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# Challenges for the Governance of Small-Scale Fisheries on the Brazil-Bolivia Transboundary Region

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### ABSTRACT

Developing institutional arrangements for supporting sustainable fisheries has been a critical challenge for the governance of common-pool resources, especially in transboundary regions. In this paper, we analyze the impact of governance arrangements on a small-scale fishery system on the Brazil-Bolivia border in the Amazon region. Data collection involved documental analysis, literature review and conduction of semi-structured interviews with fishers and environmental protection/regulatory agencies' staff. We present an exploratory qualitative analysis of the interactions between the fisherv system's attributes (biological, environmental, technical and governance), examining institutional arrangements among diverse stakeholders. Results reveal that the small-scale fishery characteristics and the relationships between resources and stakeholders has contributed to stock maintenance and overall sustainability of the fishery system. Nevertheless, we also found that the governance structure is fragile due to weak institutional arrangements within and between countries, resulting in increased vulnerability of the fishery system to imminent threats.

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### Introduction

Implementing sustainable governance processes for transboundary small-scale fisheries is challenging for both fishery managers and policymakers. The ecological sustainability of fish stocks and the fishery reflects the combination of biological and ecological conditions, user behavior (Lorenzen 2008), and system's governance arrangements (Burns and Stöhr 2011; Aguilera 2018). Governance in this context refers to "the decisionmaking structures, mechanisms, and administration apparatus which influence the

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operation of management systems" (Short and Winter 1999 p. 614). In addition, it also involves the interaction between diverse state and non-state actors (Schoon 2013; Suhardiman, Giordano, and Molle 2012).

The management of transboundary fisheries is difficult for several reasons. First, resource mobility makes it difficult to control, monitor and reinforce regulations (Schlager, Blomquist, and Tang 1994). Second, it generally entails structural differences in formal and informal institutions between two or more countries (Mostert 2003). The different jurisdictions and interests at the state or at international levels, make the implementation and enforcement of policies and rules for shared resources very complex (Mostert 2003; Maldonado et al. 2017). Some places are abandoned by the State, especially in developing countries such as in the Amazonian region, due to the size of the basin, difficulties in transportation, lack of communication, and fishing communities' remoteness (Ruffino 2016). These issues make the sustained use of the resource challenging and more vulnerable to threats from external drivers such as climate change and/or infrastructure development (Mostert 2003; Freitas, Reis, and Apel 2010; Salzáno 2011).

Despite the existence of documented experiences of transboundary resource (water and fish) governance around the world (Wolf 2002; Sadoff and Grey 2005; Sneddon and Fox 2006; Wolf 2007; Chen 2008; Dore, Lebel, and Molle 2012; Paisley and Henshaw 2013; Clement and Standish 2018; Song et al. 2017), this topic remains poorly understood within the Amazon basin (Barletta et al. 2010; Garrick, Edella Schlager, and Villamayor-Tomas 2016; Maldonado et al. 2017). An exception is the study by Braga, Varella, and Gonçalves (2011), who discussed the challenges of managing water across the Amazon basin, identifying opportunities for cooperation among the eight countries that share the region. In the Amazon, numerous riverine and indigenous communities share water resources and utilize small-scale fisheries as a source of income and animal protein (Ruffino 2014; Hallwass and Silvano 2016). Nevertheless, despite the importance of fisheries as a source of both income and food across the basin, there is a persisting lack of coordination of policies and actions for shared resource management between Amazon countries, exacerbating existing threats to fisheries systems sustainability (Barletta et al. 2010; Doria et al. 2012; Ruffino 2016; Maldonado et al. 2017).

Previous studies carried out in the Brazil-Bolivia border region revealed diverse problems related to local fisheries management. On the Brazilian side, a comparative analysis between traditional fisheries knowledge (TFK) and scientific data indicated that fishing closure rules, adopted during the reproductive season, were not effective for all the local commercial species, and that TFK was not considered in the elaboration of such rules (Doria et al. 2008). Other studies documented the lack of effective fishing regulations, resulting in conflicts and threatening fish stocks conservation (Doria and Brasil de Sousa 2011; Doria et al 2011; Lima and Doria 2015). Based on these studies, we suggest that, in addition to stock assessments and scientific studies, research aiming to inform transboundary fisheries sustainability needs to investigate institutions involved in fisheries governance; the relationships between environmental and socioeconomic variables; as well as the local and regional political scenarios that influence the dynamics of these systems.

