.6.5.2 Fisherman owning a boat

Lastly, there are "fishers owning a boat". This requires a major investment in fishing gear and goods (constituting high entry barrier). Apart from the initial investment of buying a boat, which can cost around USD 3,000, each trip necessitates its own investments. For every trip, on average, owners buy 200 litres of diesel, 1000 kg of ice, USD 119 in food, and 50 more litres of gasoline. Altogether means an investment of USD 477.00 roughly every 15 days. Everything is provided for the fisher participating, apart from their fishing gear. The reason given for not providing the fishing gear would be the recent fishing restrictions and the reduction on profits, as described by Informant 17 "*to have any profit I need to fish at least 50Kg and my crew 200Kg of Pintado (sold for USD3.00 per/ kg) each fishing trip, we did not*

reach this in the last two fishing trips". Fisherman owning a boat earn from USD 243 monthly in low season to USD 1845 monthly in the high season. Only three families own fishing boats in Settlement 1 (Table 4-1).

Table 4-1: All types of fishing jobs and associated earnings during the high and low fishing season.

Type of fishing	Entry barrier	[Earnings] – [Investment] = Total USD monthly	
		Low season	High season
Bait Gatherer	Low	86	292
Bait Gatherer Middleman	Middle	106	862
Fisherman	Low	90	297
Fisherman owning a boat	High	153	1323

4.6.6 National insurance for fishers

Legally all fishers (bait gatherers or fishing large fish species) should receive a national fishing insurance benefit during the closed season (4 months of a minimum wage, USD 247). However, some people living in the settlements do not have personal documents, such as ID or any kind of identification, and, therefore, they cannot be registered as a fisherman in the federal database. This bureaucratic process is meant to be backed up by the local fisher's association. Nonetheless, with the policies supporting small-scale commercial fishing in the region having come to an end, all financial provision was withdrawn leaving the local fishers' associations in a very precarious situation. As a consequence, normally, each fisher needs to do all the bureaucratic process of registration alone, limiting the chances of success. As described by Informant 34 (fisherman, 27 years):

> "I went to Corumbá to do my fishing ID, after 2 hours in the queue they told me that I was in the wrong place, then, when I went to the right place they told me that I should bring some documents that I have no idea about it, after that I gave up".

As a result, several genuine fishers in the settlements do not receive their fishing insurance during the closed season. In Settlement 1, it was estimated that, this amounts to 20% of all professional fishers.

A second problem is the inefficiency of the system in dealing with people living far from national insurance "collection point". To receive their payment, fishers need to go each month to the collection point to get their money. However, Settlement 1 are far from the nearest city and travel is difficult and expensive (sometimes 24 hours by boat to the nearest city) people tend to avoid going there. A widespread solution found is to give their IDs to "loan sharks" to collect their money. Loan sharks pay all the four months' benefit in the first month for the fishers in exchange for between 20% and 40% of their whole fishing insurance payment.

4.6.7 Selling fish directly to consumers

People who are primarily bait gatherers or middlemen also trade fish. They sell fish directly to tourists not able to fish themselves, or to boatmen who pass by the settlements loading cattle or other commodities. There are two possibilities: either someone who is sailing up the river orders fish to be collected later on the way back or they ask for surplus fish. Normally the fish price charged is lower than in the city, however, the profit is higher as people do not need to go through the market chain to reach the consumer. The fish is not necessarily paid for in cash, sometimes it is traded for gasoline or diesel.

4.6.8 Different types of natural resources

4.6.8.1 Livestock

Livestock are not very common in the settlements within the Western Border of the Pantanal. Only few families keep livestock. For instance, in Settlement 1, of the 22 families living there only two have any kind of livestock. People argue that the high numbers of jaguar (*P. onca*) and anaconda (*Eunectes sp.*) make it hard to keep any kind of livestock. This is partly true especially for small animals. For instance, in the first two days of the flood period, a 4-meter anaconda ate all five chickens owned by informant 7. However, people's spatial organization, based on mobility and extended families living separated, may be a second important cause, as moving around a flooded landscape and sharing small living areas with livestock, can be tricky. This is

especially true during the flood period when areas of grass are reduced and there is almost nowhere for livestock to feed.

Moreover, livestock can cause conflict with neighbouring nuclear families. As already described, Settlement 1 is located on an area surrounded by rivers, having grown up when three different extended families were grouped together after conservation interventions displaced them from their original areas. Cattle are raised all over the island, and the families owning them do not have fences to enclose them. The consequence is that they eat all neighbours' plantations causing damage to areas that could otherwise grow fruits or vegetables. Some families tried to build fences; nonetheless, during the flood period when there were no places for the cattle they broke all these down and invaded people's plantations. After every flood period, new fences need to be built again. Some families have now given up both building fences and also planting any kind of vegetable or fruits. There are constant complaints about livestock damage, however, no solution has so far been found. Families keeping cattle are all fishers owning boats, and are therefore, the wealthiest people in the settlement. Hence, the cattle, probably, are used as a wealth store, and signal of economic and political power. However, it is important to bear in mind that this problem would not exist if the three extended families were still living in separate sites.

Figure 4-8: House with no plantation around due to the cattle grazing on the Settlement 1.

4.6.9 Alternative Livelihoods

Although the main economy in the Western Border of the Pantanal is fishing, people tend to seek other sources of earnings to complement their income. There are several ways people do this. It can be through a new type of job or by trading a different natural resource.

The most common opportunities for new jobs arise when farmers or tourism companies ask families to take care of the cattle or help in a tourist lodge for a season. Informant 7 (settlement 1, female, 46 years), for instance, has worked in several tourist lodgings all over the Pantanal, and for her gathering bait is only the "*alternative when there is no job*". Sometimes, a man goes alone to the new place, leaving his wife in the Settlement while he is employed elsewhere. This was most seen in cases where men were asked to work in civil construction or decided to go to the mining sector in the North Pantanal. It is interesting to note that even when

moving away from the settlement and undertaking a new activity, some members still keep gathering bait or fishing.

The most common source of new jobs, however, is related to public services. For instance, in Settlement 1 and Settlement 3, there are municipal schools for the local children. Both places hire settlement members to undertake activities such as cook, kitchen porter, boat pilot, school watchman, etc. These jobs are very hotly contested because they have the guarantee of a regular income of USD 272 per month. Hence, these workers can open a bank account, and most importantly they do not need to rely for their livelihood only on the "kindness" of the tourism companies. For instance, Informant 15 (male, 65 years) and Informant 19 (male, 50 years) had contracts to gather bait for a tourism company, and both gave it up to work as a school watchman and children's boat driver respectively. Ideally, this kind of job should rotate among settlement members every year. However, in practice, some people have occupied the same position since the first appearance of these school job opportunities.

In each school, there are between two or three teachers. Children of different levels are grouped together because of the shortage of staff. The department of education of the municipality chooses the teachers, they need to go through a selection process and all teachers interviewed must have no formal link with local families. They stay living within the school between two or three months before going back to their homes for between 15-20 days. There is a very high turnover of teachers, who presumably, see it as a hardship posting. During the two years' period of fieldwork, every three or four months a new teacher was replaced in Settlement 1.

The second source of jobs is in the National Park, which has its office nearby Settlement 1. Currently two settlement members are hired in the Park, one as a kitchen porter and a second as office watchman. However, the Park has the potential to hire higher numbers of local people. This because all federal Protected Areas in Brazil that are under forest fire threat are allowed to hire a certain number of firemen. The number of people hired depends on the potential threat. This program is called "prevfogo" and the National Park of the Pantanal is allowed to hire seven

people for six months during the dry season every year. Managers all over Brazil tend to use this program to help surrounding communities with money and to create a better partnership among the Protected Area different stakeholders (Dias and Drummond, 2008). Chiaravalloti et al., (2015) showed that managers point out that using the surrounding human capital in the "prevfogo" can achieve results far beyond the reduction of forest fires, such as reduction in deforestation, enhancement in local participation, better knowledge of the importance of the park etc. However, in the National Park of the Pantanal none of the firemen hired are from the region. Informant 27 (Protected Area Manager, 35 years) justified this by saying "*all the training need to be undertaken in the city of Caceres and we did not have money to take local people from here to there and then bring them back*".

4.7 Discussion

Restrictions imposed and negative impacts on local peoples' livelihoods can trigger opposition to conservation initiatives and, sometimes, actively exacerbate impacts on the environment (Adams and Hutton, 2007). Thus, a community-based conservation (CBC) approach should bring the environmental agenda closer to its main goals (Smith et al., 2009). However, CBC has been applied in ways that has often brought no change, and has sometimes exacerbated the impact on local people (Campbell and Vainio-Mattila 2003), Thus, scrutinising each of CBC's tools is a fundamental step towards a sustainable development.

The Brazilian National Policy on Traditional Peoples and Communities ("Political Nacional de Povos e Comunidades Tradicionais") was an important instrument to guarantee that conservation interventions respect a specific type of local group that depend on natural resources for their livelihood and wellbeing despite being invisible to the state for centuries (Calegare et al., 2014; Little, 2002). However, it brought under state control many powerless groups, while reinforcing the impact on the others that were not listed. For instance, environmental groups used the fact that local fishers living in the Western Border of the Pantanal are not part of the established list of traditional communities in Brazil to justify strict conservation measures that jeopardized local livelihoods and have led to economic and physical displacements. This paper has shown that local fishers living in the Western Border

of the Pantanal, indeed, do not share the characteristics of the Pantanal's established "Traditional People". For instance, the listed riverine communities, which could be the closest group, are described as settled families living around sugar mills (Neuburger and Silva, 2011; Silva and Silva, 1995) while those living in the Western Border of the Pantanal have as their main feature mobility. However, the accusation that these people moved to the region after 1974 and are destroying the environment (Franco et al., 2013) is unfounded and untrue. The evidence shows a long history of occupation in the area, probably of at least 150 years. Moreover, it has been shown that they undertake a fishing system that is likely sustainable, based on common property regime and customary regulatory institutions (Chiaravalloti, 2017).

The invisibility of these fishers in the Pantanal, is part of the global challenge to recognize mobile societies as being legitimate members of local groups (Chatty, 2003; Dyer, 2013). One of the main reasons is that their movements searching for natural resources often is not restricted within formal borders of individual municipalities, states or countries, and the governments of their administrative units tend to exclude them from formal group categories (Randall, 2015). Moreover, mobile livelihoods are not registered in the national, regional or international consciousness (Chatty, 2003; McNeely, 2003; Overa, 2001; Randall, 2015; Wadley, 2003). Therefore, the problem remains even when governments or scientists locate and recognize these communities. Sometimes the lack of information may be strategically beneficial for some stakeholders (Upton, 2010); simply put, negative consequences for an invisible group are equally invisible.

The observations presented in this paper lead to two important discussions regarding the Brazilian classification of "Traditional Peoples and Communities" and its practical consequences. On the one hand, the case emphasises the caveats of the term. There are uncountable communities that are not labelled as "Traditional Peoples and Communities" yet undertake sustainable use of natural resources managed through customary governance (Calegare et al., 2014; Creado et al., 2008). Like the fishers from the Western Border of the Pantanal, Castro et al., (2005) pointed out that, in the Atlantic Forest groups settled more than 200 years ago are considered traditional communities, on the other hand, groups from 100-50 years ago are seen as non-traditional settlers or squatters, even though the evidence shows the

presence of customary use and sustainability regardless of the "traditional" label. This is partly because the concept is based on the assumption that in order to sustain this label, local people have to keep their social structure, customary use, property regimes (or tradition) unchanged (Creado et al., 2008). The case study in the Pantanal showed that fishers adapt and re-adapt according to internal and external changes. Hence, the formal category of Traditional Peoples and Communities by the Brazilian Legislation disregards the fact that communities are a continually evolving product of on-going social, economic and political negotiation; comprising a group of different actors or stakeholders with different preferences for resource use (Allison and Ellis 2001). To consider a community as an homogeneous unit is to ignore the ways differences between people within the community may affect resource management, local politics, and strategic interactions, as well as the possibility of layered alliances that can span multiple levels of interactions (Agrawal and Gibson, 1999; Haller et al., 2013). A clear-cut division between traditional and non-traditional communities fails whenever complex social interactions take place (Castro et al., 2006).

However, on the other hand, communities living in rural areas normally lack governmental support, most of them have no access to public health, education and sanitation (Cunha and Almeida, 2000). Being labelled as a "Traditional Community" can bring benefits ranging from economic incentives to tenure rights; it is a way to fight the prejudices against rural communities and their natural-resource based livelihood (Little, 2002). This explains why local environmental groups in the Pantanal have fought so hard to exclude fishers of the Western Border of the Pantanal from being defined as part of "Traditional Peoples and Communities" (Franco et al., 2013). Therefore, in that sense, labelling this group could become an important political move to support, otherwise, powerless people. This paper presents the foundations to do so. This will be better illustrated in Chapter 6, section 6.3.1.

4.8 Conclusion

Community-based conservation tools have to capture important social aspects of people's life, such as social relationships, autonomy, adaptiveness, customary

arrangements and wellbeing (Woodhouse et al., 2015). Labels, therefore, will always be a snapshot of people's reality (Allison and Ellis, 2001; Lechner et al., 2014). The complex realities that dictate local people lives ought to have, at least key dimensions, part represented in CBC's tools. Otherwise, such tools can be used for the completely opposite purpose they were created. Therefore, the Brazilian National Policy of Traditional Peoples and Communities is an important tool of CBC, it could be a key example for other countries in the global south facing similar challenges of biodiversity conservation and local development. A more flexible and fluid categorization of traditional peoples must be incorporated in order to not create tools reinforcing the already oppressive restrictions placed on local communities.

Chapter 5 Overfishing or over reacting? Understanding management of floodplain fisheries[7]

5.1 Abstract

This chapter analyses the narrative of overfishing in the Western Border of the Pantanal as a result of local fishers' resource use. First enforcement over fishing in the Pantanal, as set out in Chapter 1, section 1.5.2, is revisited. Time series regression is then used in order to establish which variables best explain the observed variation in tourist numbers. The chapter goes on to use participatory observation and mapping data to deconstruct the environmental narrative, in order to further explore Pantanal fisher's complex traditional system of use. The case study firstly illustrates the adverse consequences of misconceived top-down fishing management practices. Secondly, it develops one possible approach as to how such environmental narratives may be deconstructed. It goes on to present important aspects of customary management in inland floodplains fisheries, including high levels of mobility within a mix of common property regimes and unexploitable reserves. It concludes by identifying fundamental elements that must be taken into account in designing appropriate management policies in inland floodplain fisheries.

5.2 Introduction

As presented in Chapter 1, section 1.5.2, for the last 40 years or so, professional fishing in the Pantanal has been scrutinized by different stakeholders. Environmentalists claim that that the use of the floodplain should be forbidden, accusing local people of destroying the environment (Franco et al., 2013). Tourist companies bringing approximately 10,000 people to the south Pantanal for sport fishing, lobby for a prohibition of commercial fishing, equally accusing local people of overuse. Tour operators point to the claimed overuse as the main cause of a tenfold reduction in tourist numbers coming to the Pantanal. Due to the huge political pressure over commercial fishing, different laws have been imposed to restrict fish catches. All enforcement was focused on single species and types of gears. As a consequence, today, fishers (either professional or tourists) in the Pantanal can only

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use hook and line; and those local people who continue to gather bait may only do so legally in the southern Pantanal (Catella et al. 2014; Maymone 2015)

Overfishing accusations are not new nor are they unique to the Pantanal (Chapter 1, section 1.4). However, allegations of overfishing must be supported by science, which is often not the case. Changes in the fish stocks are normally immediately attributed to problems due to local fishing effort even though such relations are far from being one of straightforward cause and consequence (Abbott and Campbell, 2009). Ecologically, overfishing means that more fish are being taken from the stock than can be replaced by natural process. Long term overfishing may mean the collapse of the fish stock, leading to drastic social, economic and ecological consequences, as seen on some cases worldwide (e.g. the collapse of Atlantic Cod in Canada: Hutchings and Myers, 1994). However, although the identification of overfishing cases is pivotal for sustainable development schemes, the evaluation of such phenomena is rather complex. For instance, overfishing leads not to single-species responses, but to a fishing down process: put simply, larger species disappear to be replaced by smaller ones leading to a decline in mean size of individuals and species in the assemblage (Welcomme et al., 2010). In practical terms, even though fish communities are subject to considerable fishing pressure, overall weight of catch may remain relatively unaffected. In other words, decline may only be apparent when collapse is underway (Welcomme, 1999). Therefore, conventional concepts of overfishing are thus difficult to apply (Welcomme, 1999). Moreover, most studies are derived primarily from industrial marine fishing, and the knowledge on inland fisheries is still minimal (Cooke et al., 2016). In face of such complexity, approaches to local sustainability should be based on fostering adaptive management through local-level self-governance and co-management, building on traditional ecological knowledge, and traditional governance structures (Cooke et al. 2016).

Policy makers, however, have been underpinning their actions on the basis of regulatory actions that do not necessarily lead to better management, such as: enforcing strong restrictions on fishing gears, creating strictly protected areas, closed seasons and minimal size regulations, or even displacing fishers from the region altogether (La Valley and Feeney, 2013). This approach has brought limited success,

especially for inland fisheries (Allan et al., 2005; Cooke et al., 2016; Kolding and Van Zwieten, 2014). Scholars argue that one of the main reasons is that fisheries management "placebo" policies are underpinned by concepts of environmental equilibrium, distributional homogeneity, simple predictions of density dependent population growth and the idea that fishers are uniquely driven by profit maximizing extraction (Wilson et al., 2013). However, as presented, fish population growth and decline may behave in ways not captured by these models (Welcomme, 1999), especially when the environment is rather unpredictable, and local groups constitute complex institutions (Penha et al., 2014). In these circumstances ecological dimensions of connectivity, number of patches suitable for the species and ecological variations through time are more important drivers of sustainability (La Valley and Feeney, 2013; Parsons and Maguire, 1996; Wilson et al., 2013). Moreover, people's fishing behaviours are embedded in a complex social context of rules for use and access (Chapter 1, section 1.2.2). Ostrom, (2011, 2009) built on findings emerging from ethnographic studies to show that customary mechanisms can sustain long term fishing through adaptive forms of management (Berkes, 2009, 2004; Kittinger et al., 2013; Monnereau and McConney, 2015). Consequently enforcement measures designed around ideas of equilibrium in population dynamics and enforcement on local resource users may have little relevant effect on sustainability (Wilson et al., 1994). On the contrary, they may even jeopardize customary arrangements that are effectively securing sustainability of local resources. Another important point for discussion is raised by new postulated property category "Management of Open Access". The main idea is that open access (lack of rules) and rotational movement provide conditions necessary to create sustainable systems, called "Management of Open Access" (Moritz et al., 2014a) (Chapter 1, section 1.4). However, this hypothesis is yet to be proved.

This chapter aims to address the following questions:

To what extent do current management practices in floodplain fisheries, focused on regulating overfishing map onto local realities?

- Is the claimed link between decline in tourist numbers and overfishing is backed by evidence?

- What evidence is there for overfishing in the Pantanal?
- How is small-scale local commercial fishing adapted to the flood pulse?
- Are there customary rules to control overfishing and what are the likely effects?

5.3 Methods

In order to test the validity of the narrative of local people overfishing driving tourist decline, data on tourist numbers and small-scale fishers use of natural resource were analysed separately.

5.3.1 Drivers of change in tourist numbers

The variance in the number of tourists in the state of Mato Grosso do Sul (MS) from 1994 till 2013 presented in Catella et al., (2014) was analysed with respect to (Figure 5-1):

- Changes in annual flood size measured through annual hydrologic index (AHI) (used as a proxy for fishing availability (Welcomme 1999))
- Increase in 5 cm of the minimum legal fish size for Pacu (*Piaractus mesopotamicus*) in 2000
- Increase in 5 cm of the minimum legal fish size for Pintado (*Pseudoplatystoma fasciatum*) in 2006
- Decrease in the tourist fish's quota from 30 kg to 25 Kg in 2000, to 12 Kg in 2002, to 0 kg in 2003, then increased to 10 kg in 2007.

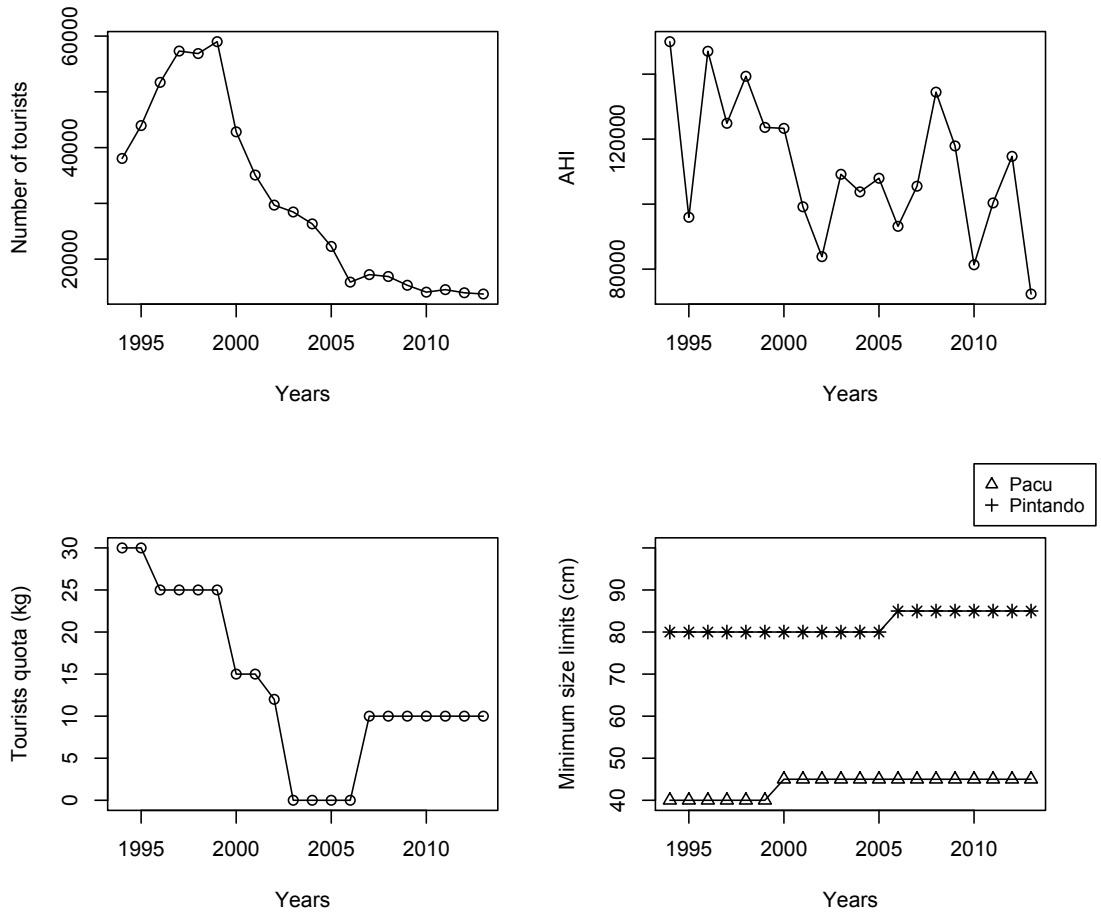

Figure 5-1: Number of tourists for 1994-2013 (top left) and all explanatory variables tested: the inundation size as captured by the AHI index (top right), changes in tourist fish quotas (bottom left), and increase in the minimum legal fish size for Pacu (*Piaractus mesopotamicus*) and Pintado (*Pseudoplatystoma fasciatum*) (bottom right).

It is important to point out that the variables chosen to be tested are those raised by other authors studying fisheries in the Pantanal as the main cause of tourist numbers reduction (Albuquerque et al., 2012; Catella, 2004; Catella et al., 2014). Therefore, although there are uncountable other external factors that may influence the variance in the tourist numbers, such as opening of new fishing spots, change in fashion, Corumbá city infrastructure to host tourists, economic crises, etc. (Cooke and Cowx, 2006), none of these are as important as the ones tested (Catella et al., 2014). The main point is: mathematical models are simplified explanations of complex realities intending to explore the most outstanding patterns. More nuanced understandings of socio-ecological systems may only be uncovered through qualitative approaches, such as participant observation and interviews (Drury et al., 2011).

5.3.1.1 Time series regression and models created

A time series regression was built in order to understand the most important of the drives of change in tourism numbers: as dependent variable the number of tourists per year 1994-2013 (data for southern Pantanal) and explanatory variables being minimum legal fish sizes (Pacu minimal size – PaMS and Pintando Minimal Size – PiMS), quotas for the same years (FQ) and AHI for the previous year (Welcomme 1999).

However, time series regression usually differs from a standard regression analysis because the residuals of the fitted model also form a time series and therefore tend to be serially correlated (Crawley, 2007). Regression tests have the assumption of no correlation between the residuals. As presented Hornik, (2009, p. 57):

> "If this correlation is positive and unaccounted for, the standard errors of the parameter estimates will be less than their true value, so the estimates will appear more accurate than they should, which can result in incorrect 'significant' values appearing in standard regression output."

In order to account for this correlation (Apendix 2 and 3), it was used a test called generalised least square. This test does not have the assumption of independence in the residuals (Hornik, 2009).

Akaike's Information Criterion (AIC) and AIC weight were used to select the best model created to explain the changes in tourist numbers. AIC is based on the concept of entropy, in which the information lost in the model is measured (Bozdogan, 1987). Both measures allow to find the models that represent reality more accurately (Burnham et al., 2011).

All generalised least square analyses and model selection were carried out in R 3.2.3 (R Core Team 2015) using the package AICmodavg.

5.3.2 Customary patterns of use of the Pantanal

As presented in Chapter 1, in order to gain an in-depth understanding of local people's fishing patterns and adaptive strategies addressing the proposed questions of

this chapter, one year of qualitative data collection, participatory mapping and citizen science was undertaken with local stakeholders in the Western Border of the Pantanal.

5.4 Results

5.4.1 Drivers of change in tourist numbers among years

The best model explaining annual variation in tourist numbers considered changes in minimum legal size for Pacu and Pintado, and in tourist quotas. Flood size did not emerge as an important explanatory variable (Table 5-1).

Table 5-1: All different models produced to explain the decline in tourist numbers coming to the Pantanal from 1994-2013. In bold is the model that showed the best fit with the data analysed (lowest AIC and highest AIC weight).

Models	AIC	ΔAIC	AICweigth
PiMS+PaMS+ FQ	**340.7**	**0**	**0.9864**
PiMS+PaMS	349.3	8.5	0.0136
PaMS	363.6	22.8	0
PiMS	373.8	33.0	0
FQ	375.3	34.5	0
FQ+AHI	382.4	41.7	0
PiMS+PaMS+FQ+AHI	382.4	41.7	0
AHI	395.0	54.3	0

PiMS – Pintando Minimal Size; PaMS – Pacu Minimal Size; FQ – fishing quota; AHI – annual hydrological index.

The best model explained the variance in tourist numbers through the following formula:

Number of Tourists = 271147 + (-1,307.06) *(Pintado minimum size) + (-3,203.22) *(Pacu minimum size) + 21.21 *(Tourist quota)

In other words, for each increase of one centimetre in the minimum legal size of Pintado there was a decrease of ~1,300 tourists. A comparable change in Pacu minimum legal size led to a further decrease of ~3200 tourists and, finally, each kilo added to the tourist quota increased by 20 the number of people coming to fish in the Southern Pantanal. Fish availability as represented by flood size in the previous years made no significant change to tourist numbers visiting the Pantanal.

5.4.2 Fishers and customary management practices

With the support of grassroots human rights organizations, Settlement 1 created a formal association to have a political voice in government decisions. However, according to local informants, although the president of the local association is invited to participate in public discussions, such as on the establishment of fishing policies, she frequently does not go, due to the distance from the settlement to the city. Moreover, part of the group depends on the bait trade and some avoid any argument with tourism companies, as they "*want to keep a good relationship with them*" as explained by informant 1 (Chapter 4, section 4.6.4.3). Therefore, most fishing legislation is established without consultation of fishers.

Qualitative and quantitative data showed that fishers, whether gathering bait or fishing, follow the flood pulse drawdown throughout the year. Figure 5-2 shows all points of use, boat tracks and zones collected during fishing and gathering bait activities in 2014 for Settlement 1. These can be divided into three main phases Figure 5-3.

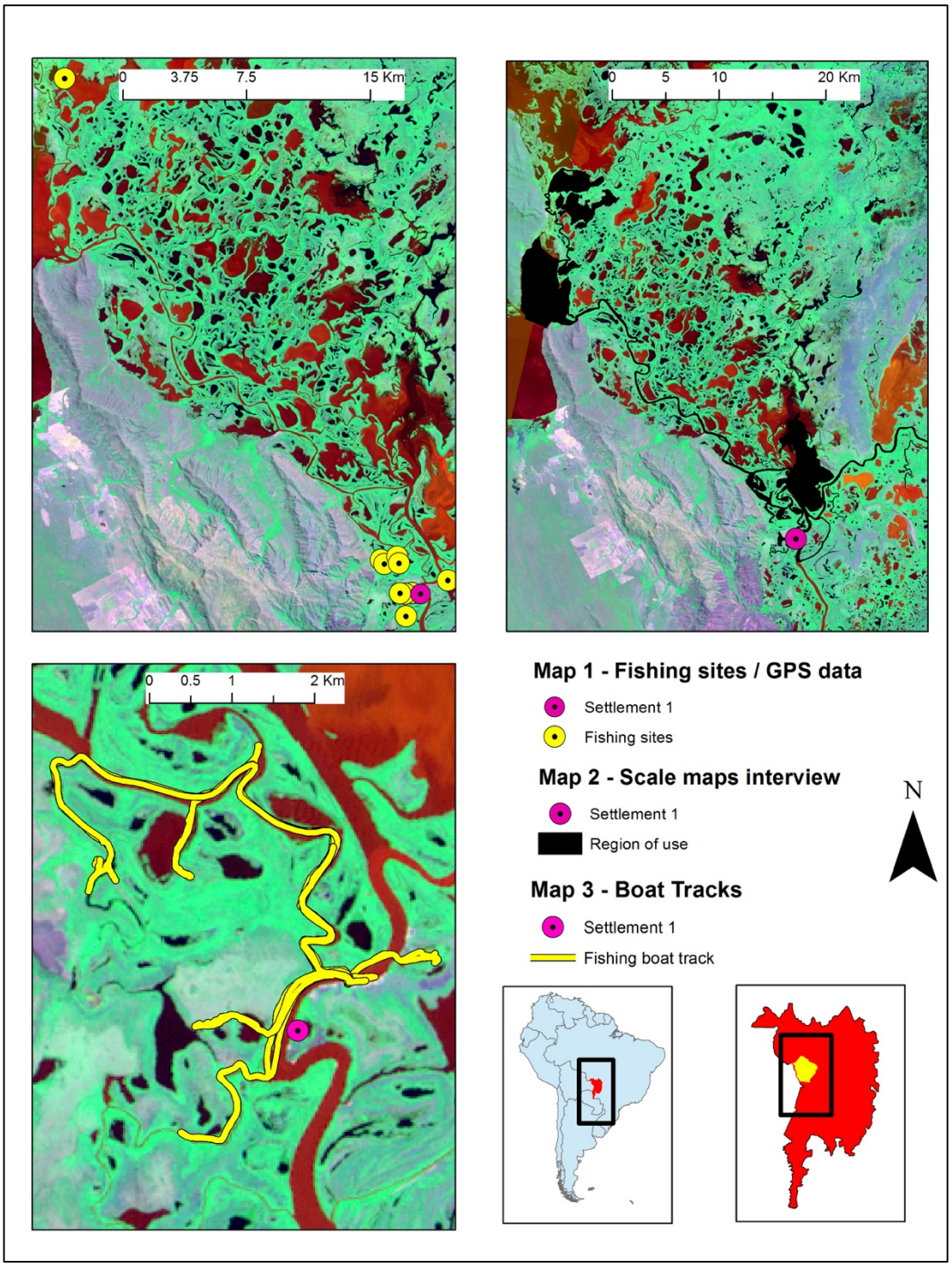

Figure 5-2: The three maps show the spatial data collected in Settlement 1 about fishing and gathering bait. Top left, data from handheld GPS. Top right, data from semi-structured interviews. Bottom, data from GPS trackers. Inset: location of the Pantanal in South America (left) and location of the study area in the Pantanal (right).

However, according to local people, 2014 was atypical. Apparently, in 2012 and 2013 the fishing season did not finish around the settlement. Instead there was a fourth phase: "*in the last two years we finished the gathering season in Ranca Rabo*

Bay" (roughly 14 Km river distance south from settlement 1). Areas around the settlement were already too dry by the end of 2012 and 2013 fishing seasons and fishers moved south to where the drawdown was still taking place. During 2014, areas took longer to dry out, so fishing did not move further south at the end of the fishing season (Figure 5-3).

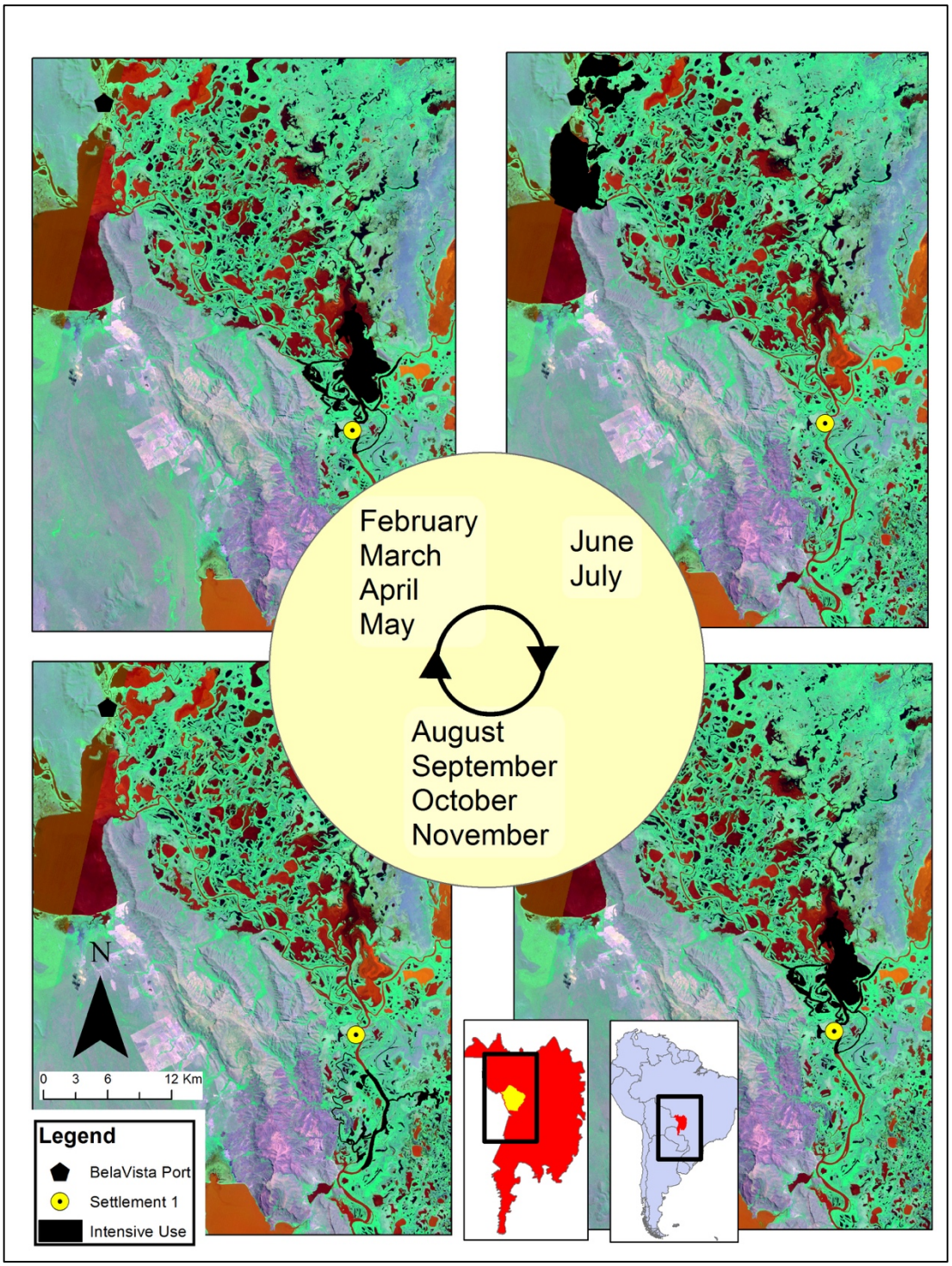

Figure 5-3: Fishing effort for Settlement 1. Fishing sites are shown in black. Clockwise from top left (a) February-May 2014. (b) June-July 2014. (c) August -November 2014. (d) October – November 2012-2013. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

In each of the three or four zones of the rotational fishing system (RFS), there is a continual turnover of fishing sites. People continually try new spots to verify whether they are worth fishing. The length of stay in each spot varies from two days to two or three weeks, depending on the characteristics of the flood pulse each year and the site-specific consequences. Using the map of ecosystem types produced by Conervation International et al. (2009) on a scale of 1:50 000, 88 different bays and river channels were formally identified. To optimize the search for the best spot each time, people constantly share information with other fisher folks about good fishing or gathering spots. The fishing system works in the following way: a group of fishers or bait gatherers go to a fishing or bait gathering 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 method is constantly repeated during the fishing season. Throughout the year this moving process creates the three or four phases of the rotational fishing system along with a spread of sites within any one phase.

The information about good fishing or gathering spots is shared during several ice tea drinking sessions held each day ("tereré"). People tend to not hide such information, establishing a sense of reciprocity. During this study, some families received visitors for more than five ice tea 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 bait they have stored. Therefore, the tea sessions are an adaptation for optimising resource use in the context of on-going change in natural resource distribution.

In the last few years this iterative process of trial and error was increasingly affected by the cost of fuel, as explained by informant 4 "*I tend to not spend more than 5 litres of gasoline when I know I will not gather more than 300 crabs*". Today, in Settlement 1, most fishers' families have a special boat engine called "rabetas" [tailed]. Only one family still uses rowing boats. Rabetas can be attached to any kind of canoe. In contrast to other engines, the rabetas has a long extensor with the propeller linked at the end. Its shape allows the boat to navigate in regions with shallow water despite high abundance of aquatic vegetation. Hence it reduces the physical strength needed to do the job. However, the fuel consumption of a "rabeta"

is high, roughly 1 litre of gasoline per 5.7 km. Based on the average price of USD 1.00 per litre, this can represent a large percentage of fisher's income (Chapter 4, section 4.6).

However, calculating the costs and benefits of trade-offs based on quantity of fish and gasoline is not straightforward. Intangible favours among people are constantly traded for fuel. For instance, Informant 1 used to gather bait with his wife, nonetheless in the last months of her pregnancy she could not accompany him and he asked several other people in the settlement to take her place helping him. Each week someone went with him to gather bait. At the end of each week they shared the baits but he did not charge the fuel spend, as, according to him, they were doing him a "favour". After a while one of Informant 1's substitute partners asked him to join in on a trip to gather bait because his own wife was away in the city, and he did not charge the fuel consumption either. Therefore, families may spend more or less fuel depending on the informal support they give or receive from each other.

5.4.3 Customary and natural restrictions on fishers' resource use

However, the openness and reciprocity shown by people from Settlement 1 towards other Settlement 1 dwellers does not extend to people from outside their area. People from all three 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, the idea was to not compete with anyone else because bait gatherers here are focused on crabs. However, after a week when fisher folks realized they were going to live here, people started to come and say they should leave. A meeting was called to decide their future, and although they tried to argue that they were not going to compete with anyone because they were going to gather only tuvira, everyone started to say they do indeed gather tuvira. Even though my uncles and I knew that was a lie, 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 3: "*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*".

During the interviews carried out with printed versions of satellite images from the region, it became clear that people tend to not recognise on map river channels and water bodies from regions other than their own. For instance, when Informant 19, from Settlement 3, 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 2, 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 really 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 Settlement 1 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. Figure 5-4 shows an approximation of what they drew, nonetheless there are some important caveats. First, 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. Moreover, the shape was outlined by members of the three extended families living together in Settlement 1, which joined after the displacement in the 1980s and 1990s caused by the Protected Areas being established (Chapter 4, section 4.4). Therefore, this shape is at least in part consequence of that management intervention. With all these caveats in mind, the area defined as the territory of settlement 1 covers 33,651 ha. As shown Figure 5-4, most of their territory is composed of water bodies and flooded vegetation.

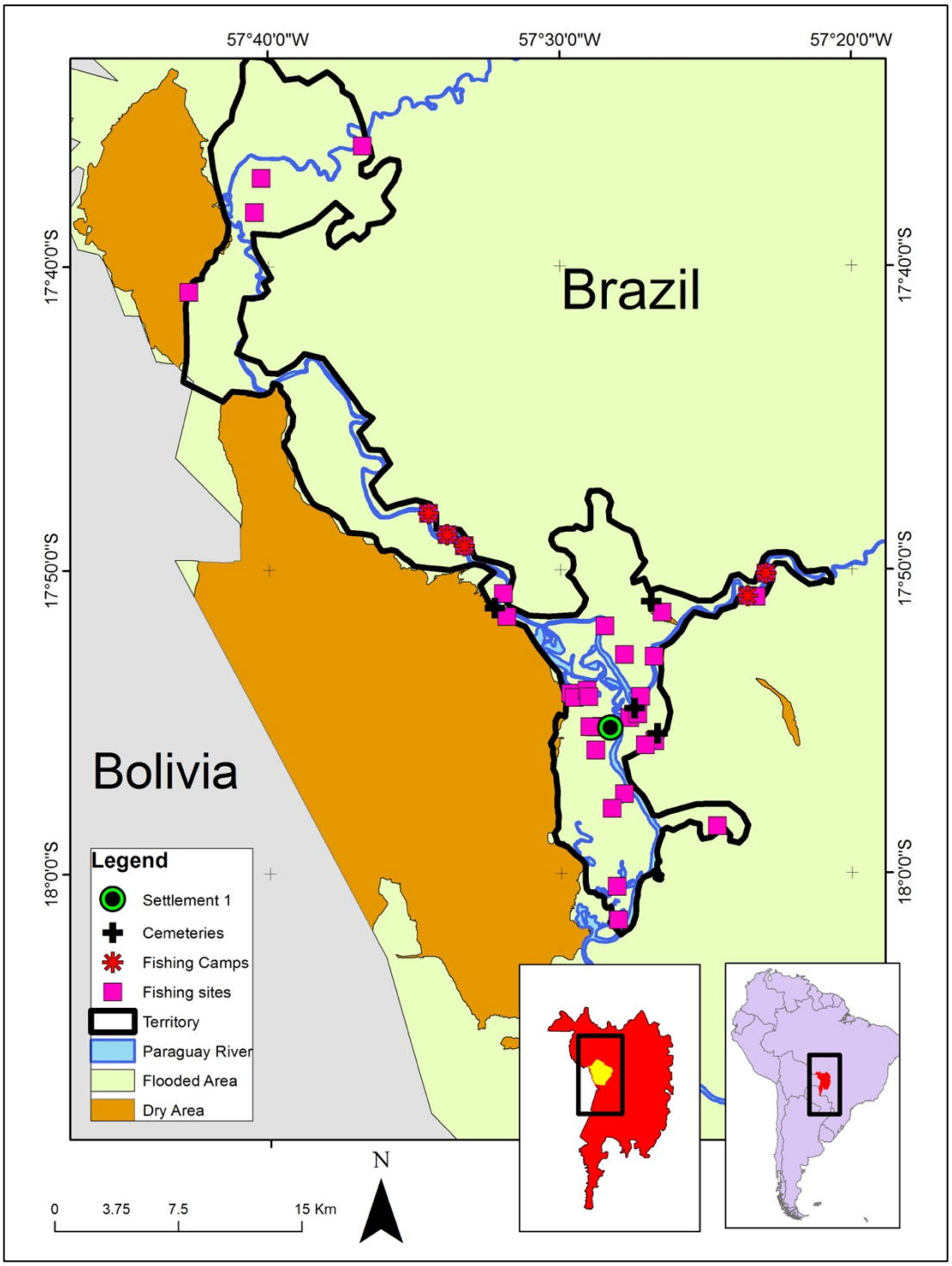

Figure 5-4: Territory defined by local people from Settlement 1. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

A second important point is that although the restrictions on use are enforced and constantly reaffirmed between settlements, tourists who come to fish do not respect such boundaries. The tourism trade uses the entire floodplain area indiscriminately and does not recognise customary tenure and access arrangements. However, local

people do not seek to restrain tourist use either, likely due to their dependence on the bait economy.

Moreover, the changes in connectivity between areas, through river channel and landscape-level changes or blocking off passages by floating vegetation (Chapter 2, section 2.7), are 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*". Figure 5-5 illustrates such changes through a sequence of satellite images of the same bay near Settlement 1, taken in 2008, 2011 and 2013. In 2008, the bay in the right is open and connected with a second bay in the middle of the image. In 2011, it started to lose its connection with the middle bay. Finally, in 2013, a thick body of aquatic vegetation closed the link between them. After that local people ceased using the bay. In 2014, was still closed, as shown by a 2014 bait gatherer boat track. By contrast, back in 2008, it is likely that they were using the bay as a source of bait and fish. A similar process occurs in the river channel on the left side of the image. Between 2008 and 2013 the river channel starts to become clogged, especially in the southern region. The main strategy when facing a blocked area is to find a new fishing spot nearby. This socio-ecological dynamic allows assemblages of fish to be protected from use for a period of time, creating dynamic and flexible natural reserves within the Pantanal floodplain.