The Institutional Analysis and Development (IAD) framework is a systematic method for governance analysis focusing on formal and/or informal institutional organization

and their relationships, which enables understanding of complex social situations and decision-making processes (Kiser and Ostrom 1982; Ostrom 1990). This framework has been adapted and applied to common-pool resource studies (Ostrom 2010), including fisheries research (e.g., Imperial and Yandle 2005; Lorenzen 2008; Basurto, Gelcich, and Ostrom, 2013; London et al. 2017; Yatim et al. 2018).

In this article, we present an exploratory analysis of the institutional and policy issues surrounding fisheries governance in an Amazonian transboundary region between Bolivia and Brazil, with a specific focus on the Mamoré River watershed. Our aim is to investigate how institutional arrangements might influence the sustainability of fishery systems in Amazonian transboundary regions. To do this, we characterize the fishery system (including biological, ecological, technical, social and institutional attributes and arrangements) on the Brazil-Bolivia border, and analyze relationships between resources, stakeholders and their institutions. We analyze existing policies and common property regime arrangements in this region through a systemic approach, using an adapted version of the IAD framework proposed by Lorenzen (2008). The framework assisted us in the investigation of nested interactions and relationships across the fishery system, as well as in the examination of the institutional landscape. The study is also guided by Ostrom's (1986;1990) institutional design principles, and Agrawal's (2001) and Glaser and Diele's (2004) propositions of conditions for sustainable fisheries. Finally, we discuss implications of our findings for improved participation of local fishers in the design and implementation of policies and management strategies across international borders.

# Study Region: The Mamoré Watershed in the Brazil-Bolivia Transboundary Region

The study area is located along the Mamoré River, and in the mouth of its tributary the Beni River, which has its headwaters in the Andean foothills of Bolivia and flows between the province of Beni in Bolivia and the state of Rondônia in Brazil (Figure 1).

In Bolivia, the studied area included the city of Guayaramerin (44,663 inhabitants) and Cachuela Esperanza (a riverine community of 900 inhabitants), both in the province of Beni. In Brazil, our study included the cities of Guajará-Mirim (41,656 inhabitants), and Nova Mamoré (22,546 inhabitants), both in the state of Rondônia (IBGE 2010). In both countries, the main regional economic activities include livestock (cattle, pigs, poultry and goats), agriculture (*cassava*, rice, beans, bananas, coffee and corn), timber and non-timber forest products (wood, *açaí*, latex, and *copaiba* oil), and fishing (Lima and Doria 2015). Small-scale fisheries are characterized by the use of traditional fishing techniques and small boats, with the local production directed to small markets. In 2011, the Fisher's Association of the Guajará-Mirim fish market had an average annual fish landing of 260 tons and 272 associated fishers. Nova Mamoré and Guayaramerim had smaller markets and fewer associated fishers (72 and 60 respectively); and Cachuela Esperanza had no fish market and few fishers (33).

### Methods

This is an exploratory analysis of the fishery system along the Brazil-Bolivia transboundary region in the Mamoré river. To frame our analysis, we used Lorenzen's proposed



Figure 1. Map of Brazil (left) with reference to the Madeira, Mamoré and Guaporé (shaded area) rivers basin and map of Guaporé and Mamoré rivers (right) together with the main fish markets.

framework (2008), who adapted the IAD framework from Ostrom (1990) and Oakerson (1992) to investigate fisheries systems. This adapted version of the IAD framework allows for a structured way to conduct a systemic analysis of fishery systems including biological, environmental, technical, and market variables as well as formal and/or informal institutions, considering the interactions among them. This enables a better understanding of complex social-ecological situations by breaking them down into manageable sets of information (Ostrom 1986; Lorenzen 2008).

Lorezen's work considers three components of a given fishery system: a) situational variables (i.e., the attributes of habitat and environment, fish population biology, fishing techniques, stakeholders, marketing, and institutional arrangements); b) patterns of interaction among these variables; and c) outcomes of these interactions, which are influenced by the situational variables via the physical-biological processes and stakeholders actions (see Methods SOM 1).

For each framework component, we selected variables and their descriptors to qualitatively characterize the fishery system considering the governance architecture elements from Burns and Stöhr (2011) (Table 1). To analyze the governance performance, we used the guidelines for fisheries management established by the Brazilian and Bolivian governments (IBAMA 1996; BOLIVIA 2015; see Methods SOM 02) and the criteria in Table 2.