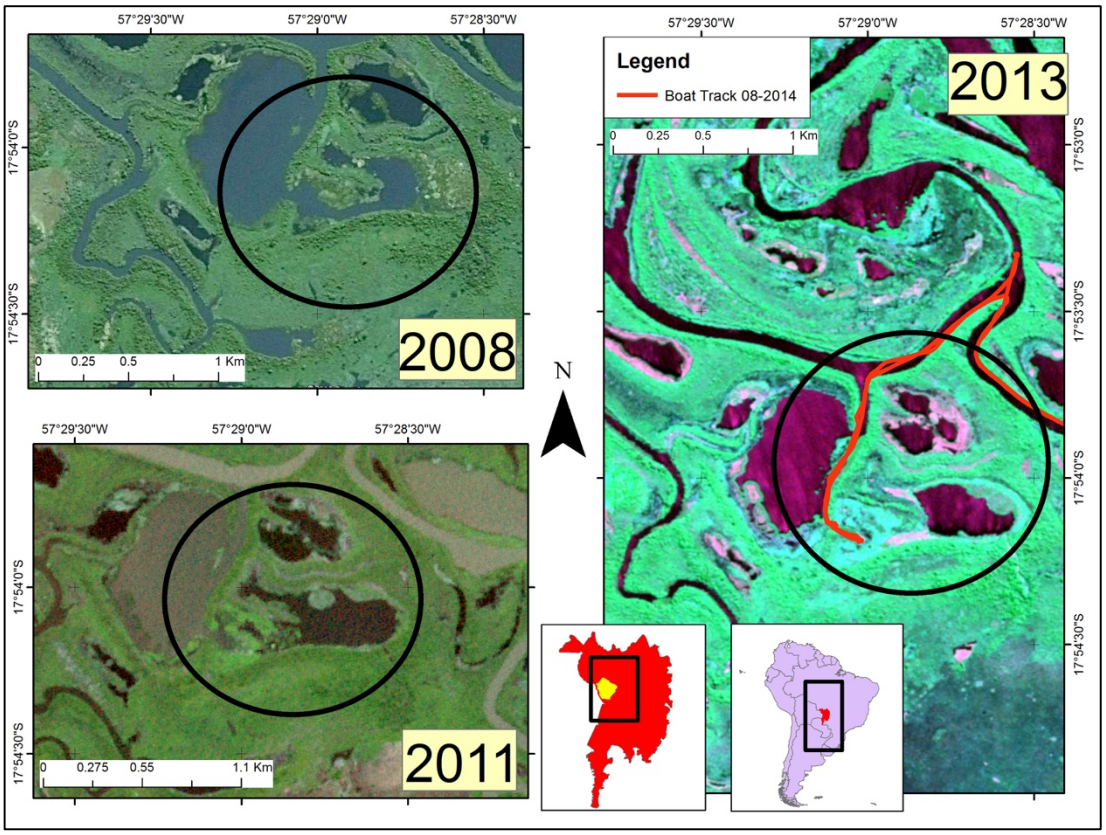

Figure 5-5: The three figures show images from the same bay and river channel near the Settlement 1 in 2008, 2011 and 2013. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

5.5 Discussion

Overfishing is an intrinsic part of the dominant environmental narrative in the Pantanal and in many other small-scale inland fisheries (Allan et al. 2005). However, in the case of the Pantanal, first, no long-term or spatially extensive data exist on fishing in relation to fish production. Fish population studies using maximum sustainable yield (MSY) calculated for individual species showed no damage to the stocks (Mateus et al. 2011). However, this method is ill-adapted to deal with the social-ecological complexities of multispecies inland fisheries (Lorenzen et al. 2016). Moreover, the level of use in the Pantanal is low compared with other inland fisheries worldwide (Welcomme et al., 2010). Official data show that every year roughly 333 tons of fish are captured by tourists and professional fishers in the South Pantanal (a region covering 93,000 Km^2 of floodplain) (Catella et al., 2014). In the Amazon basin, by comparison, the total capture is 133,306 tons and in Lake

Constance in Europe (known as Bodensee in German), with an area of 536 Km^2, the total capture is on average 725 tons/year (Barletta et al., 2016).

Even in face of low level of use, unpredictability, complexity and obstacles to evaluation, in the Pantanal wetland, policymakers instead enforced top-down fishing restrictions targeting a few species, limiting the use of alternative gears by local people and giving no weight to local knowledge and management practices. This drove local fishers to migrate out or seek alternative livelihoods locally and undermined the local economy, reducing almost tenfold the financial input of tourism as one of the most important businesses in the region (Moraes and Seidl 2000; Girard and Vargas 2008; Catella et al. 2014). However, this study suggests the link assumed to exist between local fishing and tourism decline is misconceived. According to the analysis here, variation in tourist numbers is instead primarily attributable to changing tourist fishing policies.

Moreover, Pantanal fishers undertake a rotational fishing system structured by both customary socio-cultural and natural biophysical restrictions, using local knowledge to adapt to unpredictable changes in resource distribution, creating a form of governance of resource use that is likely sustainable. Fishers from Settlement 1 use a sequence of drawdown areas as these emerge, fishing where the big fish are migrating from floodplain to the main river and its channels, where Tuvira (Gymnotus sp.) are moving to the floodplain and lakes, and where Pantanal crabs (*D. pagei*) are living in aquatic macrophytes, having reached the end of their reproductive cycle (Resende, 2011). This rotational fishing system is very similar to mobile systems used by other communities around the developing world, practices hailed as displaying sustainable management for Non-Timber Forest Products (Assies 1997), grazing (Kothari et al. 2013), fishing (Berkes 2006), agriculture (Sunderlin et al. 2005), and bushmeat hunting (Kümpel et al. 2009), in line with the biological principles of metapopulation dynamics (Hanski, 1998). In principle, and often in practice, mobile exploitation helps avoid exhaustion of natural resources and allows different species populations to recolonize the areas that have been used (Wilson et al. 2013).

A second important feature is that local people from any one settlement tend not to secure individual areas of use. They know the distribution of resource is continually shifting, and that securing a specific area does not guarantee a long-term income. Instead, local people uphold the idea that the floodplain is a public good and should have no boundaries, an idea expressed and reaffirmed through their constantly sharing fishing information in tea drinking sessions. The need for both collective territory and also mobility within territory constitutes a clear parallel with the paradox of pastoral land tenure (Fernandez-Gimenez 2002). Pastoralists need secure access to pasture and water, but also flexibility in resource use to deal with inter- and intra-annual changes in local resource availability. Fernandez-Gimenez (2002) points out that, in principle, high unpredictability calls for high levels of mobility and reciprocity. The same paradox extends to small-scale inland floodplain fisheries facing similar unpredictability, and management should take this into account. Besides reciprocity and mobile use characterizing their rotational fishing system (RFS), both sociocultural and biophysical restrictions shape local use and militate for sustainability. Each settlement has its own territory, with clear notions as to numbers of people allowed access, as to who controls use of specific spots and as to whom each person shares information with about such spots (Agrawal 2001). Moreover, the simple closing off of bays and river channel entrances by floating vegetation mats can turn water bodies into naturally unexploitable refuges for aquatic species. Therefore, the paradox of land tenure in mobile resource use and the existence of flexible natural reserves created by biophysical processes as part of ecosystem dynamics is fundamental to guaranteeing sustainability in the Pantanal.

5.6 Conclusion

To conclude, this chapter has presented an in-depth and interdisciplinary analysis of environmental narratives and small-scale inland fisheries management. First, it deconstructs through statistical analysis the claim that tourist numbers declined in the Pantanal because commercial fishers extirpated local fish stocks; suggesting an alternative approach to evaluating environmental narratives in face of a lack of long-term, large-scale research projects. Secondly, it clarifies the lack of evidence of overfishing in the region. Rather, it shows that local fishers' adaptive strategies of reciprocity and territoriality in dealing with local environmental complexity,

alongside the presence of unfishable reserves, are likely to create sustainable use of the aquatic resources.

Chapter 6 Sustainability and Land Tenure: who owns the floodplain in the Pantanal?[8]

6.1 Abstract

In seeking to achieve poverty alleviation and environmental conservation, public policy has often centred on guaranteeing land titles to local peoples. However, such approaches have brought unintended outcomes, replacing small-scale economies and natural areas by intensive exploitation of resources with no clear improvement in local people's wellbeing. To understand this, the chapter goes beyond a general political ecology framing to consider relations between sustainability and land tenure, focusing on the intersection of economics, ecology and anthropology to understand how land tenure, property and resource use play out on the ground. The significance of this three-discipline view in Western Border of the Pantanal wetland, is made clearer from the way whereby conservationists, the government and the local population contest ownership of the Paraguay River floodplain. Government has sought to address conflicts around tenure and access through applying a narrow view of property, which has failed to encompass the overlapping layers of land tenure, property and use on the ground and has only served to create further legal battles. The chapter delivers a nuanced account of local systems of tenure and access, of how these diverge from western property concepts, and of their environmental implications. It concludes by showing the importance of a more complex view combining economic, ecological and anthropological perspectives in cases of contested property rights in order to resolve conflicting claims and foster sustainability.

6.2 Introduction

As presented in Chapter 1, section 1.2.2.2, although the link between sustainability and property regime is presented in official narratives as established, policymakers and management practices are still failing to achieve sustainability in practice. Rather, the current approach is leading to unanticipated outcomes. Understanding why land titling is failing is fundamental to proceed more effectively in poverty

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alleviation and biodiversity conservation. The first step in doing so is to unpack this assumed link (von Benda-Beckmann et al., 2006), to give a more nuanced grasp of local systems of tenure and access, of how these diverge from western property concepts, and of the environmental implications of different systems. In doing so it is important to understand the political ecology behind the way the assumed link between property system and sustainability is used in the power plays between different groups competing for control of a valuable resource. It is also important to analyse the legal frameworks which can and should preclude silent violence towards marginalised groups on the one hand, and destructive environmental practices on the other. Even where in reality enforcement is currently weak, the law provides a foundation for ultimately more effective regulation.

6.2.1 Social Ecological Systems: Unpacking sustainability and Land tenure

Land tenure arrangements embody the relationships among people, as individuals or groups, with respect to land. Land tenure defines how access to natural resources is granted[9] (Ribot & Peluso, 2009). Economists, ecologists, and anthropologists have all looked intensively at land tenure and its relation to sustainability. This section firstly outlines how each discipline looks at these issues, and then at how the intersection between them can be used to help better tackle sustainability.

6.2.1.1 Economists' perspective

6.2.1.1.1 Background theory

For most economists, land tenure and sustainability are grounded in ideas of private property. This economic concept of property co-evolved with the western view of nation states and the rise of mercantilism in the 18th and 19th century, along with a focus on individual property rights, and private accumulation of capital (Horsley, 2011). The idea of property facilitated the implementation of those principles based on law and state power (Freyfogle, 2011). The nation state using the power of law can guarantee and enforce legal rights over property such as land, which ensures that the owner has the right to restrict use by others. As Jeremy Bentham (1789) said,

[9] http://www.fao.org/nr/tenure/en/

"*take away the law and property disappears*" (cited in Freyfogle, 2011: 416). These two features: "ownership" and the "right to exclude", came to be, for neoclassical economists, the defining features of a properly functioning property regime (Dagan, 2011). In other words, according to this view, without defined ownership and rights of exclusion, there is no property. This has come to be called the Blackstonian notion of property (Rose, 1998).

It was rational, therefore, for 20th century neoclassical economists facing the first signs of man-made environmental destruction in areas where natural resources were shared as common pool resources (CPoRs), to start to use this western concept of property to predict sustainability. Hardin (1968), as already explained in Chapter 1 section 1.2.1, suggested that common pool resources such as grazing lands and fisheries lack any kind of regulation when owned and used collectively under a common property regime (CRP). He predicted that the instinct for individual accumulation would inevitably drive such resources to degradation or exhaustion, leading these socio-ecological systems to collapse, an outcome for which he coined the term "Tragedy of the commons". According to this idea, the only way to guarantee long-term use would be to establish formal parameters of property according to the western view: private ownership and the right to exclude through privatization or state control. E. Ostrom later on proposed a different perspective. Building on multiple empirical examples, she pointed out that customary rules governing access to and use of common pool resources could function as collective ownership giving people the right to exclude outsiders and regulate use, leading to sustainability (Ostrom, 2011; Ostrom et al., 1999; Schlager and Ostrom, 1992). Therefore, in such cases there should be no need for privatization or state control to achieve sustainable management (Agrawal, 2001). It is important to note that, although Ostrom and Hardin proposed completely different ideas, both used the same economic rationale, supporting the dichotomy that with respect to common pool resources, "rules" on use can lead to sustainability (property regimes) and "lack of rules" (open access or non-property) leads to overexploitation (Behnke et al., 2016). Based on this view, property is commonly divided into four categories: private property (owned by an individual or corporate body), state property, common property (owned by a socially-defined group of individuals, often with quite flexible

social and spatial boundaries), and finally, open access (no exclusive owners, "first-come-first-served"). Together these categories have become so widely accepted that they are widely known as the "Big Four" (von Benda-Beckmann et al., 2006).

6.2.1.1.2 Current view

Although the notion that property is defined by ownership and rights of exclusion is still present, already in the 1920s and 1930s, the so-called progressive property movement started to challenge this approach (Rose, 1998). Using empirical data about ownership, they began to uncover a complex reality underlying evolving notions of property. For instance, places may have more than one owner, normally with different levels of ownership, and at each level a co-owner can share their rights within their own network, blurring the boundaries as to who is the owner and who can be excluded. Moreover, in many cases, ownership is normally linked to a given time and place, changing according to external and internal factors (Freyfogle, 2011). Property, then, should be seen as evolving multiple components layers of ownership perhaps best captured by the term "bundle of rights" (Klick and Parchomovsky, 2016). The conclusion is that the widely accepted "Big 4" property categories do not adequately capture the full range of multi-layered rights and resource conditions seen in natural resource management. The corollary is that, defined ownership or the right to exclude is not clearly tied to any particular one of the given "Big 4" categories, and the absence of a particular Big 4 category does not denote inevitable over-use. Therefore, these categories do not map in any straightforward way to sustainability (Galik and Jagger, 2015).

In face of this more nuanced understanding of property, there have been many attempts to re-shape the so-called "Big 4". As outlined in Chapter 1, section 1.4, Moritiz et al. (2013)'s Management of Open Access is one of the many examples. As presented and discussed earlier, these authors argue that, in some systems, common pool resources are shared through an "ethos of open access" with no customary restriction on use (Moritz et al., 2015, 2014a, 2013). However, besides not encompassing the different drives of customary governance and ecological constrains presented in Chapter 5, section 5.5, the same criticisms of the "Big 4"

outlined earlier apply equally to "MOA" and other attempts at property categorizations. Sustainability would not be due to a specific property category but rather to multiple specific interacting factors (Dagan, 2011). Creating new categories and labels will not help approximate theory to reality.

6.2.1.2 Ecologists' perspective

6.2.1.2.1 Background theory

Although the idea of land tenure was never formally part of ecological models, these constantly use related concepts such as exclusion and territoriality to explain wildlife population dynamics and animals' use of natural resources. Many underlying theories in ecology have their roots in economics (Macarthur and Pianka, 1966). Early ecological models were focused on population management to understand and plan for commercial extraction, aiming to foster sustainable use. Initial theories centred on stable equilibrium and density dependence; supposing that species would be auto-regulated around a steady state carrying capacity (May, 1974). These two theories underpinned important emergent concepts, such as Optimal Foraging (Macarthur and Pianka, 1966), Ideal Free Distribution (Kennedy and Gray, 1993) and Metapopulation (Hanski, 1998), which have been key in most ecological management actions focusing on sustainability.

Optimal Foraging (OF) is built on the idea that animals forage for and use natural resources according to underlying behavioural rules that ensure they optimize their net energy gains. This leads to the second theory, Ideal free distribution (IFD). IFD postulates that because of OF, competitors adjust their distribution in relation to habitat quality so that each individual optimizes their own rate of acquisition of resources, as explained Chapter 5, section 5.5 (Davies et al., 2012). IFD is in many ways equivalent to open access in economic theory. In ecological thinking, however, IFD leads to distribution in equilibrium with resource availability (Behnke et al., 2016), where open access, in economists' thinking, combines with individual accumulation to lead to the polar opposite of over-use. Although OF/IFD were developed as concepts for "natural ecosystems", some authors have started to use them to explain resource use behaviour of pastoralists, fishers etc. (Behnke et al.,

2016; Beitl, 2015; Wallace et al., 2016), postulating this as the reason that some socio-ecological systems are sustainable (Moritz et al., 2014b, 2013; Xiao et al., 2015).

Metapopulation constitutes another important dimension in theorizing sustainability and management of natural resources. The first insights came from the "Theory of Island Biogeography" popularized by MacArthur & Wilson (1967). They were trying to predict the species richness of ocean islands and found out that the rate of immigration and extinction among islands and between islands and mainland were the most important model variables to explain observed richness. Though the theory was based on an equilibrium model, other authors start to use it to explain different non-equilibrium dynamics of several ecosystems. Levins (1969) was the first to apply this idea of spatial distribution and density-dependence to mainland patchy landscapes, elaborating the "meta-population" concept. Metapopulations are fragmented, spatially isolated populations linked by the continual dispersal of individuals, with repeated extinctions and re-colonisations in each population generating a dynamic that can sustain the whole metapopulation (Hanski, 1998).

6.2.1.2.2 Current view

Once these primary concepts came to be tested in nature, density-dependence emerged as a significant driver of regulation mainly in very low or very high population densities (Turchin, 1995). For many non-temperate systems, populations display chaotic changes rather than any smoothly density-dependent response (May, 1974). As a result, ecological systems may shift between multiple alternative temporarily stable states, without ever progressing to a climax (Ellis and Swift, 1988; von Wehrden et al., 2012) but also without undergoing irreversible degradation or collapse (Derry and Boone, 2010).

This thinking has tremendous implications for human use of biodiversity (Berkes, 2009). As already presented for the case of inland fisheries (Chapter 1, section 1.3 and Chapter 5, section 5.2), multispecies fish population growth is mostly chaotic, and consequently enforcement designed around ideas of equilibrium in single-species population dynamics has little relevance for sustainability (Wilson et al.

1994). Thus, connectivity, the number of patches suitable for the species and ecological variations throughout time may be more important variables for sustainability of natural resource use than the size of resource stock itself (Valley and Freeney 2013; Wilson et al. 2013). Spatially explicit evaluations considering "how", "where" and "when" people use should be added to the current focus on "how many" are taken (Wilson et al. 1994). Another important component is the presence of temporarily "ungrazeable" (or unfishable) reserves, as has been shown to underpin sustainability for grazing systems in East Africa (Homewood, 1994; Homewood and Rodgers, 1988) and inland fisheries in the Pantanal (Chapter 5, 5.5).

However, at the same time, although scholars support a more complex understanding of the environment and natural resource use to predict sustainability: density-dependence, equilibrium, OF / IFD, and metapopulation all remain important drivers of socio-ecological systems. For instance, IFD dynamics can partly explain how resource users are spread over the landscape and their use's sustainability (or lack of it) (Behnke et al., 2016). Metapopulation theory can give important insights to deconstruct narratives of overuse (Hayden et al., 2015). In the face of such a mix between equilibrium and chaos, linear regulations and complex systems, long and short-term changes, some authors argue that all of these theories and predictors should be gathered together, because in one way or another they are all part of the innumerable influences that together produce or preclude sustainability (Turchin, 1995). Hence, it is the temporal and spatial combination of these many factors that will dictate species population responses and their distribution. Therefore, from an ecological perspective, the best way to guarantee sustainability of natural resource use is to monitor the drivers that are most important in a given time and place, and constantly re-evaluate that potentially changing importance and whether they should be replaced or aggregated with others. This approach is now called adaptive management (Rebecca and Robert, 1996; Rist et al., 2013; Westgate et al., 2013).

6.2.1.3 Anthropologists' perspective

6.2.1.3.1 Background theory

Anthropologists tend to see land tenure concepts in a different way, looking at how property arrangements embody the relationships among people, as individuals or groups. From this perspective formal property ownership is just one of a number of factors determining how access is granted (Ribot & Peluso, 2009). People's ability to use natural resources is driven by *de facto* extra-legal as well as *de jure* legal factors (Ribot, 1998).

Extra-legal (*de facto*) mechanisms include all the social relationships and identities that are embedded within a group of people (for instance friendship, status, age, historical ties, etc.). *De facto* mechanisms can be divided into control (defining who within the group has the right to access certain types of resources, and who does not have that right) and maintenance (the expenditures made to guarantee the continuity of the resource) (Ribot & Peluso, 2009). Both are social constructions that are being constantly reworked with some people gaining access and others losing it (Benjaminsen and Lund, 2002). The continual changes throughout time leave their marks imprinted in current patterns of use (Behnke et al., 2016). Therefore, historical understanding is fundamental in comprehending the current status of access and use in any socio-ecological system. *De jure* factors involve the legitimization of access by politico-legal institutions with recognition and authority to do so (Sikor and Lund, 2009). The institution legally recognizes the claims of a group of people and gives the right to use a certain type of resource (Ribot 1998). However, as for the extra-legal (*de facto*), legal rights over land use can change through time as a consequence of changes in powerful groups or in legal and political perspectives on the target natural resource (Benjaminsen and Lund, 2002). For instance, when a species that is part of the local livelihood is listed on an "endangered list" this can trigger restrictions by the government no longer allowing access. However, formal and informal land tenure access and use have, normally, an unclear separation. Each continually influences institutions and governance, and continually morphs into the other (Benjaminsen and Lund, 2002). Therefore, the bundle of rights metaphor maps

well onto anthropological notions of property as a fluid concept (von Benda-Beckmann et al., 2006).

The different notions of property are social constructions that are being constantly reworked with some people gaining access and others losing it (Benjaminsen and Lund, 2002). The continual changes throughout time, adding the fact that, as already discussed in Chapter 4, section 4.7, communities need to be understood as a fluid and continual evolving group of people (Allison and Ellis 2001), leave their marks imprinted in current patterns of use (Behnke et al., 2016). Therefore, historical understanding is fundamental to comprehending the current status of access and use in any socio-ecological system.