We collected primary data through semi-structured interviews<sup>1</sup> conducted with randomly selected local fishers and with one official representative of fishing-related

Situational Variables	Descriptor	Indicators			
Habitat and	Environmental characteristics	River basin deforestation index <sup>a</sup>			
environmental attributes		Fishing environments and defined boundaries <sup>a</sup>			
		Relationship between ecosystem dynamic and fishery production <sup>c</sup>			
Biological attributes of the	Diversity and life cycle	Number of species, dominant species <sup>b</sup>			
fish population		Species characteristics: mobility <sup>a</sup>			
		Species total catch/year <sup>b</sup>			
Fishing technical attributes	Fishing characteristics	Fishing fleet characteristics <sup>b</sup>			
-	-	Fish storage; fishing gear <sup>b</sup>			
		Fishing effort <sup>b</sup>			
	Group	Size, defined boundaries, shared norms, social			
		capital, leadership <sup>c</sup>			
Stakeholders attributes	Fishery importance	Income from fishing / other activities <sup>b</sup>			
		Fish consumption			
Market attributes	Commercialization	Urban population <sup>a</sup>			
		Sale and storing <sup>b</sup>			
		Landing localities and number of fishers <sup>b</sup>			
		Characteristics and issues <sup>b</sup>			
Institutional arrangements	Social organizational	Main stakeholders; other affected stakeholders <sup>c</sup>			
	configuration	Authority and responsibility <sup>c</sup>			
		Expertise and knowledge requirements <sup>c</sup>			
	Rules and regulations used	Procedures for legitimate decision-making (formal			
	for the governance of the	and informal), national and binational			
	resource system	Existence of regional and binational fisheries forums with stakeholder participation <sup>c</sup>			
		Enforcement and management strategies <sup>c</sup>			
	Cognitive - normative	Conceptualization of the situation, issues			
	configuration	and solutions <sup>c</sup>			

Table 1. Situational variables with the corresponding descriptor and indicators.

Sources: <sup>a</sup>interviews; <sup>b</sup>fish monitoring; <sup>c</sup>secondary data (details on supplementary online materials - SOM).

organizations from the municipal, state and federal government (Table 3) (details on Methods SOM 03). The sample considered fishers registered in the fishing monitoring program of the Ichthyology and Fisheries Laboratory from the Federal University of Rondônia (UNIR), and the number of fishers registered in the fishing colony, including a minimum of 10% of the fishers registered for the bigger colonies, and 30% for the smaller colonies, with a lower number of fishers (Table 2).

Questions with closed answers (yes/no or multiple choice) were analyzed by the percentage of answers per group (fisher or organization). For the open answers, a content analysis was performed, from which the main topics and ideas were extracted. The answers were coded from the first five questionnaires, and additional codes were added when necessary. At the end of the initial analysis, the responses were reviewed and codes with similar topics were re-grouped. The highest percentage (equal or above 20% of the total, considering the 2–3 main responses) of responses by group (fishers or organization) were considered as representative of the group's perspective.

In addition, our trained collectors monitored daily commercial landings in Guajará-Mirim and Nova Mamoré fishing markets (Brazil) between April 2009 and March 2012<sup>2</sup>. It was not possible to collect this type of information for Bolivia. From the monitoring, we used data collected for total and specific catch (Kg), travel expenses, fishing trip duration (days), type of gear, environmental characteristics, fishing location, fleet type and number of fishers per trip (Methods SOM 03). We also compiled secondary data from governmental and non-governmental technical documents regarding legal

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enterna to analyze governance periornance	Table 2.	Criteria	to	analyze	governance	performance.
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Topics (Reference)	Criteria
Types of institutional arrangements (Imperial and Yandle 2005).	<ul> <li>Bureaucracy-based;</li> <li>market-based, community-based or;</li> </ul>
Ostrom's design principles (1990)	<ul> <li>co-management.</li> <li>clearly defined group boundaries;</li> <li>governing rules well matched to local needs</li> </ul>
	<ul> <li>most stakeholders affected by these rules participate in modifying the rules;</li> <li>rights of community to formulate their own rules are</li> </ul>
	<ul> <li>respected by authorities;</li> <li>system for monitoring the behavior of members in place, with the community members themselves undertaking this monitoring:</li> </ul>
	<ul> <li>use of a graduated system of sanction;</li> <li>community members have access to low-cost conflict resolution mechanisms.</li> </ul>
Agrawal's conditions of sustainability of the commons (2001)	<ul> <li>small size of a user group;</li> <li>location close to the resource;</li> <li>group members homogeneity;</li> <li>effective enforcement mechanisms;</li> <li>cooperation experience;</li> <li>strong leadership.</li> </ul>
Biological, economic and social sustainability indicators (Glaser and Diele 2004)	<ul> <li>composition landing stable over the years;</li> <li>basin deforestation index;</li> <li>catch per unit effort (CPUE) stable.</li> <li>gross income is higher than the local <i>per capita</i> income;</li> <li>the institutional arrangement does not endanger social peace.</li> </ul>