6.2.1.3.2 Current view

Empirical and ethnographic analyses constantly reinforce the idea that property is better seen through the lens of "bundle of rights", in which resources, rights to their access and use can be broken up and reorganized into uncountable layers depending on time, space, and history (Kay, 2016). However, an important theme in ethnographic analysis is the understanding that property is not just a western creation. Rather, indigenous communities have representations of ownership, exclusion and, property (Hann, 1998). Indeed, these groups may have a very different view of property from that conceptualized by western groups. It is common to find property incorporating emotive claims of identity for small-scale societies; in some Amazonian groups, concepts of ownership bind places together through relations between non-human persons with whom humans must interact in a variety of ways; property concepts may be used to span hunting, gardening and shamanism (Brightman et al., 2016). For such societies property itself appears as a process, it is a way of establishing relations between people and things. The most important element of this view is that the encounter between the western and non-western cultures is not an encounter between societies with and without property (Brightman, 2011), but rather between very different concepts of property, making conflict almost inevitable. Therefore, to propose sustainable solutions for this it is essential to better understand the full range of notions of property.

6.2.2 Sustainability and a multi-faced view of property

Although these three views of property come from different disciplinary backgrounds, they intersect on the current understanding that sustainable outcomes are best explained by a combination of the different layers that dictate how people and other species control and access natural resources (Berkes, 2007, 2004). Thus, rational choice theory, property categories, and ecosystem complexity need to be integrated with understandings gained from history and other social drivers, and vice versa (Hayden et al., 2015). The use of these different yet complementary views of property are more effective to tackle sustainability (Figure 6-1).

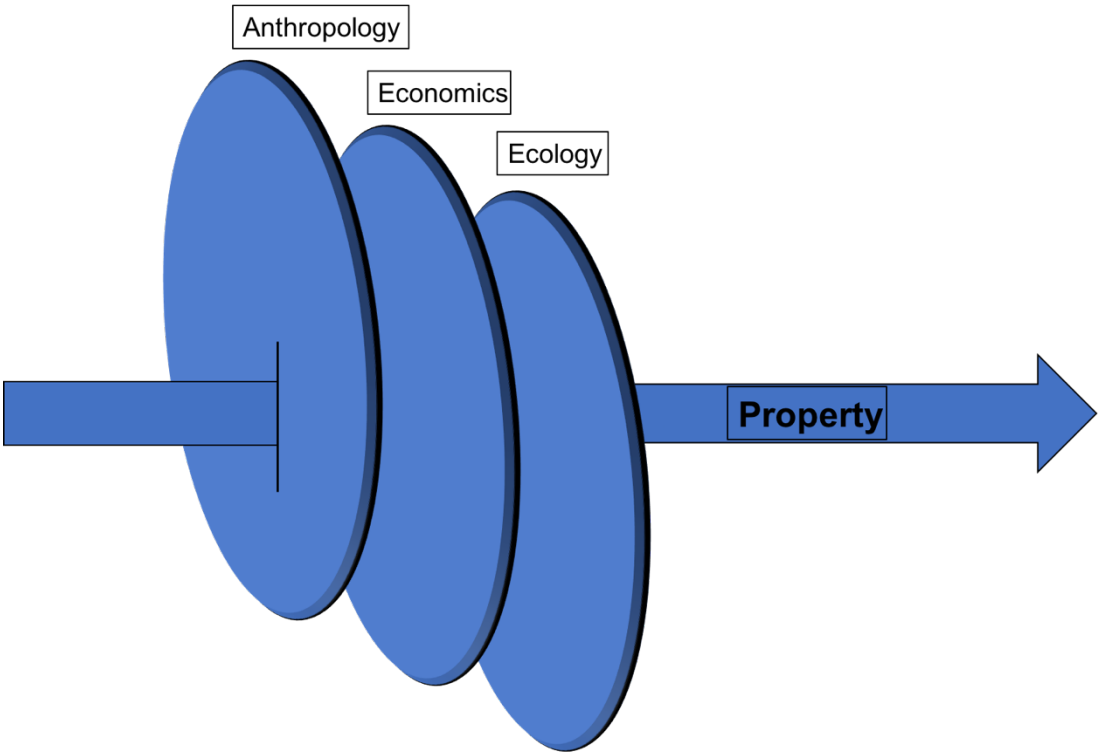

Figure 6-1 The intersection between the economic, ecological and anthropological views of property

The Western Border of the Pantanal wetland, Brazil, presents a telling case study of land tenure conflict and sustainability. Different claims and understandings of floodplain ownership have led to intense conflict among environmental NGOs, local people and, ranchers and ultimately, federal prosecutors trying to define ownership and rights over the Pantanal floodplain. It is an important case showing that the

disjunct between reality and management practice is one of the main reasons for the failure of property rights to achieve poverty alleviation and biodiversity conservation.

The Chapter intends to answer the following research questions:

What is the relation between sustainability and land tenure in floodplains?

- How do Pantanal property systems map onto the region's unpredictable, dynamic ecosystem?
- Is the conflict in the Pantanal will be resolved through setting defined ownership and rights to exclude through land titling?
- How can the integration of economic, anthropological and ecological approaches help to address land conflict in Brazil's Pantanal?

6.3 Methods

As presented in Chapter 3, section 3.8, over a period of almost three years, qualitative data collection through interviews, participatory mapping, and citizen science was undertaken with local stakeholders in the Western Border of the Pantanal to understand the conflict over property rights (April 2014 till March 2015; January 2016 till June 2016).

In order to uncover the legal battles in the region seven prosecutors involved in the case were interviewed and all legal processes reviewed and analysed. Moreover, eight protected area staff and 10 local scientists working in the region were interviewed.

6.3.1 Conflict over land tenure in the Pantanal

6.3.1.1 Protected Areas' rights

As presented in Chapter 1, section 1.5.1, a mosaic of Protected Areas in the Western Border of the Pantanal was built up by the state, environmental NGOs and ranchers between 1971 and 2015, eventually securing strict conservation of 262,000 ha and creating the enforcement group "Protection and Conservation Network for the Amolar Region" (PCNAR) (Bertassoni et al., 2012). According to informant 28, 29,

and 30, all of them part of the group, PCNAR started with USD 1.44 million from a Brazilian mining company owning one of the Private Protected Areas, and then continued activities funded by an endowment from a Brazilian investment bank owning another Private Protected Area.

Apart from the historical displacement involving the location of Settlement 1 described earlier (Chapter 4, section 4.5), there is a conflict regarding the fishing area of this group. Managers from Protected Areas claim that local fishers should not access fishing sites inside the Protected Area boundaries, and argue that in doing so they are committing a crime. Indeed, managers are backed by the Conservation Units Law, which specifies that National Parks or Private Reserves do not allow any kind of use of natural resources from traditional communities (Law 9.885 from 2000[10]. Moreover, it is important to note that because this area has been partly inundated since the 1970s, most Protected Area boundaries are either permanently under the water, or partially inundated during the flood season Chapter 1, section 1.5.1. However, even so, all Protected Areas have been recognized by the federal government through the Brazilian Agency of Protected Areas (ICMBio)[11] and their land titles certified by federal prosecutors during lawsuits (MPF, 2013).

[10] http://www.planalto.gov.br/ccivil_03/leis/L9985.htm

[11] http://sistemas.icmbio.gov.br/simrppn/publico/rppn/MS/

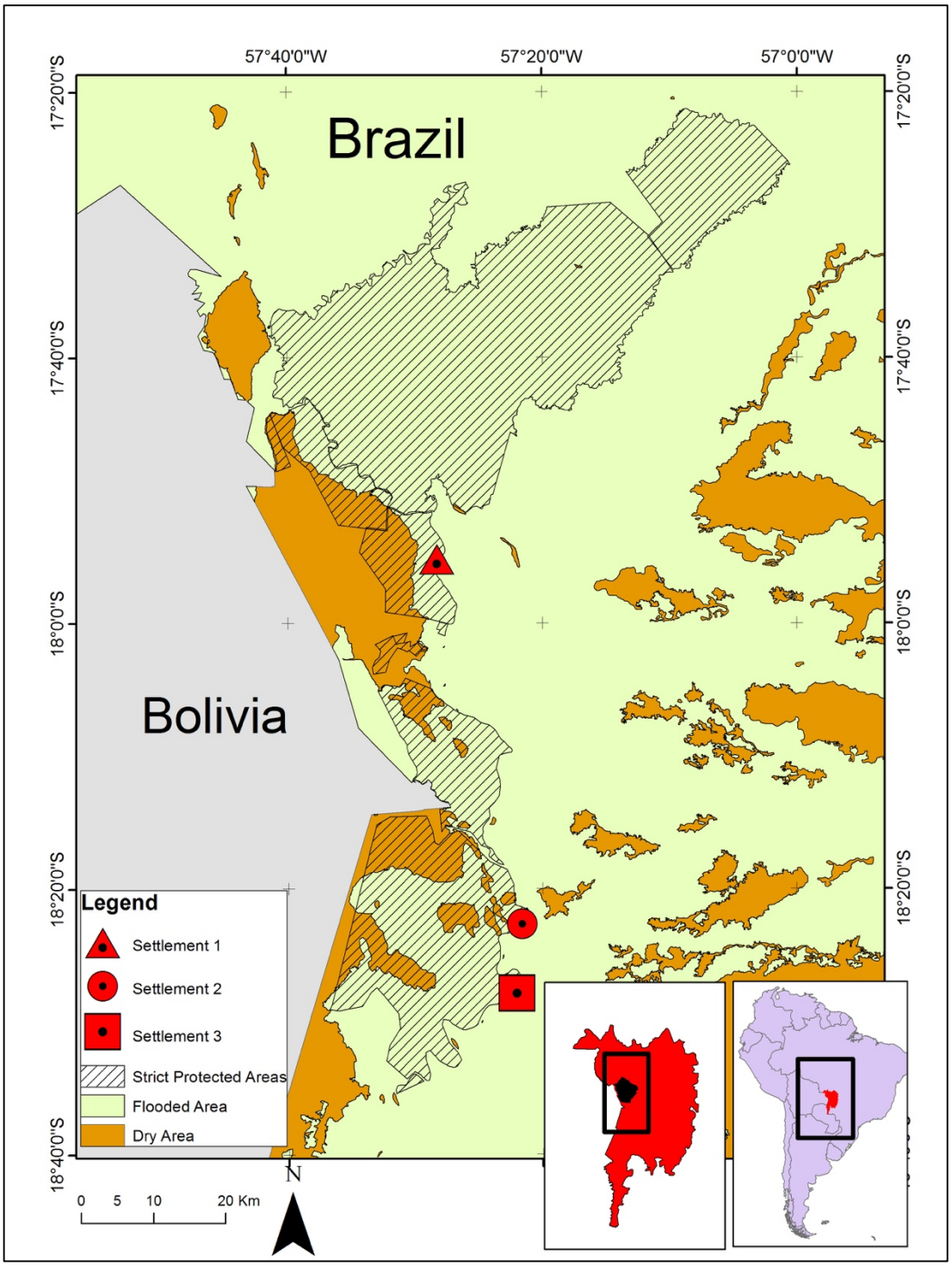

Figure 6-2: Protected Areas in the Western Border of the Pantanal. The map highlights that most of the region protected is partly or continually flooded. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

6.3.1.2 Local People' rights

Environmentalist pressure on local people has led some grassroots human rights organizations to support fishers and to publicise their conflict. They helped settlement families to create a Formal Association, which allowed them to access small grants; around USD 10,000 were invested in the community between 2007-2014[12]. The local municipality built a new school in the Settlement, which all children attend; a public telephone was installed because there is no mobile phone signal, and doctors and dentists go the region to assist in any disease or health problem every three months.

Federal Prosecutors brought in to review the case (MPF, 2013). In 2015, I was formally asked to present my view about the conflict, and I wrote a report exploring the data presented in Chapter 4 and Chapter 6. After a long period of analysis, federal prosecutors recognized local people's rights and established that due to their traditional occupation and sustainable use of natural resources they are backed by the Brazilian Constitution of 1988 (Articles 215 and 215), by the Indigenous and Tribal Peoples Convention – ILO 169 (ratified by the Brazilian Government through the Decree number 5051 from 19th April, 2004) and, especially, by the National Policy for the Development of Traditional Peoples and Communities (PNPCT - decree number 6070, 2007) to live and use resources throughout the so-called "traditional territory" described in 0 (Shiraishi-Neto, 2007).

The terms and rules that dictate the use of "traditional territories" are not clear in Brazilian legislation. These areas are neither Protected Areas nor Indigenous Lands. They still lack a detailed regulatory framework. The only binding requirement is that local residents must adhere to sustainable use of natural resources (Shiraishi-Neto, 2007). However, there are no definitions of what constitutes sustainable use of natural resources, or as to how local people should manage these areas. In fact, the right to use traditional territories was established as a way to offer communities living in rural areas the means to secure their livelihood, social cohesion and individual rights in face of threats of physical and economic displacement (Calegare et al., 2014). The main idea underpinning this legal procedure is that once human rights are guaranteed, the management rules can be subsequently drawn up (Silva,

[12] http://www.casa.org.br/pt/

2007) and other legal agreements established to guarantee ecological sustainability. This can be done through, for instance, fishing agreements (Pinedo-Vasquez et al., 2011 – common in the Amazon floodplains), commitment terms specially created to authorize local communities to use their traditional areas inside Strict Protected Areas (Sautchuk, 2007), or even creation of Sustainable Use Protected Areas (Calegare et al., 2014) among other possibilities. However, although no further agreement was reached to regulate natural resource use in Settlement 1's traditional territory, there are strong indications from the RFS, the unexploitable reserves and customary restrictions and reciprocity that local people's use may be consistent with local ecological sustainability (0).

6.3.1.3 Federal Government' rights

The federal government's recognition of local people's settlement and use rights, however, led to a property rights overlap. As shown in

Figure 6-3: Ownership overlap in the Western Border of the Pantanal. The red line indicates the traditional territory, the black line the Protected Area limits and the yellow area is, in principle, state owned. The red area is the region prosecutors excised from Protected Areas to give to local people. The green dot indicates the location of the new settlement. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

, Settlement 1's traditional territory overlaps with Protected Area boundaries. Thus, on the one hand, the Conservation Units Law rules that fishers are not allowed to access roughly 22,000 ha of the region, equivalent to 70% of what the local people consider their territory. On the other, the National Policy of Traditional Peoples, the Brazilian Constitution and ILO 169 assert their right to do so. To try to solve these conflicting understandings of overlapping ownership, federal prosecutors used a third official layer of property rights, regarding national ownership of floodplains.

According to Brazilian legislation (decree n. 9660 from 1946[13]), federal rivers are a public good. Under this law natural features such as the Paraguay River crossing two states are part of federal assets and cannot be privatized nor their exclusive ownership claimed. It is important to note that prosecutors calculate river limits as follows: "*We consider as the river limit the furthest point reached by water in an ordinary inundation during the flood period*" (informant 34, prosecutor). In the Pantanal, the margin of the Paraguay River, in an ordinary inundation, extends across most of the floodplain, an area of 86,441 km^2 or roughly half of the Pantanal ecosystem (Padovani, 2010). Taking into account that 86.2% of the Protected Areas and 98.7% of the traditional territory are either permanently or periodically inundated by the Paraguay River during 3-4 months of the year, they are, according to law, federal river areas. Therefore, regardless of land titles or historical and customary ownership claims, the Paraguay River floodplain areas in the Pantanal are, in principle, state property. Moreover, recently, a new ordinance was published that authorized federal prosecutors to give provisional ownership to local peoples undertaking sustainable use of federal lands, such as rivers, marsh areas or floodplains (Ministerial ordinance n. 89, 2010[14]). This is a new provision of Brazilian legislation and it is a direct consequence of the Brazilian National Policy for the Development of Traditional Peoples and Communities. It was created to solve precisely these sorts of conflicts of land tenure in rural areas, giving local people a provisional authorization of use known as the "Term of Authorization of Sustainable Use" (TAUS).

6.3.2 Proposed solutions to the conflict

In an attempt to solve the conflict, federal prosecutors used all described national policies and laws to open 18% of the Private Protected Areas to Settlement 1's dwellers for fishing, and to give communities a small part (0.04%) of one of the Private Protected Areas to use as a temporary living site during the flood period[15]. However, this solution only led to further battles, and brought no land tenure security to either group.

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13 http://www.planalto.gov.br/ccivil_03/decreto-lei/Del9760.htm

14 http://patrimoniodetodos.gov.br/pastaarquivo.2009-07-09.3759851862/SPU_89-2010-TAUS.pdf

15 http://www.prms.mpf.mp.br/servicos/sala-de-imprensa/noticias/2013/04/comunidade-do-pantanal-recebe-autorizacao-para-uso-sustentavel-de-area-tradicional

On the one hand, local fishers still faced *de facto* restrictions on their use of the protected floodplain inside their customary territory, and were being prevented from undertaking their traditional rotational fishing. As claimed by local fishers:

> "Prosecutors came here and said that we could fish inside the Private Protected Areas, however, we went there and rangers took all our fishing gears; what should we do? We need to eat" (informant 9, male, 52 years, bait gatherer)

> "Prosecutors do not live here, they come, say something and leave; how will they guarantee I will not be arrested if I use the Protected Area region?" (informant 1, male 27 years, fisherman).

On the other hand, Protected Area Managers did not see the new rules as offering a feasible solution, as presented by informant 28 (Protected Area manager, head of the enforcement group PCNAR):

> "prosecutors spoiled everything, we used to have good relations with local people… These TAUS given to local people threaten the core principle of protected areas: perpetuity – they are setting a dangerous precedent that can bring about the collapse of the whole Brazilian Protected Area System".

The environmental group took several actions to regain property rights over the protected floodplain. First they sued some prosecutors involved in the case, trying to repeal the property rights given to local people[16], as presented "*they tried to revoke my act and it did not work, they did for a second time and it did not work either, now they are suing me in the Supreme Cour*t" (Informant 35, prosecutor). The second approach was to deconstruct the idea that fishers from Settlement 1 are covered by the Brazilian National Policy for the Development of Traditional Peoples and Communities, and to argue that they should not be granted title to their traditional territory. As already presented in Chapter 4, to do so, PCNAR supported the publication of a book claiming that fishers settled on the floodplain no more than 30 years ago, that they do not use traditional practices, and they are destroying the environment (Franco et al., 2013). Finally, the argument was used that Settlement 1

[16] All legal and lawsuits were presented in the conciliation panel held in the Settlement 1 with all stakeholders on May 18, 2015.

location is suffering from erosion, claiming that is "*putting at risk the school structure and families' security*" (informant 28, Protected Area manager). Specialists on Pantanal soils agree that "*the community area is exposed to marginal erosion*". However, they give no timeline for this settlement site to be eroded to the point where it disappears, as explained by informant 36 (Pantanal researcher): "*to define whether it will be in one, two or three years is extremely hard […] it will always depend on the flood regime*".

Under mounting pressure, prosecutors made a second attempt to solve the conflict of property rights and use of natural resources on the Pantanal floodplain. They gave provisional land title to people from Settlement 1, excising a small part of a flooded cattle ranch on a site 12 km south from the original settlement location[17] (

Figure 6-3: Ownership overlap in the Western Border of the Pantanal. The red line indicates the traditional territory, the black line the Protected Area limits and the yellow area is, in principle, state owned. The red area is the region prosecutors excised from Protected Areas to give to local people. The green dot indicates the location of the new settlement. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

). The area is a non-flooding, man-made mound of roughly 2 ha constructed by the federal government in the 1970s. The Prosecutors' main rationale for doing so, however, is not the conflict itself but the erosion in the Settlement 1, "*the permanence of these people in the area is impossible because of the river dynamics […] they will be safer in this new location*" (informant 35, prosecutor). The proposed deal is to build new houses and a new school for local people, to be delivered by a local NGO partner of the community association. Supporters of the deal point out that the new settlement is based on the idea of an "*Eco-Village, where people would live close by each other and will have a football pitch and a meeting centre*" (informant 40, NGO practitioner). According to prosecutors they will not be obliged to move to the new place, but the area currently made available from the protected areas will probably be restricted again:

[17] http://riosvivos.org.br/pagina-inicial/destaque-inferior/spu-declara-ser-de-interesse-publico-area-da-comunidade-da-barra-do-sao-lourenco/

“We are still under negotiation, it will be like an exchange, Protected Areas managers build the new school and I cancel the use of the Protected floodplain by local people” they will be able to access the Protected floodplain but fishing will be restricted to just self-consumption” (informant 35, prosecutor).

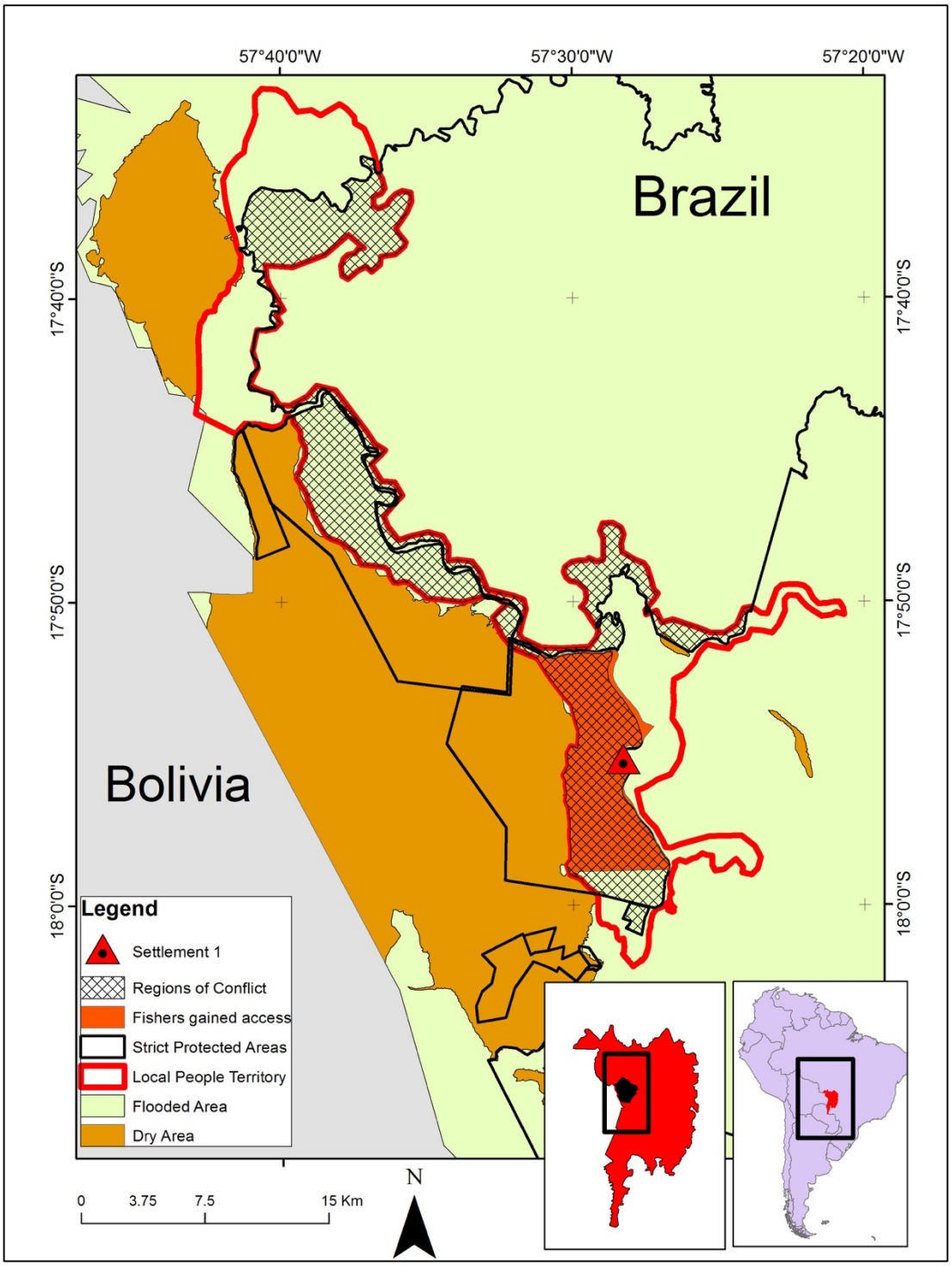

Figure 6-3: Ownership overlap in the Western Border of the Pantanal. The red line indicates the traditional territory, the black line the Protected Area limits and the yellow area is, in principle, state owned. The red area is the region prosecutors excised from Protected Areas to give to local people. The green dot indicates the location of the new settlement. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

Each group reacted differently in face of the new solution. Protected Area managers are supporting the new solution "*the new settlement is the best strategy for*

community development" (informant 39, Protected Area manager). Researchers on the other hand are very concerned "*families have an identity with the place, this does not relocate with them [...] this will weaken the community*" (informant 37, researcher). The community itself is equally divided, the president of the local association linked with the NGO supposed to build the houses is very supportive of the relocation, pointing out that 16 nuclear families out of the 23 are looking forward to moving, however, others argue that no more than 2 or 3 nuclear families are moving out. Local people raised many concerns. The first concerns spatial organization, as "*living very close to each other does not work*" (informant 9, male, 52 years, bait gatherer). The second is related to the size of the area designated for them: "*If they build a football pitch there, only two players will be able to play*" (informant 7, female, 48 years, fishers). Finally, concerns regarding the location of the new settlement were pointed out "*there are plenty of dry areas around here*" "*the new location is five hours by boat from here*" (informant 41, female, 45 years, fishers).