Table 3. Number of stakeholders	interviewed in each locality.
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			Fisher		
Localities	Total number of associated fishers	Interviewed fishers	Association president	Government Federal/State	agency Municipal
Brazil-Porto Velho				3	
Guajará Mirim	272	34	1	2	1
Nova Mamoré	72	23	1	2	1
Bolivia-Guayaramerin	60	18	1	1	2
Cachuela Esperanza	33	10	1	1	
Total		85	4	7	4

fishing regulations for both countries, when available. One important limitation of our study refers to the quality and availability of fisheries and institutional data, which is disproportionally better for Brazil in comparison to Bolivia.

## Results

### **Attributes Description**

## **Environmental Attributes and Habitat**

The Mamoré river basin and their resources are shared by Brazil and Bolivia. Its floodplain has an area of  $241.660 \text{ km}^2$  and includes a protected area of tropical forest with a low deforestation rate in 2010 (less than 25% in Brazil and 3% in Bolivia) (INPE 2010, Killeen et al. 2007). The hydrological regime influence on fish catches was evident in fish production records: the highest peaks occurred during the dry season (Lima and Doria 2015; Figure SOM 01), when fish concentrate in the main river channel, facilitating their capture. The main channel of the Mamoré river was the habitat preferred for fishing ( $\sim$ 60% of the fish landings), followed by lacustrine environments in the Mamoré flooded area. There are no defined borders for fishing areas.

### **Biological Attributes of Fish Populations**

Fishing in the study area is multi-species, but a small group of species was predominant in the landing data (presented in Table SOM 01). The most exploited species include the curimatã (*Prochilodus nigricans*), tambaqui (*Colossoma macropomum*), the branquinha-comum (*Potamorhina latior*), the jatuarana (*Brycon amazonicus*), and catfishes (e.g. *Pseudoplatystoma fasciatum*). These are middle-distance migratory species, representing highly mobile resources. The dominant species showed little variation in the landings recorded in the Guajará-Mirim region from 2003 to 2008 (Doria et al. 2012). We didn't find this information for Bolivian localities.

### **Technical Attributes of Fishing**

In all studied localities, the fishing fleet was mainly composed of small wooden canoes (average length: 5 m; motorized or not) and a few small boats (average length: 12 m; motor power:14 hp; carrying capacity: 3000 kg). Fishers used varied fishing gear: gillnets; trawls, long lines, and handlines. Most fishers (>70%) stored their catches in ice; only in Cachuela Esperanza fish was sold fresh because of lack of electricity. The effort employed per fishing expedition varied between 2 to 8 days and the monthly average of the catch per unit effort (CPUE) was  $21.6 \pm 7.97$  kg/fisherman\*day<sup>-1</sup> in Guajará-Mirim and  $6.5 \pm 2.46$  kg/fisherman\*day<sup>-1</sup> in Nova Mamoré. The Guajará-Mirim CPUE was not different from the CPUE recorded in 2004 ( $21 \pm 12$ ) by Doria and Brasil de Souza (2011), showing stability of fisheries in the last decade.

### Stakeholders' Attributes

Stakeholder groups included the 437 fishers registered in the fishers' association or colonies in each locality. However, previous studies show that this number could drop by half if we consider active fishers (Doria et al. 2012). Fishing was carried out along the border area (Mamoré river), in communal fishing areas, with high fisher mobility between the two countries.

Most of the family income (>50%) was derived from fishing, and it was complemented by other activities such as agriculture, livestock, and services (Table SOM 02). Of all fishers, 21% are above the poverty line comparing their average family income  $(U\$596 \pm 269 \text{ for Guajará-Mirim} \text{ and } U\$278 \pm 134 \text{ for Nova Mamoré})$  with the *per capita* official family income of US\$262 for Guajará-Mirim and US\$180 for Nova Mamoré (considering U\$1 = R\$1,8 in 2010) (IBGE 2010). Fish consumption was the main source of protein in the region (500 g fish/day *per capita*) and represents an important contribution to food security.