No exact date has been set for the resettlement, nor have agreements been made as to whether it really is going to happen. For instance, in face of the families' criticism, the local NGO due to build the new houses has already put plans on hold.

6.3.3 Property and prospects in the Pantanal

The case in the Western Border of the Pantanal clearly illustrates overlapping understandings of property rights. On the one hand, environmental NGOs and private ranchers have acquired land title to the floodplain to create Protected Areas, which in principle gives them the right to exclude outsiders. On the other hand, local communities established in the area roughly 100 years earlier than the Protected Areas claim access to those floodplain areas based on their historical customary use, and they are backed by the National Policy of Traditional People's Development to do so (MPF, 2013). The government maintains that neither group can have legal title, arguing that the Paraguay River floodplain is by definition a public good and it is state owned. After a failed first attempt to solve the conflict, the second solution proposed by prosecutors to end the battle and promote sustainability in the region is to relocate local people giving them title to a new area further south.

However, no attention has been paid to the perspectives that different groups have on property. The government approach is to use a legal / economic view to solve the conflict, giving different stakeholders title for different parts, and the right to exclude non-owners. Therefore, the state does not take into consideration local people's customary property arrangements; yet the data collected in the present study showed that these are of central importance for local livelihoods allowing adaptation to the changes in landscape accessibility and flood pulse (Chapter 4 and Chapter 6).

6.4 Discussion

The conflict in the Western Border of the Pantanal is an important case study in exploring the link between sustainability and land tenure, but also in analysing the power play between competing interest groups, and the potential for legal frameworks to add to or conversely minimise conflict. The Government, NGOs and traditional communities using different perspectives claim ownership rights over the same floodplain and, interestingly, each is backed by some basis in law. Moreover, the main goal of each of the three contenders is ostensibly to promote sustainable use of natural resources, the common objective whether of the Protected Areas Law, the National Policy backing local communities' territorial claims, or the law authorizing prosecutors to give provisional titles. However, stakeholders' interests clash instead of converging. The consequence has been comprehensive mismanagement, with the prospect of further damage being done through the relocation of the weakest group – local communities of fishers – if they are given land title in a distant area.

It becomes clear that the real intention of each group is to impose their own view over the others, rather than to aim for either sustainable development or a clearer and more workable delineation of property regimes, tenure and access. Without reiterating the details, many features of the conflict suggest this: the conservation group funded by powerful corporations; the state's intervention, which it is then powerless to enforce; the documented harassment (Chapter 4, section 4.4) and proposed displacement of the weaker community. The local situation can be understood as a power dispute, in which stakeholders use narratives of property ownership and environmental conservation to argue their interests.

Another important point to make about the case in the Pantanal is that all solutions proposed by state and environmental NGOs seek to secure the rights of their focal group by establishing fixed boundaries, establishing defined properties through title. However, such an approach runs counter to the current understanding of flood pulse and other dynamic ecosystems, which recognizes that temporally and spatially fixed boundaries cannot track changes through time and space (Hayden et al., 2015; Levin et al., 2013; Lourival et al., 2011). The natural resources distributions we see today are likely to be very different in the future and fixed solutions do not adapt to those changes (Rist et al., 2013; Westgate et al., 2013), leading to a further disjunct between the western economic view of property and ecological understandings of sustainable natural resource use in ecosystems with unpredictable dynamics.

Setting aside defined areas for local people may undermine their livelihoods. In the Pantanal, the on-going changes in river flow regulate fishers' territories, and their adaptation to those changes is likely to be the keystone for sustainable use of natural resources in the region (Chapter 6). Restrictions on this adaptive customary management of natural resource use, such as establishing defined areas that fishers can use and others from which they are excluded, are likely to disrupt the rotational fishing system, which is emerging as underpinning both biodiversity conservation and income for local people.

The disjunct between property as it is conceived of locally, and the hegemonic western view of property, can become the basis for environmental narratives justifying aggressive management practices and interventions, including displacements, implementation of alternative livelihoods, or heavy-handed enforcement around use of natural resources (Adams and Hutton, 2007; Rantala et al., 2013; Wright et al., 2016). These interventions are often adopted from quite different systems, opening space to financial capital and external investors in the region, allowing monetization of the area (Büscher et al., 2012). As a consequence small-scale users of natural resources are replaced by large investors, focusing either on (claimed) environmental conservation or on extraction of natural resources (Zoomers, 2010). It is no surprise, therefore, that, in the Pantanal, the "Protection and

Conservation Network for the Amolar Region" (PCNAR), according to local informants, was funded by a mining company and an investment bank.

6.5 Conclusion

To conclude, secure access to land and guaranteed property rights are indeed key elements in tackling poverty alleviation and environmental conservation in the Pantanal and elsewhere. The approach to guarantee such a link, however, needs to encompass a broader perspective than simple land titling or fixed areas. Property is composed of multiple components involving social, economic and environmental dimensions. The conflict in the Western Border of the Pantanal illustrates a case study of just such a persistent disconnect. As presented the current Pantanal property system as understood by state, ranchers and environmentalists does not map well onto the region's unpredictable, dynamic ecosystem. Therefore, setting defined ownership and rights to exclude through land titling is a poor way to solve the conflict in the region. Such an approach is likely to keep the conflict unresolved, and to mean the state will be likely to continue to fail in enforcing rulings, all of which may jeopardize both effective biodiversity conservation and support for local people's livelihoods. Before allocating land title to different groups or individuals, a first step should be to describe the most important drivers dictating property from a multidisciplinary perspective encompassing the intersection of anthropology, ecology and economics. This wider understanding is more likely to integrate management policies with local realities in sustainable ways.

Chapter 7 To what extent are local people's needs captured in prioritization models? systematic conservation planning in freshwater and floodplain ecosystems [18]

7.1 Abstract

Systematic Conservation Planning is a promising sustainable development tool. It is underpinned on the idea that multi-stakeholders' need should be considered in any conservation intervention. The possibilities are many, including a more equitable approach for setting aside protected areas. However, few areas have seen the implementation of the tool. In this chapter a systematic conservation planning exercise was developed for the Pantanal in order to propose a more equitable disposition of protected areas in the Western Border of this region. In order to test the validity and feasibility of the solutions, maps of the proposed solutions were brought to the field and shown to local people. Fishers feedback was negative, with none of the proposed possible scenarios being accepted as worktable. The chapter discuss the possible reasons for the failure to encompass fishers needs adequately within the Systematic Conservation Planning process, despite attempts to do so. The argument is based on the idea that the fixed solution proposed by the framework does not map sustainably onto the flexible features of the local socio-ecological system. It is concluded that adaptive solutions need to be used in order to turn multi-stakeholder planning into a successful sustainable development tool.

7.2 Introduction

In the Western Border of the Pantanal a prioritization of conservation actions through a multi-stakeholder process could have the potential to promote sustainable development in the region. During the last 30 years, most of conservation actions have been based on enforcement over use of natural resources. The focus has been mainly on the quantity of natural resources local people were extracting. However, the approach has led to economic and physical displacement, conflict and, possibly, has partly jeopardized a customary system that is likely sustainable (Chapter 4). Recently, a second approach focused on land titling was carried out. As presented in

[18] This chapter is part of the paper "Chiaravalloti, R.M. Systematic Conservation Planning in floodplain fisheries: to what extend are fishers' needs captured in prioritization models. **Fisheries Management and Ecology** *in press"*

Chapter 6, federal prosecutors gave land title to local people in order to promote a more equitable solution. However, no account was taken of the different views of local groups, despite the fact that such diversity characterizes most socio-ecological systems. As a consequence, prosecutors had to step back, and current the solution proposed is to relocate people from Settlement 1. Therefore, the possibility of establishing zoning in the region, with conservation actions being decided based on all stakeholders' needs, sounds more promising than the previous approaches.

This chapter aims to answer the following research questions:

To what extent are local people's needs captured in prioritization models?

- What is the relative importance of data on local people's territory and economics for systematic conservation planning in floodplains?
- To what extent do local people concur with the zoning models produced by Systematic Conservation Planning in the Pantanal?
- Is Systematic Conservation Prioritization a promising solution for management of resource conflict in floodplains?

7.3 Methods

7.3.1 Spatial Conservation Prioritization

To carry out the analysis the software Marxan with Zones was used (Marine Reserve Design Using Spatially Explicit Annealing) (Watts et al., 2009). This software is an extension of Marxan and allows any parcel of land or sea to be allocated to a specific zone. It can be used in interactive ways, functioning as an extension of any GIS software.

SCP was carried out based on steps adapted from Game & Grantham (2008).

1. Set aside a study area to be analysed.
2. Divide the selected area into several planning units.
3. Define the different zones of interest.
4. Stipulate the cost of implementing each planning unit for each zone.
5. Establish different social and environmental variables for each zone and estimate the abundance, quantity or percentage of each one inside the planning units.

6. Stipulate the desired representation (or target) of each variable inside a reserve system.
7. Repeat the process several times using appropriate adjustments.

For the purpose of this research, a further step was introduced

8. Revisit communities to present findings, discuss and receive feedback.

The following defines how each of these steps was met:

7.3.2 Study Area

The boundaries of the study area were defined by local environmental features and region of use of fishers from Settlement 1. Thus, the Western and Eastern Borders were defined based on the Paraguay sub-region borders. This region is characterized by the great influence of the floods triggered by the so-called Paraguay River, which encompasses the central region of the Western Border of the Pantanal. Its borders have been defined by Silva & Abdon (1998). The northern region of the study area was defined based on the Paraguay sub-region border; however, in the northwest region, there were some water bodies and floodplain areas outside the region thus defined that are, nonetheless, part of local people's use. Hence, they were aggregated into the study area. The southern region of the study area was defined on the basis of the furthest use of natural resources by local people of Settlement 1. The total size of the study area thus delineated is 560,052 ha (Figure 7-1).

7.3.3 Planning unit

Planning units are sites or regions that have a specific combination of environmental and social features. Based on its individual characteristics and location, the software set aside each one for a specific use (e.g. fishing, strict protection, available, etc.). In this chapter the "planning unit" size was established based on the local use classification called "fiscal module". This is defined by the Brazilian government as the minimum agrarian unit that a rural property needs to have to be considered economically sustainable (Landau et al., 2012). In Brazil, all environmental regulations over rural private properties (such as how much Riparian Forest needs to be protected, or how the Legal Reserve of each property can be managed) are defined by this unit of measure, demonstrating the interplay between economic and

environmental perspectives. The size of the fiscal module is different for each Brazilian municipality, therefore the average of the three municipalities that encompass the study area was used (Municipality 1 (110 ha), Municipality 2 (80 ha) and Municipality 3 (80 ha)), giving an average of 90 ha (Landau et al., 2012). In total 6452 hexagonal planning units were built up (Figure 7-1).

7.3.4 Zones

Zones are the regions that best fit the combined priorities of all stakeholders. In this study three types of zones were established. The first one is the area that should be strictly protected, which, ideally, would satisfy the protected area managers' goals. The second is the fisheries area, which, ideally, would satisfy the local people's needs. The third is the "available zone", which, ideally, would be a multiple land use region free of any kind of conservation enforcement.

7.3.5 Cost

Cost is used as a variable in the model to weight the difficult to set aside specific region within each zone more heavily. For instance, regions with higher costs are unlikely to be part of the zone. Cost can be any feature that measure the difficult to setting aside a specific area. In this model the measure of cost used for all zones was distance. In the Western Border of the Pantanal the majority of trips are done using motorboats. Therefore, there is a direct cost of fuel and equipment for moving around. For the protection zone, the cost for each planning unit was estimated through the average distance of each planning unit from the three enforcement offices within the study area. The idea underpinning this variable is that all protection campaigns start from one of these three enforcement offices; therefore, regions closer to them, ideally, would be less costly to control. For the fisheries zone, the cost for each planning unit was estimated through the distance from Settlement 1. This settlement is the main living camp for all Settlement 1 dwellers, and, all fishing journeys start from this area, therefore, regions closer to their village, ideally, would have a lower cost use. No costs were established for the available zone.

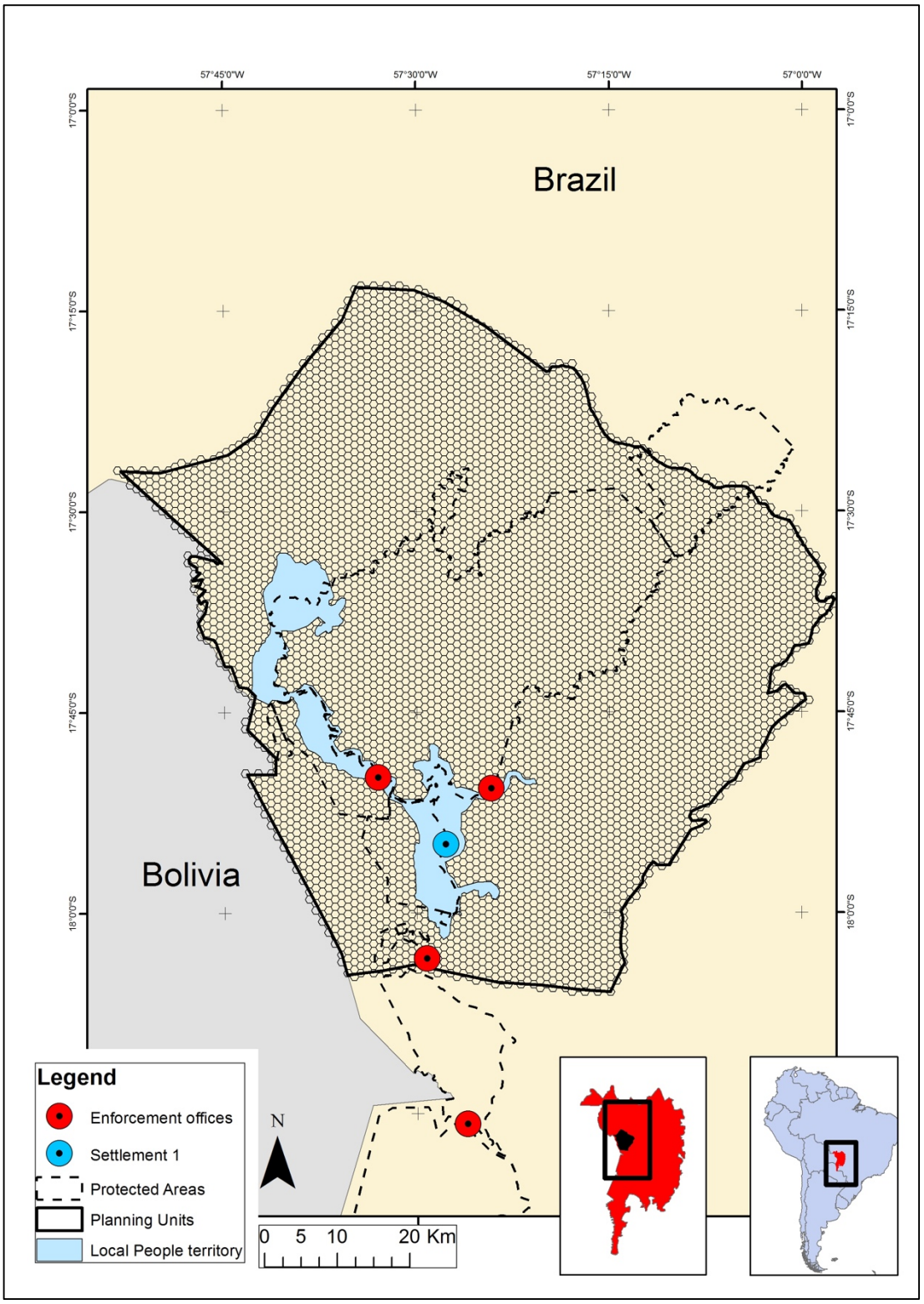

Figure 7-1: Study area divided into hexagons in grey. Red polygons indicate the protected areas. Blue polygon represents local people's territory. The small map on the right highlights the location of the study area within the Pantanal. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

7.3.6 Features used as input in the model

7.3.6.1 Environmental features

Ecosystem types of the Western Border of the Pantanal were used in order to establish environmental variables in the model. In principle, diversity of ecosystems has a positive correlation with level of biodiversity (Grantham et al., 2010). Hence, the area (in hectares) covered by each vegetation / ecosystem type in each planning unit of the study area was evaluated. 15 different vegetation types and water bodies were considered. The vegetation types and water bodies data were from a secondary source provided by Conservation International, ECOA, WWF and SOS Pantanal based on reference images from 2010. They used images from Landsat 5 TM satellite on a scale of 1:50 000, which is the most precise scale available for Pantanal vegetation map (Rosa et al., 2009) (Table 4)

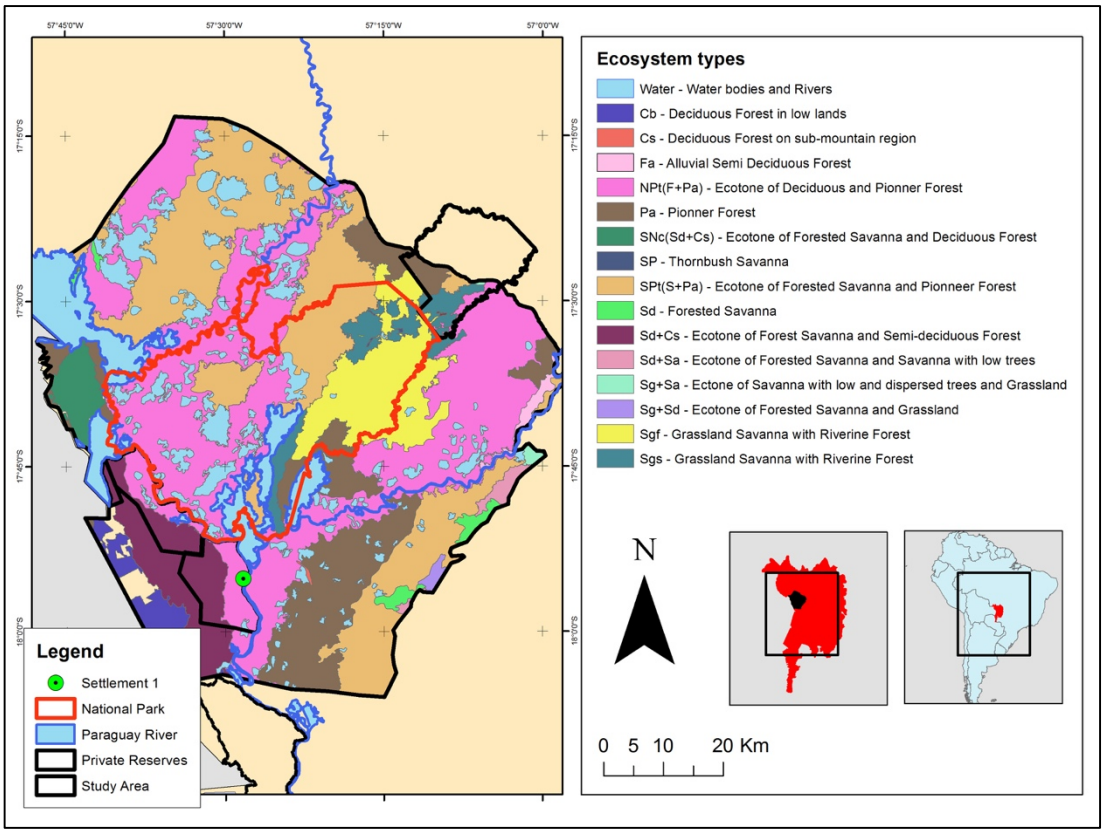

Figure 7-2: Each coloured polygon represents the spatial distribution of each vegetation or ecosystem type. In red are the Protected Areas. The small map on the right highlights the location of the study area within the Pantanal. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

The use of social features in systematic conservation planning is a relatively novelty in Marxan software (Watts et al., 2009). In the early versions, the main way to incorporate local people's needs was through the "Cost" variable, in which areas facing conflict with people were given a higher cost to be protected (Lechner et al., 2014). Currently, Marxan with Zones, clearly incorporates local people's needs, however the type of data the software accepts is limited to quantitative data. In this chapter, two different scenarios were created, called here "Scenario 1 – economic gains" and "Scenario 2 – access to territory", in order to try two different types of data. The next two sections explain how each scenario was generated.

7.3.6.2 Scenario 1 – economic gains

"Scenario 1 – economic gains" is based on the assumption that local people's needs can be simplified as "economic gains". This approach is the most used among systematic conservation planning exercises, in which researchers use fishing catches, frequency of landings, willingness to pay, etc. as the only social variable in order to create zones that can promote local development (Lechner et al., 2014; Whitehead et al., 2014). In this chapter, this variable was created based on real fishing sites collected during the fieldwork and two spatial analysis techniques called Algebra of Maps and Cost Path Analysis that allowed to generate a raster (or surface), in which different values were given for the whole study area based on the possibility of each site being used as a fishing spot:

1) The first step was to evaluate the main features of the spots used as fishing sites by fishers from Settlement 1 and aggregate them up. It was established that people only fish in water bodies, they tend to fish in those ones that are connected with the main river, and in low altitudes areas (mainly floodplain). In order to carry out this aggregation (formally called Algebra of Maps) all information used had to be standardized.
    a. A raster of an altitude of the region was standardized to a scale of 0 to 100. The underlying idea here is that given people mostly use regions from the floodplain area, places with lower altitudes were more important than the ones in higher altitudes.
    b. A raster was created in which all water bodies were given a value of 20 and the rest of the area a value of 100. The idea was to represent on a map that dry regions are unlikely to become fishing sites (100) and currently water bodies are likely to be used (20)

c. A similar map was created in which water bodies that are connected with the main river and the main river itself were given a value of 10 and the rest of the area a value of 100. Similarly, the idea was to represent in map form that water regions people can easily access are more important than those that have no inter connection and therefore no simple access.

2) All the maps were summed up through the technique called Algebra of Maps and a final raster map was produced, in which regions where people are very unlikely to fish scored 300, and regions where people are likely to use as fishing spot scored values close to 0. The final scores do not represent real measures; they are simple used to compare different sites features.
3) The raster with the fishing features created was finally compared with the real fishing grounds recorded during the fieldwork through Extreme Citizen Science and Participatory Scale Maps (Chapter 3**,** section 3.8.4.3). To do so, a spatial analysis called Cost Distance Analysis was carried out in order to weight heavier those regions that are close to the real fishing grounds and have similar features.

The result of this process was a raster (surface) which showed areas that were more likely to be used as fishing sites by the local people in Settlement 1. In order to facilitate the understanding and its use in the software, the inverse value was used (low values for areas unlikely to be used and high values for areas likely to be used) (**Error! Reference source not found.**). To use the results of the spatial surface in the model, the intersection between the raster created and the planning units was tabulated, giving a unique value for each point.

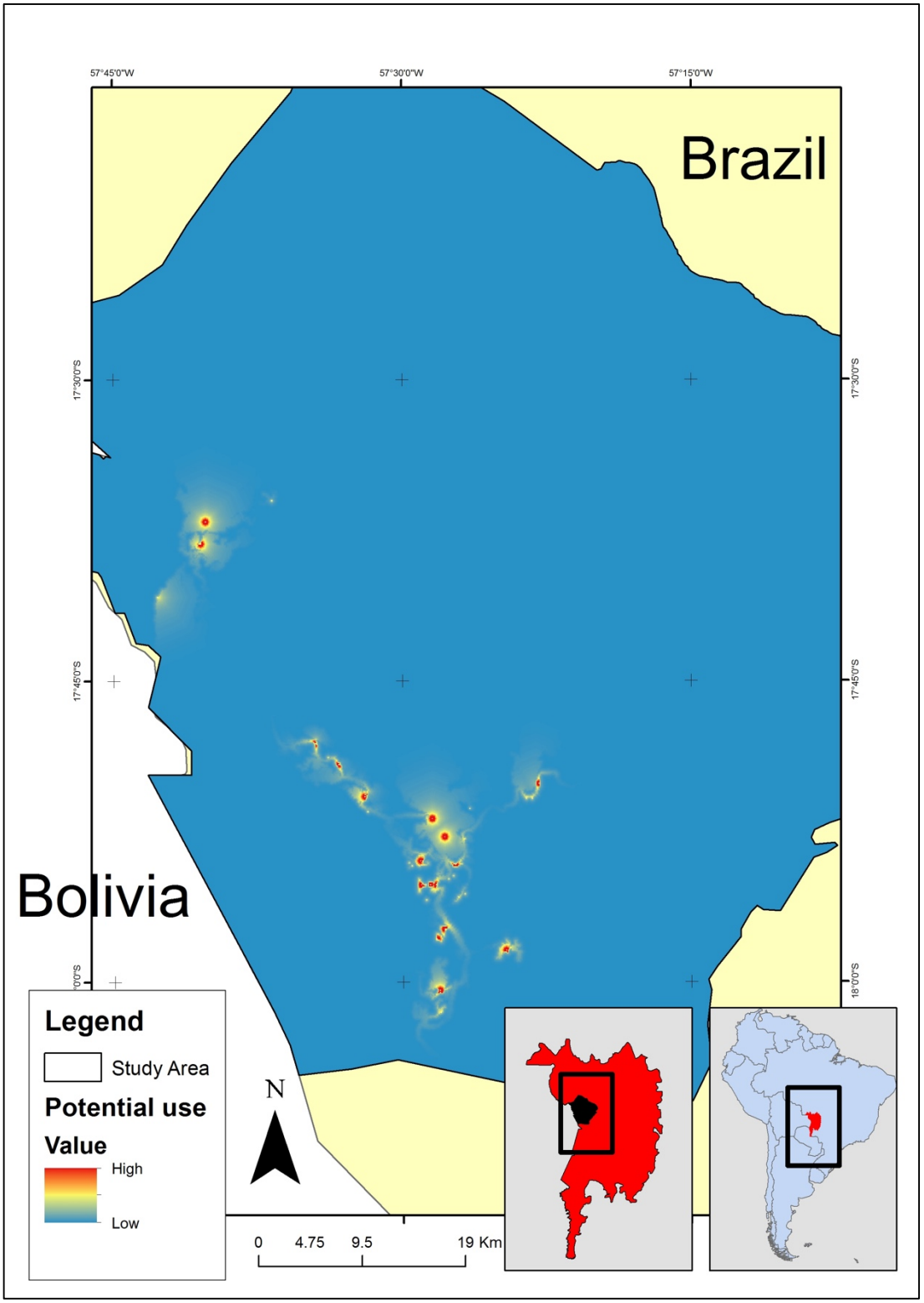

Figure 7-3: Areas very likely (dark blue) and extremely unlikely (white) to be used as fishing sites. The small map on the right highlights the location of the study area within the Pantanal. Inset: location of the Pantanal in South America (right) and location of the study area in the Pantanal (left).

7.3.6.3 "Scenario 2 – access to territory"

In scenario 2 the social variable used was local people's territory. The map is a representation of the area that local people see as fundamental for their livelihood and well-being (Chapter 5, section 5.4.2). For the prioritization exercise, the planning units were overlaid onto the territory and the quantity of hectares presented in each one used as the input information.

According to fishers, their territory encompasses living sites, fishing areas, rotational fishing system, customary use, and unflooded man-made mounds used during large floods (0, section 5.4.3). They perceive this area as highly important, for instance, no one from other settlements may fish in or move to their territory (0).

7.3.7 Targets

Targets are explicit goals about the social and environmental features, such as "protect a certain amount of vegetation intact", "guarantee an specific level of income", etc. (Margules and Pressey, 2000). Reaching the targets is the main goal of the analysis. The software gives a value for a collection of planning units based on the various costs of the selected set and the penalties for not meeting the established target. Hence, a measure of model quality is how has it comes to reaching the established targets. This process, however, is not solved by simply setting high targets for all variables (e.g. protect 100% of all forests). Targets need to be realistic and sometimes, modified according to the answers of the best model created. Therefore, the establishment of targets has to be carried out through an iterative process. In other words, the target has to be changed according to the output of the model, creating a loop process.

7.3.7.1 Protected Zone target

In 2010 the Convention on Biological Diversity established that all countries should have biodiversity targets for the next 10 years, known as Aichi Targets (Machado et

al., 2012). They are divided into 20 different targets. Target 11 concerns Protected Areas. It states that 17% of the in-land area of all countries should be legally protected[19]. Thus, as a reference for the Aichi target 11, the baseline target for all vegetation and water bodies was established at 17%. However, to avoid over-representation of common vegetation or ecosystems types in the model outputs, each vegetation or ecosystem target value was corrected using Pressey & Taffs (2001)'s measure of representativeness. The idea is to highlight vegetation types that are rare and vulnerable in the region and which therefore need more attention from a conservation perspective. The measure was based on the formula developed by Pressey & Taffs (2001) and adapted for the Pantanal:

(Target) + (Target * NR) + (Target *V) = Corrected Target

NR is the natural rarity (Table 7-1) and it was estimated by the following formula [(Amax-Ai)/Amax], in which Amax is the area of the most extensive vegetation type in the Pantanal and Ai is the area of the vegetation type being considered.

V is vulnerability class for clearing or habitat destruction (0 for none, 1 for low, 2 for moderate, and 3 for high). This was calculated based on the Pantanal habitat replacement rate for each vegetation or ecosystem type between 2002 and 2010, the percentages were categorized from 0 to 3 (Rosa et al., 2009) (Table 7-1).

[19] https://www.cbd.int/sp/targets/default.shtml

Table 7-1: Description of each vegetation or ecosystem type and the target established to be protected.

Vegetation type	Description	Natural Rarity	Vulnerability	Target (%)
Cb	Deciduous Forest in low lands	97.7	0	33.7
Cs	Deciduous Forest on sub-mountain region	74.8	0	29.7
Fa	Alluvial Semi Deciduous Forest	29.9	0	22.0
NPt(F+Pa)	Ecotone of Deciduous and Pioneer forest	81.1	0	30.7
Pa	Pioneer forest	78.3	0	30.3
SNc(Sd+Cs)	Ecotone of Forested Savanna and Deciduous Forest	98.8	0	33.8
SP	Thornbush Savanna	96.4	2	67.4
SPt(S+Pa)	Ecotone of Savanna and Pioneer Forest	37.6	0	23.3
Sd	Forested Savanna	0	0	17.0
Sd+Cs	Ecotone of Forested Savanna and Deciduous forest	97.1	0	33.5
Sd+Sa	Ecotone of Forested Savanna and Savanna with low and dispersed trees	72.4	0	29.3
Sg+Sa	Ecotone of Savanna with low and dispersed trees and grassland	45.6	0	24.7
Sg+Sd	Ecotone of Forested Savanna and Grassland	88.2	0	32.0
Sgf	Grassland Savanna with riverine forest	86.9	0	31.7
Sgs	Grassland Savanna without riverine forest	73.5	0	29.5
Water	Water Bodies and Rivers	87.4	0	31

7.3.7.2 Fishers' Zone Target

In order to establish the best model for systematic conservation planning, the target used for the fishers' zone was set through an iterative process. First, a target of 80% was set for both Scenarios. In other words, it was first established that the main goal was to guarantee 80% of the best fishing sites (in Scenario 1 – economic gains) or

80% of fishers claimed territory (Scenario 2 – access to territory). Then, slowly, the 80% target was reduced until most other targets were met, as explained below.

7.3.8 Model calibration

The calibration process is used to find the best combination of parameters that allow the software to reach all established targets or to get close to it. The first parameter adjusted is called Boundary Length Modifier (BLM). BLM can vary from 0 to infinite. Higher BLM will generate clumped zones. In other words, each zone will be clearly separated. Although this may be, in practical terms, a more feasible solution to set aside, it reduces the change of meeting the targets. For instance, most rare vegetation types do not occur in the same region. Therefore, their target protection threshold would not be met in an extremely clumped zone. To find the best fit for each scenario, several possible models were analysed varying BML from 0-10. The value used was the one that both generated a clumped solution and also met most of the targets (low penalty).

After defining the best BML, it was verified how much of the target of each feature was met. This was because, some features were not sufficiently represented in the chosen model. Where the percentage of the target met was too low (below 90%), the penalties for not meeting the target were increased to 1.5; 2; 2.5; 3 and so on. This approach forces the software to better represent those features. Finally, where the percentage of the target met was still too low, the targets themselves were slowly decreased until at least 97% of all social and environmental features targets were met. The calibration process was carried out using Zonae Cogito Software.

7.3.9 Local people's perception of SCP model output

In order to check local people's real-life responses to the proposed solutions, 30 households were interviewed. Each interview was held individually to avoid interference in the responses. To present the solution proposed in a way that local people could understand, evaluate and argue in favour or against it, in each interview three different maps were shown for "Scenario 1 – economic gains" and another three for "Scenario 2 – access to territory". The three maps were: 1) Marxan best

solution separating each zone into different colours (fishers, environment and available); 2) Marxan selection frequency showing regions most likely to be set-aside as a fishers zone (Figure 7-4); 3) Simpler version of the other two based on the local separation of region into five different sub-regions – each sub-region (named here as 1-5)[20] was coloured according to the use proposed by the software: in red (community use not permitted), green (community use permitted) and yellow (community use restricted) (Figure 7-5).

Figure 7-4: Example of a SCP output map used during the interviews, in the case is the selection frequency map.

[20] During the interviews the real names for sub-region 1-5 were used. However, to preserve anonymity in all fishers' quotes sub-region names were replaced by numbers.

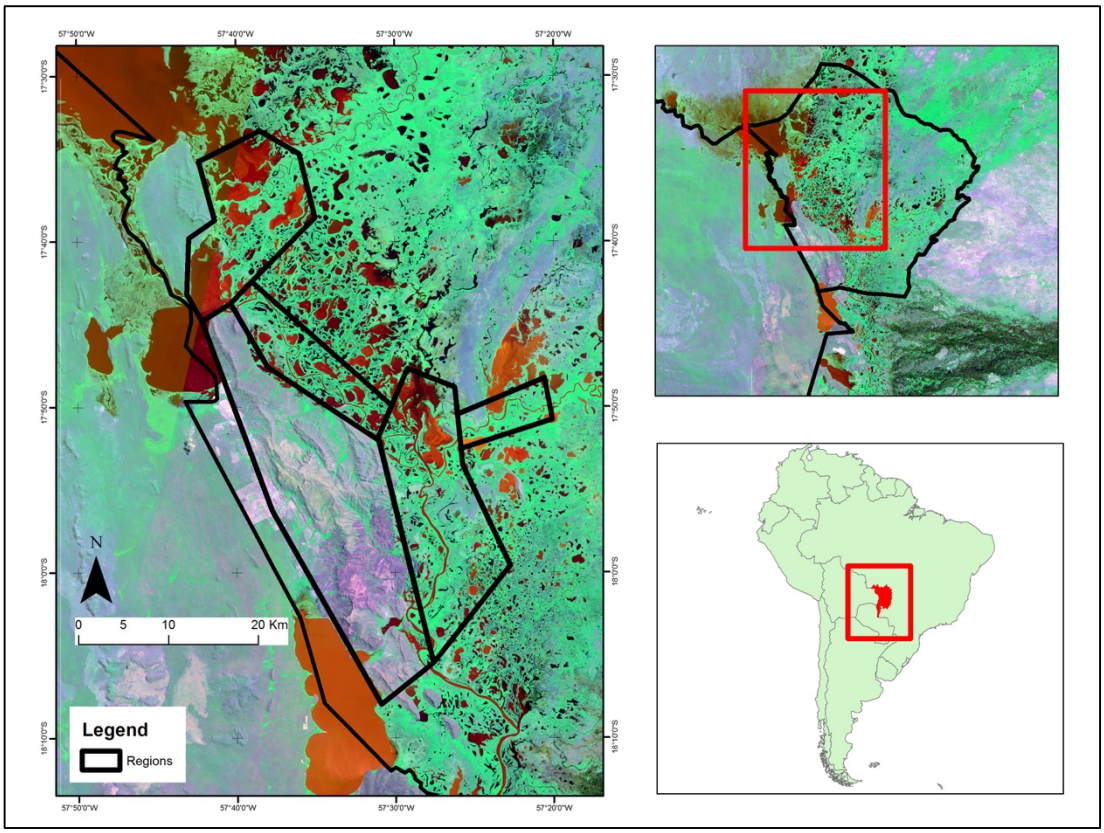

Figure 7-5: The 5 sub-regions used to explain the proposed solutions given by each SCP model. Inset: location of the Pantanal in South America (bottom right) and location of the sub-regions in the Study Area (top right).

7.4 Results

7.4.1 "Scenario 1 – economic gains"

In Scenario 1, several calibrations had to be taken in order to reach the established targets. First, the best value for BML was 1. Then, the penalties for not meeting the targets of Semi-deciduous seasonal forest, Forest in initial stages; Forested Savannah; Forested grassland, grassland, and fishing sites were increased. Finally, the target of fishing sites had to be reduced from 80% to 50%. Only combination this of BML, penalties and targets allowed the software to create a solution that reached at least 97% all targets.

Overall, Scenario 1 proposed that two different regions (sub-region 2-5 and 4) should be set aside for fishers to balance fishing potential against protection of all different

kinds of ecosystems in the Western Border of the Pantanal. The two areas are clearly highlighted in the Selection frequency map (Figure 7-6; Figure 7-7).

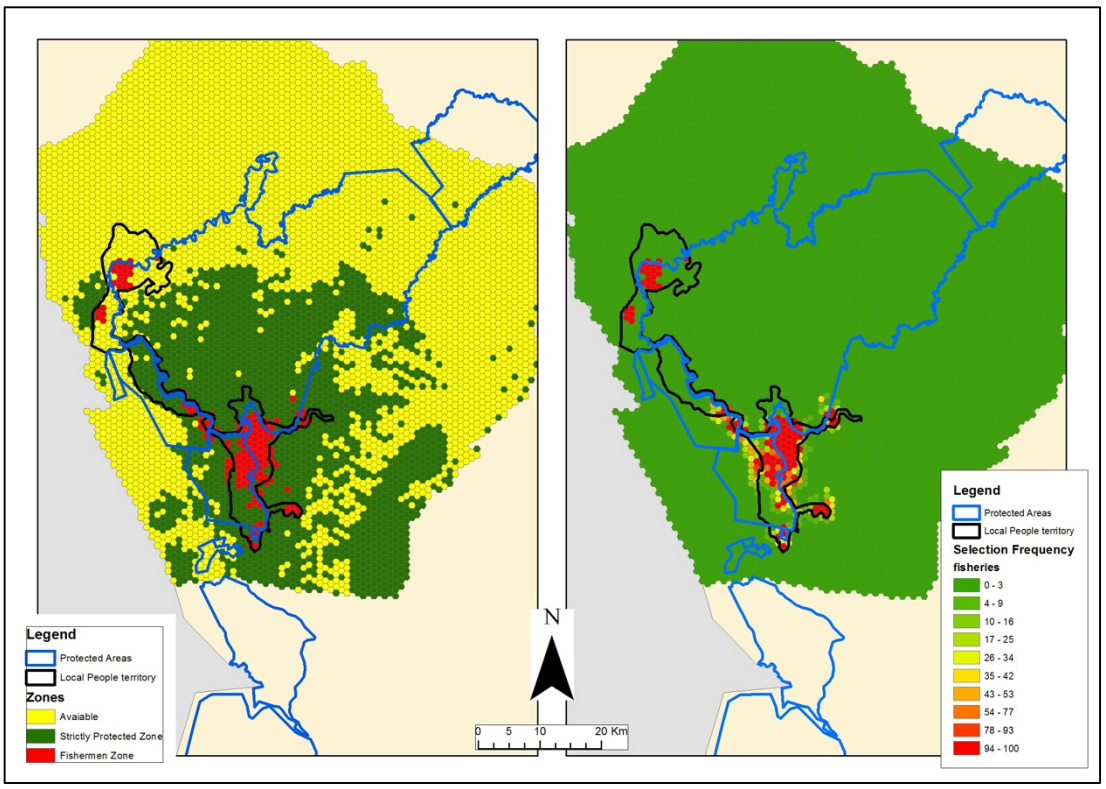

Figure 7-6 On the left is the best solution map, on the right is the selection frequency map, both for SCP Scenario 1. The black line delimits the local people's territory and the blue line Protected Areas' boundaries.

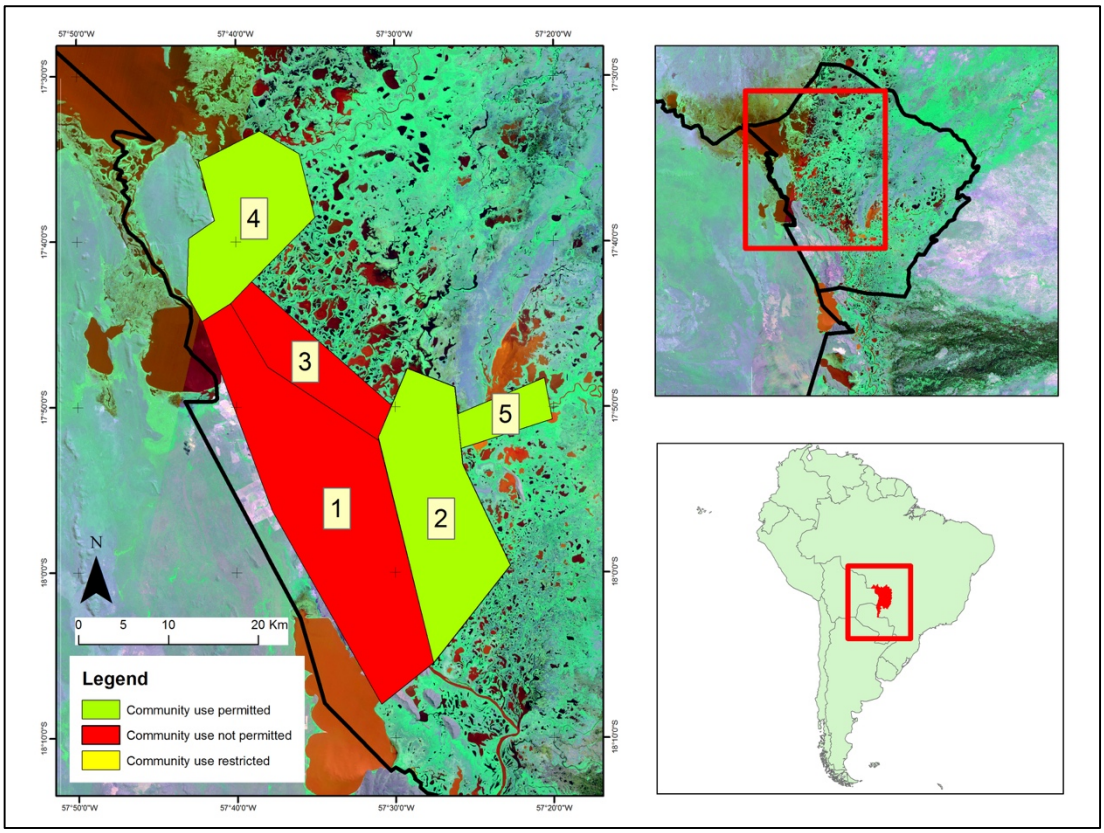

Figure 7-7 SCP Scenario 1: red areas: use should not be permitted; green area: should be set aside for community use. Inset: location of the Pantanal in South America (bottom right) and location of the sub-regions in the Study Area (top right).