### Market Attributes

Guajará-Mirim has the highest number of inhabitants (41,656) and the main fish market has an average fish landing of 83.3 (s.d.:16.9) tons per year between 2009 and 2011 (SOM1). Nova Mamoré has 22,546 inhabitants with an average of 12.3 (s.d.:3.3) tons per year over the same time period (SOM1). There are no fishing records for Guayaramerin and Cachuela Esperanza.

Most of the fish landed (65%) in the study area was marketed directly to local middlemen who resold it in the Guajará-Mirim market. In Nova Mamoré, the fishing market was smaller and less structured, and most fishers sold directly to local consumers.

The fish caught by Bolivian fishers (90%) was sold mainly in Brazil, where they could get better prices. The sale was facilitated by Brazilian middlemen who bought the fish in Bolivia to resell in Brazil; or by Bolivian fishers landing their catches on the Brazilian side, to escape both countries' law enforcement. The fish marketing chain was limited at the regional level: the professional fishers usually sell to middlemen rather than to the marketers, who sell to final consumers.

Several conflicts were reported between the Brazilian and Bolivian fishers. Brazilian fishers mentioned the devaluation of the fish price because of the competition with fish caught by Bolivian fishers, which were sold in the same market at a lower price. Thus, Brazilians fishers ended up lowering the fish price. On the other hand, Bolivian fishers complained about the invasion of their valued fishing spots by Brazilian fishers, who possess better boats and fishing gear, allowing them to capture a greater amount of fish.

### Institutional Arrangements

### Social Organizational Configuration

According to the interviews, the groups involved in the fishing sector were Bolivian and Brazilian fishers and middlemen, amateur fishers, farmers, indigenous peoples, government employees, rubber tappers and other riverine people (Figure 2).

We identified eleven organizations involved in fisheries management. The most cited by respondents on the Brazilian side were the State Environmental Agency (SEDAM) and the Fishers Associations (>20% for each) (Table SOM 03). For the Bolivian localities, the most cited was the Fishers Association (Table SOM 03).

The organizations that represent Brazilian and Bolivian fishers were local Fishers Associations. In all localities, most of the fishers (>60%) considered that the associations' role was to help and support the fishers, mainly by monitoring the fishing activity and registering fishers individual landed catches. Especially in Guajará-Mirim, fishers agreed that their association works well at organizing and keeping annual records, organizing the closed fishing season<sup>3</sup>, sharing information on the current fisheries legislation, and supporting fishers in adverse situations, such as with fishing sanctions and fines.

For Brazilian fishers, environmental government agencies should be responsible for overseeing and enforcing regulations, as well as for monitoring boats and the fishing activity. Some mentioned that government officials' main occupation is law enforcement, and that they fail to do their other "designated work." They also mentioned that they should contribute more in assisting fishers and provide additional enforcement for



Figure 2. Diagram depicting the social organization of fisheries systems in the Brazil/Bolivia border.

fish caught in the Bolivian area and sold in Brazil. In both countries, fishers believed that their associations failed to do a good job in supervising and controlling the fishing spots. In addition, fishers believed that these agencies should perform other functions, including addressing the demands of the fishery sector in the region. In both countries, government employees recognized that the main fish-related activity performed by these institutions is law-enforcement, despite their other officially designated responsibilities, such as fisheries management.

The information required for fisheries management was collected by local fishers. In Brazil, the fishing associations record the composition and species biomass of fish landings, associated to the fisher's name with his/her registration number. This information is sent to SEDAM for evaluation and determination of compliance with the fishing rules. Since 2005, UNIR's Ichthyology and Fisheries Laboratory has assisted the colonies by collecting additional information (fishing date, fish stocks status, socio-economic data) and performing data analyses. In Bolivia, at the time of this study, official fishing records had not been completed yet, and only an estimate of the type of fish transportation issued by the Navy Captaincy was available<sup>4</sup>.

### Rules and Regulations Used to Manage the Resource System

The Brazilian government's main priorities, described in policy documents, are to keep fisheries exploitation within the ecological limits to maximize the socio-economic benefits from fishing to riverine communities, with fisheries management based on scientific information and users' knowledge (IBAMA 1997; Methods SOM 2; Table SOM 03).

Rule	Brazil	Bolivia
Closed Season	November 15 to March 15	November 1 to March 1
Prohibited species in closed period	Few species (<10) are prohibited.	All species are released with a fishing quota
Fisher's receive a monetary compensation	Yes	No
Catch limit per trip	No limit, except for Guaporé river	Established limit per trip
Limits for fishing gillnet	Length of mesh size: 80 mm	70 mm
Catch minimum size (cm) for:		
Araipama gigas	150	Does not exist
Pseudoplatystoma fasciatum	80	73
Pseudoplatystoma tigrinum	80	99
Colossoma macropomum	55	62
Piaractus brachypomus	Does not exist	53
Cichla monoculus	Does not exist	23,5
Plagioscion squamosissimus	Does not exist	28
Pellona flavipinis	Does not exist	52
Prochilodus nigricans	27	27
Brycon spp.	Does not exist	35
Oxidoras niger	Does not exist	62,5
Zungaro zungaro	Does not exist	3 Kg

Tuble 4. Companyon of the Diazinan and Donvian insteries registation in 2012	Table 4.	Comparison	of the	Brazilian	and	Bolivian	fisheries	legislation	in	2012
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Sources: Bolivia (1990); IBAMA (1996); Rondônia (2009).

Furthermore, it is expected that the strategic guidelines for fisheries management established by the Brazilian government (IBAMA 1997) would be applied and shared with neighboring countries. This is also true for Bolivia (Vice-Ministério de Desarrollo Rural y Agropecuario, BOLIVIA 2015; Methods SOM 2; Table SOM 03)<sup>5</sup>.

The fisheries laws applied in Brazil and Bolivia differ in many aspects (Table 4). For example, the fishing closed season ("*defeso*") occurs in different months. In Brazil, during this season, the fishers receive monetary compensation (minimum wage) for the loss of income from fishing, but the Bolivian fishers do not get a similar compensation.

Regarding management actions to protect fish stocks, most fishers reported following the: a) fish length limits (56% in Guajará-Mirim and 50% in Guayaramirin); b) government-imposed closed season (28% in Nova Mamoré; c) areas closed to fishing (20% in Nova Mamoré and Guajará-Mirim); and d) fishing restrictions during the reproductive period (80% of the Cachuela Esperanza fishers).

On the Brazilian side, fisheries rules are discussed by the Fishing Technical Group (*Câmara Técnica da Pesca*), constituted by five representatives (four government agencies<sup>6</sup> and one fisher's association). Most fishers (>85%) highlighted the absence of a formal forum for binational discussions. The same opinion is shared by government respondents (60%), who reported not having participated in meetings between Brazil and Bolivia. In Guajará-Mirim and Cachuela Esperanza, most fishers (65%) said that they are unaware of any past or current agreements between the two countries regarding fishing permits.

Fishers' associations from Brazil and Bolivia have organized, in 2012, a regional forum with fishers from both countries. In this event, they discussed their rights and responsibilities, including joint enforcement and the possibility of establishing a single fishing closure period. Representatives of fishing agencies in both countries were invited to this meeting. The president of the Guajará-Mirim Fishers Association mentioned a Brazil-Bolivia Binational Committee created in 2003 by governmental and non-governmental institutions, to seek solutions to the various conflicts in the border region, including fisheries. However, this Committee failed to implement the proposals discussed in the initial meeting and, for several reasons, including lack of funding and political support, the initiative was discontinued.

Until the 80s, there was an agreement between the two countries allowing the fishers to fish, buy ice and sell fish across borders. However, this agreement was canceled by the Brazilian agencies, as an attempt to stop drug trafficking. The president of the Guajará-Mirim Fishers' Association pointed out that this prohibition has led to illegal nocturnal landings to avoid law enforcement. Forty-three percent of the fishers in Nova Mamoré mentioned an agreement named "permission" which is an informal authorization provided by the military captaincy (locally named the "leopards") of the Bolivian ports, allowing Brazilian fishers to fish in Bolivian areas from 7 to 30 days depending on the payment of a fee.