However, local people rapidly rejected the proposed zoning in Scenario 1. No householders agreed to close off sub-regions 1 and 3. Their main concern was about region 3, which is the river connection between sub-regions 2 and 4. In the first place, people claim that the area is always free from dequada[21]. As presented by informant 1

> "Dequada starts in National Park and moves downstream. Region 3 is on the right side of the Park. Thus, the poison water does not reach region 3. Therefore, this is the only place where we can go fishing and collect drinking water during this period".

[21] This phenomenon is related to the decomposition of submerged organic matter during the initial flooding of previously dry areas with a high biomass of terrestrial vegetation. The oxidation of organic matter in flooded fields and in the water column of rivers depletes dissolved oxygen levels and increases the concentration of dissolved carbon dioxide gas; as a result, a *dequada* of large magnitude can provoke massive fish kills (up to hundreds of tons) (Calheiros and Ferreira, 1997)

Moreover, fishers pointed out that they use some areas of sub-region 3 to rest and as a campsite, during the period when they are fishing in sub-region 4. Informant 20, who is the housekeeper for a farm in region 3, explained:

> "I know everyone from "Settlement 1"; all fishers stop by to talk, eat mangos, drink tereré (ice tea) and fish from here; the river belongs to everyone, one cannot close the river, people depend on it to survive".

People were less concerned about closing off sub-region 1. It is interesting that this sub-region is the only area constantly dry in the study site. Ideally, it could be used as an unflooded living zone. It is a mountain region forming the physical barrier of the Western Border of the Pantanal (Ab'saber, 2006). However, people do not see the area as part of their living region, as presented by informant 9 "*I am not a goat to live in the middle of rocks*" and confirmed by informant 22 (housekeeper in a farm located in region 1) "*I invited all of them to move here to this area where it is not protected, no one ever accepted it. They like to live hanging on sticks*" [referring here to stilt houses over water]. However, although not part of their living or fishing area, the region plays a role in their livelihoods. As sub-region 1 never gets flooded, it is a secure source of wood and straw. These materials are used for fuel and to build houses. Some other locations could provide these materials, such as Old Indigenous mounds and Palaeo-levees (Chapter 4, section 4.4), however, due to the unpredictability of the system, sub-region 1 is the only secure source, as suggested by 21 "*sometimes we need to gather wood in sub-region 1, there is no other option around*".

7.4.2 "Scenario 2 – access to territory"

Similarly, to the first Scenario, in "Scenario 2 – access to territory", had to go through several calibrations in order to reach a model that met or closely met the established targets. First, the best value for BML was 2. Then, the penalty for not meeting the targets of fishers' territory, grasslands, and Flooded forest were increased. Finally, because the best model was still far from showing a good quality, the target of fishers' territory was reduced from 80% to 70%. This combination allowed the software to create a solution that reached at least 97% of all targets.

Overall, Scenario 2 proposed one big area (sub-region 2, 3 and 5) should be set aside for fishers and another one its use should be restricted in order to balance use of the territory against protection of all different kinds of ecosystems in the Western Border of the Pantanal (Figure 7-8; Figure 7-9).

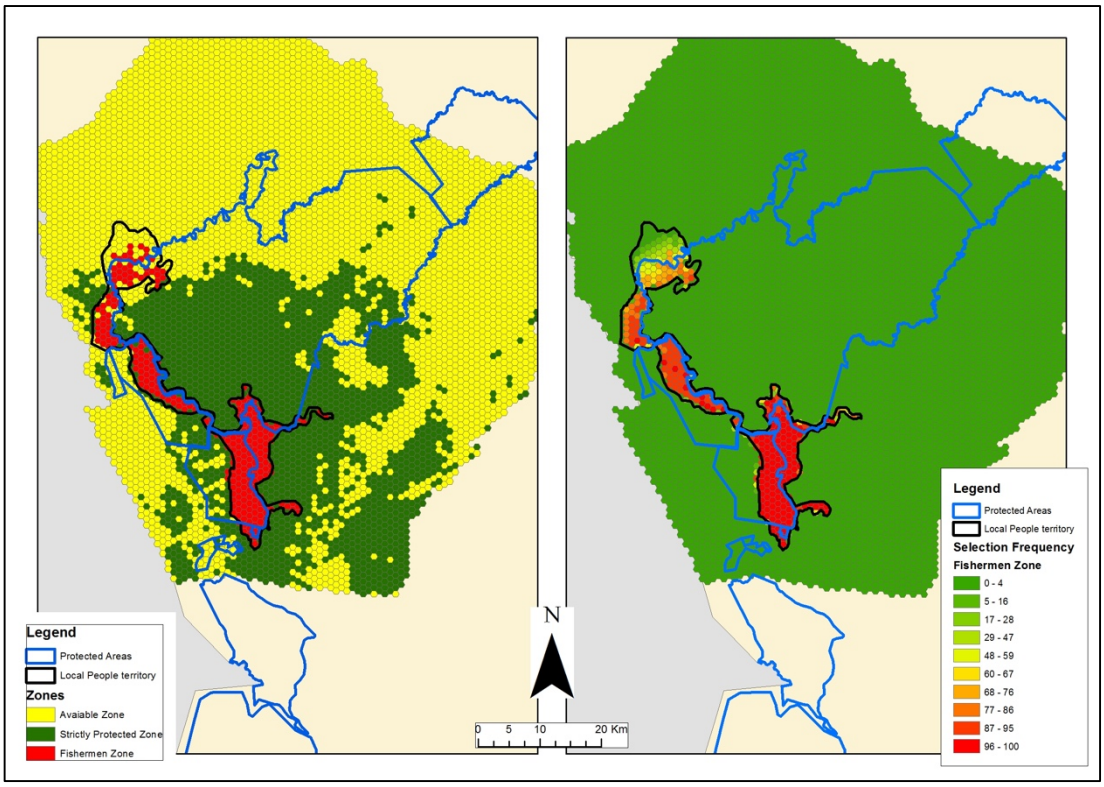

Figure 7-8: On the left is the best solution map; on the right is the selection frequency map, both for Scenario 2. The black line delimits the local people's territory and the blue line Protected Areas' boundaries

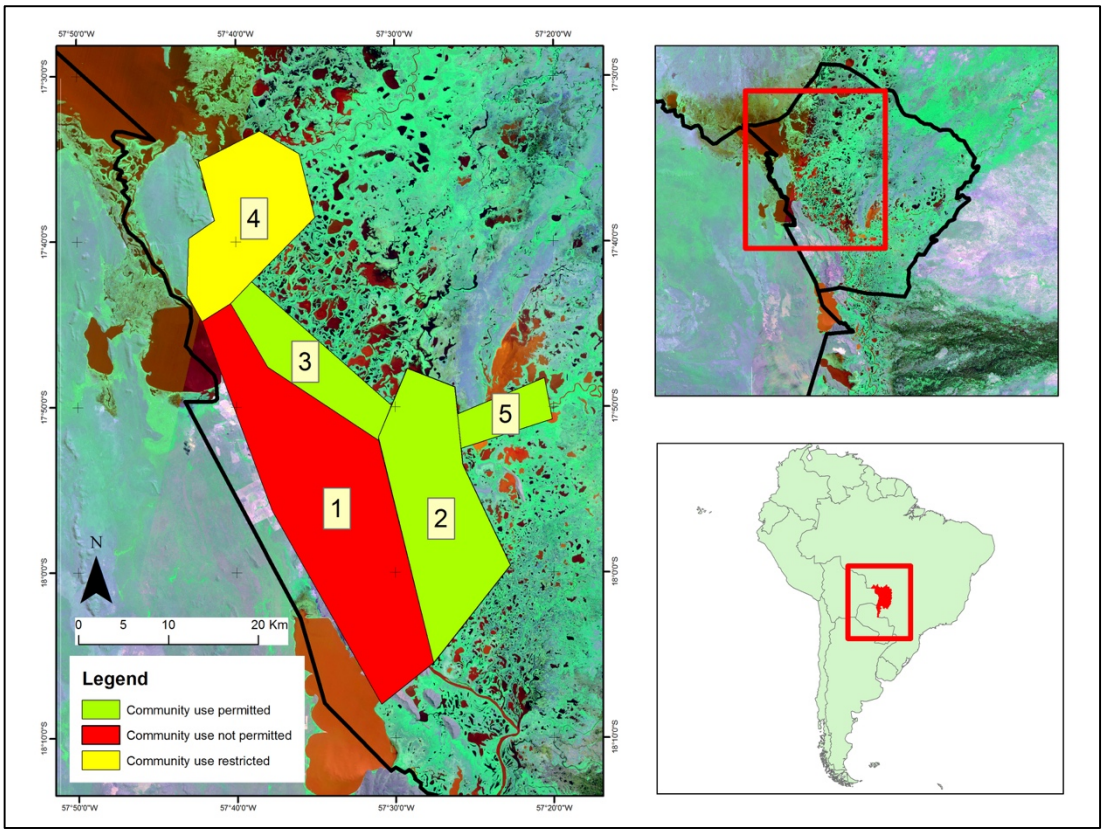

Figure 7-9: SCP Scenario 2: red area: use should not be permitted; green area: should be set aside for community use. Inset: location of the Pantanal in South America (bottom right) and location of the sub-regions in the Study Area (top right).

Local people similarly rejected Scenario 2. Although the area set aside for fishers would be continuous and relatively larger, all households pointed out that management based on scenario 2 would not work. Their main concern was about the possible restrictions imposed on sub-region 4. According to them, the bay situated in this region is one of the most important fishing spots. Should this region be closed off, they fear that their livelihood would be jeopardized. As presented by informant 5, "*everyone goes to sub-region 4 in the beginning of the fishing season. There is no good place for fishing apart of sub-region 4*". Informant 10 and 1, respectively, reaffirmed its importance:

> "sub-region 4 has lot of aquatic vegetation, and, therefore, we are able to gather a large amount of bait", "we know L. who is housekeeping a farm there and he, sometimes, hosts five or even six people from settlement 1 at the same time".

Informant 12 himself was another housekeeper in another farm in sub-region 4 during 2014 and he was similarly hosting all members of one of the extended families in the Settlement 1 during the fishing period when sub-region 4 is said to be the most productive site. Moreover, the area is part of local people's traditional living area. For instance, members of EF1 claimed to have lived there during the 1980s until they were displaced due to the creation of the National Park, as explained in Chapter 4, section 4.4. People still have strong social ties with the region.

It is important to note that during each interview people were constantly reminded that the yellow colour was referring to restrictions. Therefore, according to the scenario 1, sub-region 4 would be restricted not forbidden. However, they kept the same rhetoric, once for them, restrictions meant "fishing for home-consumption", which, according to them, does not fulfil their needs. This probably is a consequence of the legal battles in the region around use of natural resources, in which managers of protected areas and prosecutors pointed out that fishing in some currently forbidden areas would be permitted if it was for self-consumption (MPF, 2013).

Regardless of the output of each Scenario, overall people were suspicious about the idea of setting aside a fixed area for protection and another for fishing. The results of the interviews and participatory mapping showed a rather complex dynamic use of the space that challenges this approach. As presented in Chapter 3, 4 and 5, local people constantly adapt to the changes on the natural resource distribution, either moving their living sites or undertaking a Rotational Fishing System. Fishers lives are dictated by the flood pulse and the changes that it brings. Therefore, each given moment a new display of use areas is created, leading to new or alternative adaptive changes. Therefore, the idea of fixed boundaries is not part of their understanding. As presented by informant 12, "*each part of the region is important during a period of the year, closing something off is complicated*".

7.5 Discussion

SCP models considering different levels of protection for different regions are important tools for the management of socio-ecological systems (Brooks et al., 2006; Margules and Pressey, 2000; Pressey, 2004; Smith et al., 2006). In principle, their

outputs may indicate an equitable spatial explicit zoning for areas seeing conservation conflicts (Watts et al., 2009). Supporters of multi-stakeholder prioritization claim that these models provide an innovative approach to share among local actors all costs and benefits for protecting the environment (Klein et al., 2008). The results of the prioritisation models created for this paper do in part support this claim. In both scenarios, all models indicate a possible design for different use zones that should fulfil all stakeholders' needs, should they be implemented. However, although mathematical models in conservation may display satisfactory solutions, they cannot alone lead either to biodiversity protection or to local development. It is fundamental to understand the effectiveness and feasibility of the models (Kim et al., 2016). With local people's acceptance and compliance with the zoning created from multi-stakeholder prioritizatio, a key element in the process (Arias et al., 2015). One of the main reasons for the failure of SCP to be implemented on the ground is precisely the lack of practical validation of the models created. Most SCPs are formulated with little or no intention to implement action. Knight et al., (2008) revealed that this may account for almost 70% of all peer-reviewed papers. Such grounded evaluation can highlight the challenges facing any attempt to turn the theoretical models into conservation actions (Toomey et al., 2016).

In this case study, the type of social data used to represent local communities' needs in freshwater fisheries was analysed. Researchers commonly use economic gains to represent social needs in multi-stakeholder prioritization models. Among the most commonly used variables are fisheries catch (Klein, Steinback, Watts, Scholz, & Possingham, 2010), frequency of landings (Watts et al., 2009), spatial intensity of fishing (Shepperson et al., 2014), and ecosystems services (Bryan et al., 2011). However, although the solutions proposed may show how to maximize profits, they do not capture important social aspects of people's life, such as social relationships, autonomy, adaptiveness, customary arrangements and wellbeing (Woodhouse et al., 2015). Scenario 1, based on fishers' use of different areas for fishing (economic gains), displayed two areas that would, in principle, maximize fishing, if they were created. Nonetheless, it did not encompass important sites making it impossible to adapt to *dequada* or incorporate resting spots. According to local people, these were the main reasons for not agreeing with Scenario 1 solution. Hence, approaches

considering only economic data as social targets may fail to explore domains that are intrinsically complex, such as adaptation, emotions, conflicts and relationships of local communities (Drury et al., 2011), as well as rare but critically important biophysical events. Moreover, collecting social data is a complex task. For instance, fishers may not want to reveal fishing spots to the interviewer due to competition with other fishers or because of their use of illegal areas, the so-called desirability bias (Fisher and Katz, 1993). Equally, few prioritisation models consider the uncertainties associated with social attributes. Often, the data used is a snapshot of people's reality (Allison and Ellis, 2001; Lechner et al., 2014). Considering a community as a fixed unit ignores how differences between people within the community (Agrawal and Gibson, 1999; Haller et al., 2013). Therefore, SCP considering local communities as one of the stakeholders needs to encompass features beyond economic gains.

"Scenario 2 – access to territory" of this case study was carried out in an attempt to fulfil this need. The use of territory seems more promising than economic data as a variable representing local people's needs in SCP. Local people's territory encompasses information that is not captured by quantitative methods (Begossi, 2006; Drury et al., 2011; Larson, 2010), such as traditional fishing systems, customary use and mobility (Begossi, 2006, 2001). This highlights the fact that people's territory is frequently linked with common property regimes, considered an important predictor of sustainable use of natural resources (Ostrom, 2007, 2000). On a theoretical level, for the case study presented here, territory emerged as a better predictor than economic gains. This was seen through the iterative process used to established the social variable target in each scenario. Scenario 1 reached its best result with targets adjusted to 50%, on the other hand, on Scenario 2 the target could be increased by 70% while equally meeting all established environmental needs. The outcome was a larger and more connected area for fishers. However, local people revealed the same level of dissatisfaction with Scenario 2. Therefore, although using territory led to a better theoretical result, it was still not enough to guarantee local people's compliance in the multi-stakeholder prioritization model for the Western Border of the Pantanal.

Regardless of the output of each Scenario, people were often suspicious about the idea of setting aside a fixed area for protection and another for fishing. This trade-off underpins the main assumption of SCP (Margules and Pressey, 2000). For marine areas, for which most SCP software was developed, this tends to not be a problem (Abecasis et al., 2015). Studies from Ecuador (Beitl, 2015), Malaysia (Teh et al., 2012), and Brazil (Begossi, 2006) show that marine fishers' spatial behaviours are mostly based on a stable routine. In the case of floodplain socio-ecological systems, however, this is a challenging prospect (Abell et al., 2007). Floodplains tend to face inherent, frequent and unpredictable disturbances, constantly shifting from a terrestrial to an aquatic environment and vice versa (Junk et al. 2012), which leads to deep consequences for local people's behaviour. As presented in Chapter 5, fishermen from the Western Border of the Pantanal follow a particular pattern of resource use dictated by the flood pulse. As the water rises in the region, there is a continual turnover of fishing sites. People continually check whether new spots are worth fishing, constantly share information about good fishing spots. If someone finds a better place, s/he informs the others, and everyone moves there. This is constantly repeated during the fishing season. Throughout the year, this moving process creates 3-4 phases of a Rotational Fishing System. Other fisheries from floodplains like the Pantanal, especially those with low population, tend to follow this unique dynamic of use, with high mobility throughout the year (Abbott and Campbell, 2009; Adger and Luttrell, 2000; Moritz et al., 2013). This explains, for instance, why the Pantanal's fishers rejected both SCP Scenarios. Their lived experience of the fact that distribution of resource is continually shifting, and that securing a specific area does not guarantee a long-term livelihood was not captured or addressed by the prioritization maps.

It is important to point out that using local people's traditional territory to parameterise the model faces challenges similar to those from the economic indicators. In the Pantanal, people's lives are driven by the river flow; therefore, depending on each year's flood, landscape changes, and the resulting fish distribution means some places may be newly included within or excluded from their use area. Moreover, external and internal social changes can similarly add more complexity to the dynamics of local use. People's lives are characterized by a great

diversification of livelihoods, constantly switching habits and behaviours, and most important, their perception of space is different from western concepts (Abbott and Campbell, 2009). Similarly to what it was discussed over the concept of property in Chapter 6, local people see the space around them in terms of water, animals, history, river flow, etc. on the other hand, environmentalists, software developers and policy makers perceive it through its geographic coordinates limits (Brightman, 2012). Therefore, a spatially explicit map of a traditional territory is a snapshot of a fluid reality. The drawbacks of defining, geographically, traditional territories are constantly debated in the scientific literature. In Nicaragua, Larson, (2010), argues that, although local people living in the forest gained rights to establish themselves on their traditional territory, the community land boundaries have mostly been defined by political negotiations. In the Amazon, Brightman et al., (2016) suggest that the idea of ownership or territory may be attributed by many local groups to a spirit world rather than to humans, which brings even greater doubts about the physical representation of a traditional territory. Ultimately, local people's perception of their territory is based on the combination of social ties and ecological drivers that together continually create a new reality at any given time (Chapter 6).

To incorporate this flexible and dynamic pattern of use in SCP is not simple. Hitherto, there has been no way to do so. A kind of surrogate would be through the same probabilistic modification of Systematic Conservation Planning software that has been created to incorporate species mobility (Runge et al., 2014) or the uncertainties brought by global warming (Lechner et al., 2014). However, human habits do not always map well onto models created to explain wild species behaviour (Behnke et al., 2016). People's decisions over the use of natural resources are made up of multiple components involving social, economic and environmental as well as legal and historical dimensions. Moreover, multi-stakeholder SCP requires that local people agree with the solution sought (Kiatkoski Kim et al., 2016), which is not a condition applied to wild species. The current tools of Systematic Conservation Planning and their limitations seem very far from being able to incorporate livelihood uncertainty into mathematical models of fisheries living in freshwater systems, especially, in dynamic floodplains fisheries.

7.6 Conclusion

To conclude, systematic conservation planning is indeed a possible framework for sustainable development. However, the few case studies that implemented its results on the ground have failed to encompass important variables in social ecological systems, such as longitudinal connectivity, local people's well-being, etc. This may mask several weakness and limitations. The case study in the Western Border of the Pantanal is an important illustration of this caveat. This chapter has presented two different SCP scenarios, that were both tested with local people. Interestingly, even though the software showed a good model fit for both scenarios, local people would accept neither of them, the main reason being that fixed solutions do not map onto the flexible and dynamic local reality. Therefore, tools, such as systematic conservation planning, need to be better adapted to local realities. Otherwise it will continue to be a purely theoretical exercise in multi-stakeholder conservation planning. One solution may be towards flexible concepts of protected areas, in which different combinations of "take" and "no-take" areas are displayed based on the given flood pulse features and local people adaptive strategies. Although each case faces a unique combination of social and historical factors shaping their systems, such approaches could be replicated in other floodplains facing similar biophysical dynamism and comparable conflict over tenure and access.

Chapter 8 Overall discussion: sustainability of floodplain fisheries

Discussion as to the sustainability of common property regimes has been part of the development and conservation agenda since the second half of the 20th century (Berkes, 1985; Schlager and Ostrom, 1992). For more than 50 years, theories related to this have been used to underpin and justify actions intended to protect the environment and promote local development (Gordon, 1954; Moritz et al., 2015). However, there is still no agreement on the drivers and mechanisms that dictate sustainability of common property regimes (Adger and Luttrell, 2000; Sundar and Kittur, 2013), and recent publications have brought even more uncertainties, such as the newly-proposed concept of Managed Open Access (MOA) (Moritz et al., 2013; Xiao et al., 2015).

This debate is not purely academic: it has shaped and continues to shape policy and practice. Within this context, floodplain fisheries management stands out as a field that still requires considerable improvement. For many years, assessments of and conservation efforts in small-scale floodplain fisheries have simply replicated classical models derived, especially, from industrial marine practices in coastal areas (Cochrane 2011; Kolding and Van Zwieten 2014; Cooke et al. 2016). However, wetlands socio-ecological systems have unique features, in which the environment and local people tend to behave differently from other fisheries (Cooke et al., 2016; Kolding and Van Zwieten, 2014). The results of management interventions have been drastic, with many floodplains seeing suboptimal management practices and, most importantly, the rise of often misleading environmental narratives (Abbott and Campbell, 2009). This thesis has set out the ways that in the Western Border of the Pantanal practitioners have fallen into the same problem, however, it has also presented empirical evidence to deconstruct most of these claims. Throughout the preceding chapters, this thesis has shown that the accusation levelled at local people of being squatters is unfounded because there is evidence showing that fishers have been living in the region for at least 150 years (Chapter 4). The postulated link blaming the collapse of the tourist fishing industry on local people's overfishing is erroneous: variations in tourist numbers are not related to the quantity of fish in the system and local fishers' resource use practices are if anything likely to lead to a sustainable use of natural resources (0). Finally, the crisis narrative around

Settlement 1 area's eroding away and local people having to be relocated for their own good has no backing in scientific research (Chapter 6).