### Cognitive - Normative Configuration

According to the interviewees, the main issues related to the fishery governance system in the Brazil-Bolivia border region are:

- a. absence of a common regulatory framework for exploitation and management of the transboundary fishery. Cross-border fishing happens mostly through the Brazilian fishers crossing to Bolivian areas where fishing is better, and by Bolivian fishers crossing to the Brazilian side to sell fish.
- b. conflicts among fishers from both countries. The majority of fishers (>80%) and government officers (>67%) mentioned the existence of conflicts between fishers from Brazil and Bolivia. According to them, the main conflict is the capture and marketing of fish by illegal fishers ("pirates"), who lack professional affiliation with official regulating agencies and do not pay the fees required for professional fishers. Also, the *pirates* often sell fish below the market price and use prohibited fishing gear. Below, we illustrate the problem of illegal fishers identified for the studied transboundary Brazil-Bolivia region:

Bolivian fishers should pay a fee to sell fish in Brazil. (GM fisher)

Bolivian fishers hinder our sale because they sell fish below the price. (GM fisher)

There is little monitoring and enforcement, allowing pirate fishers to do what they want. (Nova Mamoré - NM fisher)

The pirate fishers do not have expenses with the colony, registration or transportation fee, selling the fish for a lower price and hindering the commercialization (NM fisher)

a. Conflict related to "ownership" of fishing areas by farmers and indigenous communities. In Brazil, this was mentioned by 17.7% in Guajará-Mirim and 14.7% in Nova Mamoré. In Bolivia, 37% for Guayaramerin and 26.3% Cachuela Esperanza. These actors don't allow the entrance of fishers in their territories, decreasing access to fishing areas previously exploited:

Farmers do not let us enter in the lakes located in their land to fish; when they see us, they cut the nets and we lose all the fishing material (GM fisher)

The fishermen have to hide to get into the farmers' areas (GM fisher)

## Patterns of Interactions and Outcomes

The characteristics of the fishery system (stakeholders, market, fish population, environmental and technical attributes), as well as the patterns of interaction and outcomes, provide evidence of elements that allow for the system's sustainability, allowing for the maintenance of a balance between economic benefits and costs, biological production and conservation of the biological resource (Figure 3). Some elements that might contribute to the system's sustainability, in this case, include stakeholders' characteristics and institutional arrangements, such as people–place connections; social networks; and community action in response to influences (even when they cannot influence the rules). On the other hand, there are negative aspects related to the institutional arrangements, the cross-border conflicts, and market characteristics, that make the system vulnerable. The governance principles indicating the sustainability of the system proposed by Ostrom (1990) were not found in the studied system (Figure 3).

### Discussion

The analysis of the conditions for sustainable management of common-pool resources in the Brazil-Bolivia transboundary fishery revealed key positive group characteristics such as small group size; sharing of informal and formal rules; social capital; leadership; and interdependence among the group members (Ostrom 1990; Agrawal 2001). These characteristics led the Brazilian and Bolivian communities to act jointly even in the absence of well-defined boundaries since fishing lacks a strictly defined property rights regime.

The fishers' practices and the regional environmental characteristics appear to support the high diversity and abundance of fish and the socio-economic profile of the fisheries activity (Castello et al. 2009; Silvano et al. 2014; Campos-Silva and Peres 2016). On the other hand, some aspects of the governance system make effective resource management challenging. These include a top-down regulatory system, lack of welldefined boundaries and jurisdictions, and resource mobility. In contrast, the localities showed overlap between user group residential area and resource location; high dependence by group members on the resource system; and relative fairness in the allocation of benefits from common resources. The Bolivian fisher capture smaller volumes than Brazilian fisher (related to less investments in material and equipment; Carvajal personal observation), which results in differences in local fishing, perceptions and conflicts.

Overall, there are problems with the institutional arrangements considering Ostrom's design principles such as top-down rules that do not match local needs and a lack of stakeholders' participation in designing these rules (Ostrom 2009). The incompatibility of the cross-border laws and the absence of coordination between the countries allow users to behave in ways that could lead to fishery over-exploitation and exacerbation of existing conflicts (Berkes and Ross 2013). Among the studied communities, official rules are not followed completely neither are adapted by the users, which can affect institutional sustainability (Ostrom 2009).

This institutional arrangement shows characteristics of the "bureaucracy-based arrangements" type, as property rights to fish are held by the government on behalf of the public and the focus is on developing regulations that maintain fish stocks at



**Figure 3.** Patterns of interactions and outcomes observed in the Brazil-Bolivia Fisheries System. Highlighted in bold are the shared attributes with the sustainability principles described by Agrawal (2001), and in italics\* with the governance principles described by Ostrom (1990).

sustainable levels (Imperial and Yandle 2005). Although this performance may be portrayed as an "efficiency system" that in theory would maintain fish stocks at desired levels (Imperial and Yandle 2005, p 55), the fishery governance system is weak because government institutions lack personnel, physical structure, and financial support to enforce rules. Also, many agencies have different and often conflicting approaches and objectives. Despite the guidelines established by the Environmental Brazilian Agency (IBAMA 1997), the state agencies responsible for fisheries management in the region do not act to the full extent of their official capacity and fail to implement the recommended sustainable fisheries practices. Besides, they do not promote the engagement of fishers and largely disregard scientific information in the fishery governance (Doria et al. 2011a). On the other hand, the fishers are self-organized and share informal rules that regulate the fisheries system and the market.