These kinds of narratives, however, are not particular to the Pantanal or floodplain fisheries. Political interests underpin most conservation conflicts. In fact, environmental narratives have long been used to impose the interests of powerful groups (Robbins, 2012, pp.13). Unsubstantiated claims of local people's overfishing, bushmeat overhunting or desertification, and the consequent setting up of management rules and legislation to regulate and avoid their assumed environmental impacts, is a theme continually reappearing around the developing world despite the frequent lack of scientific evidence (Abbott and Campbell 2009). Historically, misapplied narratives have often led to aggressive management interventions such as strong restrictions on the use of the natural resource or even physical displacement (Smith et al. 2005; Kittinger et al. 2013; Kolding and Van Zwieten 2014). Scientific knowledge offers one set of tools to test and deconstruct these narratives, giving empirical evidence to support or reject specific claims. For instance, claims of overgrazed rangelands triggering desertification in African and Central Asian drylands have been shown to be inconsistent or unfounded in a number of individual and in-depth studies (Homewood and Rodgers 1987; Homewood 2008). Amazonian rainforest communities have been accused of depleting Brazil nut trees through commercialization of its nuts, and this had been used to justify displacement of local people from their original areas (Fernandez et al., 2012; Peres et al., 2003). However, this assumed impact is contested by anthropologists showing that Brazil nut extractors help to spread the seed and promote conservation of a tree otherwise in decline due to the Pleistocene Megafauna extinction (Shepard-Jr and Ramirez 2011). Deconstructing such claims is a fundamental step towards better management of natural resources and promotion of local development (Neumann, 2011, 2010, 2009). This means understanding the resource use system and the way it maps both to ecosystem dynamics and to social organisation, and also understanding the legal frameworks from which different players draw their sense of legitimacy, and which can be invoked to rein in abuses of power or of resource extraction. However, in floodplain fisheries, the lack social and ecological understanding becomes a major barrier to deconstruct environmental

narratives (Adger and Luttrell 2000; Allan et al. 2005; Cooke et al. 2016; Dixon and Carrie 2016). The present study goes some way to address that gap. It also contributes to the emergent debate on property regimes and sustainability in floodplains (Moritz et al., 2013).

As presented in 0, fishers from Settlement 1 tend to not secure individual fishing sites, instead carrying out a rotational fishing system. These two features could place this socio-ecological system as a case of the newly-coined category of Managed Open Access (MOA) (Moritz et al., 2013), discussed in Chapter 1. MOA is argued to be the result of the interaction between movement and open access. According to its proponents this property regime arises in Lagon floodplain, Cameroon, because, on the one hand, pastoralists allow everyone to come and use the resource (open access), this leads users to adjust their distribution in relation to habitat quality so that each individual optimizes their own rate of acquisition of resources, leading to patterns of distribution proportional to resource availability (Moritz et al., 2015). The outcome is seen as a socio-ecological system in balance with resource availability (management) (Moritz et al., 2015; Xiao et al., 2015). Therefore, open access in this system is, in fact, a mechanism to manage the use of resource (management of open access) (Moritz et al., 2014a), as they present "*In a sense, management of open access is not an oxymoron because there are clear rules about who has access to the common-pool grazing resources (all pastoralists) and who can be excluded (no one).*" (Moritz et al., 2013, pp. 356). According to these authors, MOA would appears in other socio-ecological systems (Moritz et al., 2015. pp. 62). However, the findings in this research challenge the application of this theory for the Pantanal floodplain fisheries, and possibly other systems too, including pastoralists in Lagone floodplain, Camerron.

The first factor to be analysed of MAO is the non-presence of rules dictating access (open access). In the Pantanal, in Settlement 1, there were no rules imposed in the community to secure specific fishing grounds. However, on the other hand, each settlement has its own territory and local people constantly reinforce the presence of this customary rule. As presented in Chapter 4, many outsiders who have tried to move to Settlement 1 were expelled, and those authorized to do so was because they

created matrimonial links with someone from the Settlement. The same customary rule was presented in the findings of 0, which showed that only people from one of the three extended families can fish inside Settlement 1's territory. Therefore, the Pantanal emerges as very different from what is described by MOA, in which people would share use sites with everyone regardless their social ties (Moritz et al., 2013). Looking closely to Logone Floodplain system, it is possible to see that the postulated MOA is in fact more akin to a common property resource regime, with some underlying rules constant arising, such as access rights changing according to different social and institutional circumstances (the government intervention created the flooding regime of this wetland – Moritz et al., 2014a, and permission to access is constantly sought – Moritz et al., 2014b). Therefore, rules to access may not be salient to the observer, as may often be the case with CPRs, but the attempts to harass or exclude other users are nonetheless apparent (Thébaud, 1995)

Another central aspect uncovered in this thesis that challenge MOA was the importance of natural unfishable reserves for the sustainability in the Pantanal floodplain (blocked water bodies and river channels). These natural no-take areas are postulated to be the main reason why Yacaré caiman (*Caiman yacare*) never faced any real extinction threat in the Pantanal, even in the 1980s (Mourão et al., 2000), when at least 1 million animals were poached every year (David 1989). Some caimans (*C. yacare*) were living in microhabitats that could not be effectively accessed, allowing them to reproduce. (Mourão et al. 1996). Then, in the wet season, animals from hard-to-hunt refuges dispersed into hunted areas, recolonizing them and re-establishing a wider population. In the case of pastoralists from Lagone floodplain, Cameroon, a similar biophysical process happens. Scholte, (2007) studying the floodplain showed that two-thirds of the biomass is stored underground and the aboveground vegetation is inaccessible due to floods during at least four to six months of the year. An early exponent developing these theories was Noy-Meir, (1975), theorizing an hypothetical grazing system. He used graphical exercises to predict sustainability of grazing systems. Unlike earlier predator-prey models used to analyse plant-herbivore interactions, he added a new component to the system: the unexploitable reserve. It is possible that not all plant material capable of producing growth is also available for grazing, either because of some green material being

inaccessible (for example through seasonal flooding) or because of persistent residual growth stored in non-green underground reserve organs (roots, bulbs). The results showed that the presence of temporarily "ungrazeable" reserve biomass (residual growth) enables the vegetation to avoid extinction despite high herbivore grazing pressure, maintaining the sustainability of the system in face of high stocking rates. Thus, due to the presence of unexploitable natural reserves underpinning a continual process of regeneration of the resource, high densities of livestock can be kept by pastoralists, even to the point of temporary overgrazing in some resource patches, with no cumulative effect on the long-term sustainability of the system (Homewood, 1994; Homewood and Rodgers, 1988). Therefore, there is in fact strong evidence to suggest that the sustainability of the Logone Flooplain, other grazing systems and the Pantanal fisheries is underpinned by biophysical dynamics of the system not MOA.

The importance of appropriate adaptation to the natural changes and constraints goes beyond small-scale systems. In marine fisheries the presence of rotational harvesting, and the existence of inaccessible spots that could not be harvested, underpin sustainability (Hayden et al., 2015). Historically, shortage of fish resources were dealt with by moving along the coast and reducing fishing effort, allowing deep sea reserves to rebuild the biomass and export juveniles or adults to the coast (Pauly et al., 2002). However, government subsidies and technological advances have allowed vessels to harvest ocean deeps, operating in previously unexploitable areas and seasons (Hayden et al., 2015). Although some authors point to the lack of ownership over the ocean as the main cause of marine overfishing (attributing lack of sustainability to the open access regime), authoritative analysis identifies the failure of adaptation to the natural system through technology's accessing formerly unexploitable reserves as playing the most important role (Pauly et al., 2003). Therefore, the importance of unexploitable reserves has been shown to be part of many systems and is fundamental to population dynamics and evolution (Berryman and Hawkins, 2006). Fisheries in the Pantanal similarly incorporate no-take areas (unfishable reserves) created by biophysical landscape-level changes, blocking the river and water body entrances, protecting the whole floodplain from overfishing. This dynamic is likely to characterize other floodplain fisheries creating biodiversity

refuges and guaranteeing socio-ecological sustainability. Therefore, the sustainability of socio-ecological systems, most likely, are not sustainable because of the combination of open access and movement but as a classical common property regime with region-specific features (Ostrom, 2011), such as those found in the Pantanal: exclusion of access by outsiders while fostering free internal movement by residents alongside a patch dynamics of fauna refuges.

Other studies seeking empirical evidence found support not so much for MOA, but rather for a much more nuanced, historically complex situation. Behnke et al., (2016) showed that, although pastoralists in Turkmenistan could be partly seen as MOA, historical and economic factors both shape movement and reciprocity. They argue that different historical property regime layers and ongoing interactions need to be taken into account, because legal frameworks may change rapidly, leaving the imprint of historical regimes in actual practices, though with no formal recognition. In Turkmenistan, the imposition of a communist state onto a previously feudal system was followed by post-soviet conversion to a privatized system. The government owns all natural resources in the rangelands but half of all pastoralist livestock remains state property. The consequence is a plural legal system with state and pre-existing property institutions operating side by side: "*the resulting tenure system was in practice a combination of abstract territorial principles and historical contingency, an administrative system with a memory*" (Behnke et al., 2016, pp.116). In another example, Beitl (2015), shows that Ecuador's Cockle Fishers share an ethos of open access among themselves, however, they quickly display a sense of territory and common property regime when their area is threatened by shrimp farmers.This again suggests that some socio-ecological systems may appear to operate as a MOA. However, when historical, economic, ecological and anthropological factors are considered, they emerge as operating according to underlying Common Property Regime systems (Thébaud, 1995). The Pantanal case study shows the importance of a nuanced understanding of property regimes, with sustainability due to multiple specific interacting factors, rather than being specific outcome of any specific property regime category (Dietz et al., 2003)

The second important aspect encompassed in this thesis regarding management of common property regimes, especially floodplain fisheries, is the discussion on whether setting defined ownership and rights to exclude through land titling would promote sustainable development. Case studies from around the globe show how important it is to consider the combination of anthropological, economic and ecological perspectives to better understand the ways property regimes and resource use play out in reality and with respect to sustainability of socio-ecological systems. Many multidimensional property arrangements encompassing such multidisciplinary views are already formally implemented. An illustration is seen in the USA with conservation easements. These are legally recognized, voluntary, formal agreements between landowners and conservation organizations, in which the donor agrees to not use an area in exchange for a reduction of federal property tax; in practice the easements become private strictly protected areas, managed by an external NGO, with federal incentives (Kay, 2016). Today there are roughly 9 million hectares under this legal agreement of shared ownership in the USA (Mclaughlin, 2013). Although pursuing a different goal, this is in many ways comparable to what happens with sharecropping, in which private properties belonging to a primary owner are let out to a tenant who then negotiates a sharecropping deal (De Almeida and Buainain, 2016; Ofuoku, 2015). In both cases, the "bundle of rights" embodied in a specific property is formally disaggregated into separable rights shared out between different stakeholders: owner, tenant, conservation organization, etc. Another interesting if less equitable example is seen in Tanzania's Wildlife Management Areas, in which groups of villages are given title to pooled communal land, which is set-aside for conservation and tourism enterprise. However, the state owns any wildlife on that land; and also, owns any minerals under that land; at the same time villagers who are resident "owners" are excluded from using the resource they "own" (for instance, pastoralists are banned from grazing the set-aside area). The income generated from game hunting and mining mostly flows direct to state and enterprises and bypasses land 'owners' (Homewood et al., 2009; Noe, 2013; Noe and Kangalawe, 2015). Hence, although villages in principle own the land, they officially do not have rights over specific lucrative property layers. The multi-layered property arrangements are not always backed by legal rights; and, indeed, most of them are informal (as in Turkmenistan, Behnke et al., 2016). This is especially true for floodplain fisheries,

which depend on having a flexible use of the space in order to continually adapt to the environmental changes. In the case of the Western Border of the Pantanal no official attention has been paid to the different perspectives of property. The solutions sought to solve the conflict between Protected Areas and fishers have ignored the different layers of property regimes, an approach which has exacerbated the conflict. Where socio-ecological systems such as floodplain fisheries face unpredictable changes on the landscape, establishing defined ownership over the land and natural resources would always be only a very short term solution. Management practices seeking to tackle sustainable development have to consider this fluid and multi-layered characteristic of property systems. Solutions fixed in space will keep failing, regardless of their complexity and multi-stakeholder approach, as shown in Chapter 7.

Unfortunately, there is no placebo solution to tackle management of floodplain fisheries or even any common property regime. Each system is composed by uncountable layers of different variables (such as social, historical, ecological). Moreover, these layers are constantly morphing due to continual internal and external changes. Therefore, it will be important at any given time, to keep in view new combinations of enabling conditions for the sustainability of common property regimes. On the other hand, as presented in Chapter 4, even though socio-ecological systems are extremely complex and may rarely conform to dominant and commonly used property regime categories, there have to be clear rules and rights in order to protect and guarantee the wellbeing of powerless communities depending on natural resources. A possible solution, especially for floodplain fisheries, would be adaptable Protected Areas that go well beyond adaptive management. For instance, as presented in Chapter 7, SCP failed to fulfil local people's needs in the case study of the Western Border of the Pantanal, however, it may become a satisfying solution once it delivers a more flexible and dynamic output. The main idea of adaptable Protected Areas is to have systems which allow for continual renegotiation and change in the boundaries and limits of sustainable use and strict Protected Areas according to environmental and social changes, an approach which can be implemented through adaptive management. In the Pantanal, these could be merged with federal lands and areas of private properties that ranchers have set aside as

protected areas. While expensive in terms of negotiation and transaction costs, such systems would allow for social-ecological optimisation in unpredictable circumstances, as for many customary systems of tenure and access in African farming systems (Berry, 1993). This approach would, besides better adapt to socio-ecological changes, allow countries to easily met the Aichi Target and guarantee the protection of areas that are normally overlooked, while also sustaining traditional forms of resource use.

Using the already established Brazilian legislation on Protected Areas (SNUC law number 9985 from July 2000[22]), this could be done through the creation of Sustainable Development Reserves (Reserva de Desenvolvimento Sustentável – RDS). The National Park, local people territory, and all private protected areas in the Western Border of the Pantanal could become a RDS. The reason for choosing RDS out of the other 11 official categories is: first, it allows use of resource by local people; second, legally, local people have to play a role on the establishment of management practices; third, management of RDS are based on adaptive use, which means that areas can be closed off and open depending on the decision of the manager and local people, lastly, RDS allows overlapping layers of property regimes (for instance, some areas of the Private Protected Areas could continue to be private), which can minimize further conflicts regarding land tenure.

[22] http://www.planalto.gov.br/ccivil_03/leis/L9985.htm

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Appendix 1 Consent Form

Termo de Consentimento Livre e Esclarecido (T.C.L.E.)

Eu, ..., tendo sido convidado(a) a participar como voluntário(a) do estudo "Uso da abordagem Ambiental e Social para a promoção do Desenvolvimento Local na Borda Oeste do Pantanal" recebi do Sr. Rafael Morais Chiaravalloti, doutorando da Universidade Colégio de Londres, responsável por sua execução, as seguintes informações que me fizeram entender sem dificuldades e sem dúvidas os seguintes aspectos:

✍Que o estudo se destina a entender o uso de recursos naturais pelas comunidades tradicionais da Borda Oeste do Pantanal.

✍Que a importância deste estudo é a de encontrar uma solução para o conflito entre as comunidades e as áreas protegidas

✍Que os resultados que se desejam alcançar são os seguintes: fazer um histórico de ocupação das região pelas comunidades locais, encontrar um zoneamento que possa beneficiar todas as partes.

✍Que esse estudo começará em Junho de 2014 e terminará em Março 2015

✍Que o estudo será feito da seguinte maneira: através de entrevistas e mapeamento participativo

✍Que eu participarei das seguintes etapas:
[ ] Entrevistas
[ ] Mapeamento participativo

✍Que os incômodos que poderei sentir com a minha participação são os seguintes:
Redução da hora de trabalho para se dedicara a entrevista
Constrangimento em discutir temas conflituosos

✍Que os possíveis riscos à minha saúde física e mental são: A pesquisa não trará nenhum risco a saúda física ou mental.

✍Que os benefícios que deverei esperar com a minha participação, mesmo que não diretamente são: Redução do conflito com as Áreas Protegidos no entorno,

✍Que, sempre que desejar, serão fornecidos esclarecimentos sobre cada uma das etapas do estudo.

✍Que, a qualquer momento, eu poderei recusar a continuar participando do estudo e, também, que eu poderei retirar este meu consentimento, sem que isso me traga qualquer penalidade ou prejuízo.

✍Que as informações conseguidas através da minha participação não permitirão a identificação da minha pessoa, exceto aos responsáveis pelo estudo, e que a

divulgação das mencionadas informações só será feita entre os profissionais estudiosos do assunto.

- Que o estudo não acarretará nenhuma despesa para o participante da pesquisa.

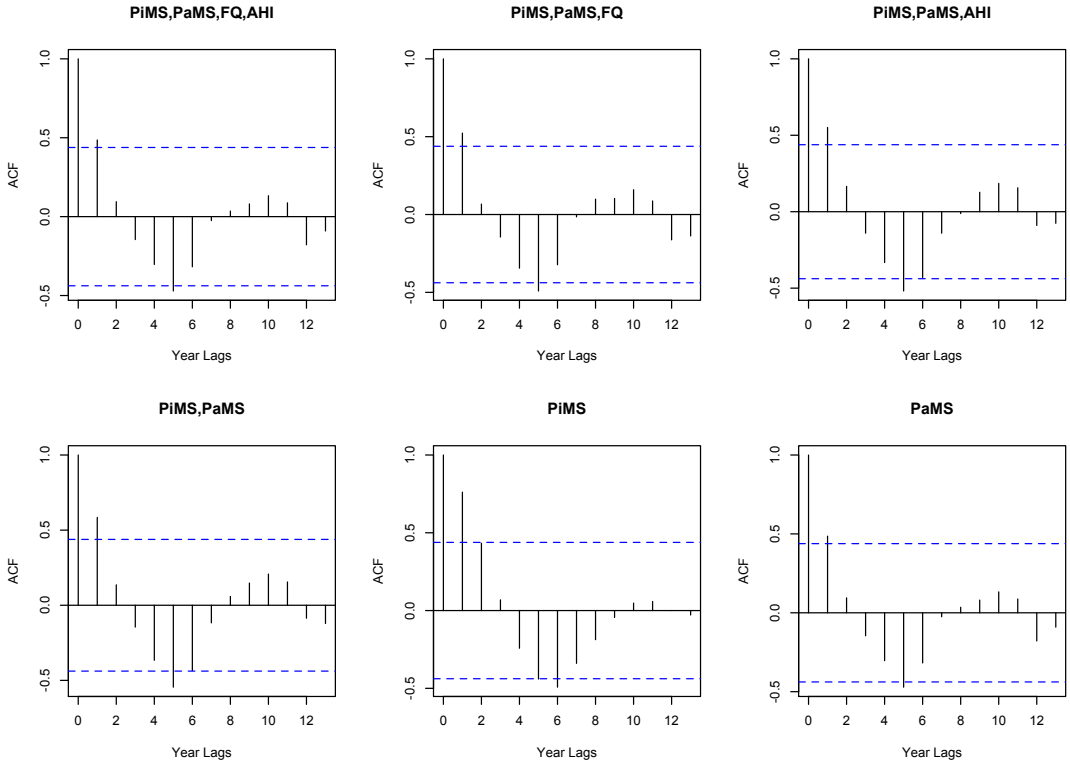
- Que eu receberei uma via do Termo de Consentimento Livre e Esclarecido.

Finalmente, tendo eu compreendido perfeitamente tudo o que me foi informado sobre a minha participação no mencionado estudo e estando consciente dos meus direitos, das minhas responsabilidades, dos riscos e dos benefícios que a minha participação implicam, concordo em dele participar e para isso eu DOU O MEU CONSENTIMENTO SEM QUE PARA ISSO EU TENHA SIDO FORÇADO OU OBRIGADO.

Corumbá,

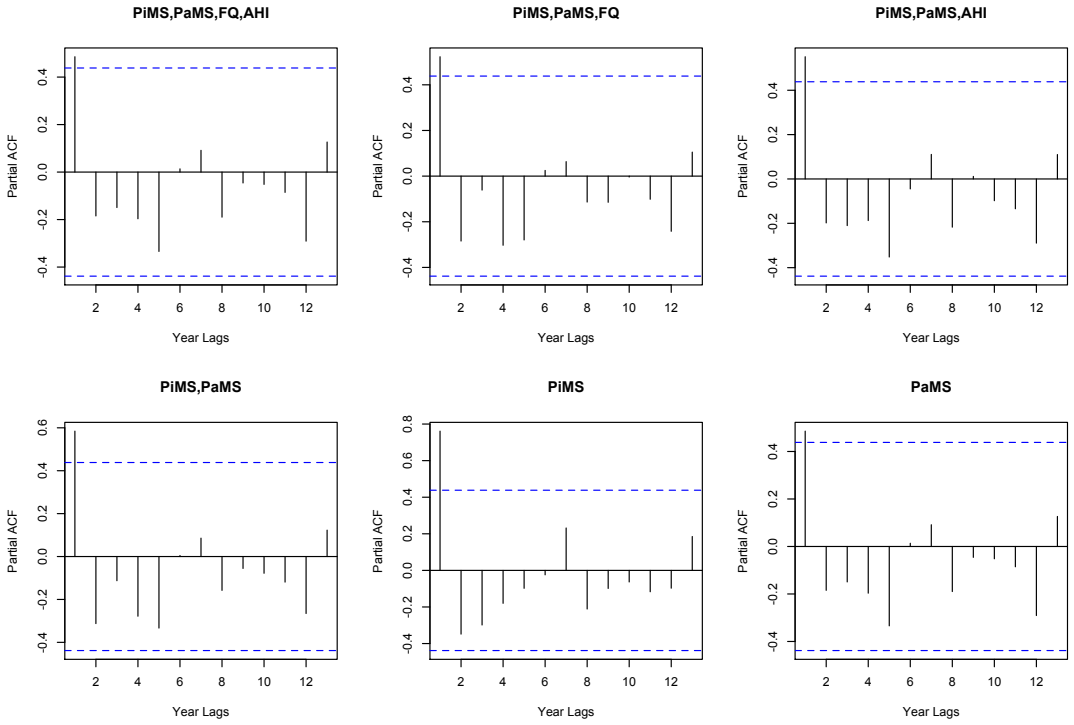
Assinatura ou impressão datiloscópica d(o,a) voluntári(o,a) ou responsável legal e rubricar as demais folhas	Nome e Assinatura do(s) responsável(eis) pelo estudo (Rubricar as demais páginas)

Appendix 2 Auto-correlation analysis of the residuals of tourist numbers time series regression



Auto-correlation analysis (ACF) of the residuals of models created. The first vertical line compares the year 1994 with itself, therefore, the correlation is 100%. Then, each subsequent vertical line compares the following year with the previous one. Values below the blue bar show no significant correlation. PiMS – Pintando Minimal Size; PaMS – Pacu Minimal Size; FQ – fishing quota; AHI – annual hydrological index.

Appendix 3 Partial auto-correlation analysis (PACF) of the residuals of tourist numbers time series regression



Partial auto-correlation analysis (Partial ACF) of all the residuals of all models created. The first vertical line compares the year 1994 with itself, therefore, the correlation is 100%. Then each subsequent vertical line compares the following year with the overall dataset. Values below the blue bar show no significant correlation. PiMS – Pintando Minimal Size; PaMS – Pacu Minimal Size; FQ – fishing quota; AHI – annual hydrological index.