Resource users can self-organize toward sustainable resource governance developing informal rules to sustain their livelihoods (Basurto, Gelcich, and Ostrom, 2013). In our study, fishers showed an adapted commercial relationship as a response to market conditions in the border area, adjusting to get the best financial return. These arrangements show that user groups are active agents associated with the use and management of the fish resource - internally and externally - responding to environmental opportunities and within the ecological, social and economic limits (Castro and Mcgrath 2001).

The relationships between the institutional arrangements and the characteristics of the resource system can affect the harvest rates, the resource conservation, and the broader sustainability. The system *status quo* is maintained because of the people-place connections, the social networks, and community action in response to drivers (but not to the point of being able to alter official rules). In both countries, there is a lack of governmental engagement and reinforcement of rules to ensure environmental and socioeconomic sustainability. The high dependence on the small local markets makes the system fragile to external impacts and results in a lack of economic alternatives (Berkes and Ross 2013). According to Agrawal (2001), the low-level connections with external markets could be beneficial because of lower influences by fluctuations of external larger markets. For the studied communities, this feature can be both negative and positive. Negative because the communities are highly dependent on a regional but small market, which shows no upward trend, and any problems could drastically affect gains from fish sales. This market has been maintained over the past few years, even with low profitability. Even though most of the fishers are below the poverty line, fishing is the main source of income and protein in the region, increasing the system's fragility. On the other hand, the low market demand, large distances to big cities (Tregidgo et al. 2017) and the fisheries artisanal characteristics, can be positive since they don't promote increased exploitation, and are aligned with the maintenance of biological production and resource conservation.

In the Brazil-Bolivia border, the absence of common regulations for fishery resources, and the lack of communication among local stakeholders and authorities (Agrawal 2001) have led to local and regional fisheries conflicts. This scenario reinforces the importance of implementing and strengthening institutional structures for the conservation of transboundary shared resources (Schoon 2013; Dallimer and Strange 2015). The fragility of the government architecture in Amazonian border areas reveals weak institutional arrangements in and between the countries, making the system vulnerable. This fragility increases with the absence of state and/or non-official implementation of essential guidelines for sustainable fisheries. This corroborates Cleary's argument (1993) that the dynamics and inherent problems in the Amazon result from the absence of interventions. In this context, stakeholders' involvement and accountability in the decision-making and implementation of public policies could potentially help to address some of the Amazonian fisheries-related issues.

Despite the existence of internal elements contributing to the sustainability of the fishery activity in the region, governance structures are inadequate to guarantee fishing sustainability in the face of major threats such as 1) the increase of alien species introduction in the region, that has been endangering natural populations<sup>7</sup> (Carvajal-Valejos et al. 2011; Doria et al. 2020); and 2) the implementation of a complex of hydroelectric power plants across the Madeira basin<sup>8</sup>, which has caused a huge impact on the abundance of migratory fish (Vam Damme et al. 2019), and can intensify existing social conflicts.

### **Concluding Remarks**

This study summarizes the characteristics and implications of governance structures and mechanisms on the sustainability of fisheries systems across an Amazonian international border. Despite the fragility of the system, fishing has remained an important component of local communities' livelihoods. The versatility shown by fishers to self-organizing has guaranteed the maintenance of their fish-based livelihoods.

The fragile governance system in the Brazil-Bolivia Amazonian border area highlights the weak institutional arrangements existing in and between the countries, where the absence of the State makes the system even more vulnerable. Transboundary fisheries governance encompasses managing common-pool resources that are subject to independent, different and sometimes conflicting rules, in geographic areas where government agencies lack the necessary infrastructure (human, physical, financial) and continuity for enforcement and/or management to ensure resource sustainability and socio-economic development. This unique scenario involves uncertainty and conflicts and imposes an endogenous model on the system, where informal rules are developed by the fishers and local market.

Difficulties in the organization of the fishery sector are due to its complex legitimacy and internalization by the various user groups. A strategy to address this issue could be supporting the formation of forums at the state and municipal level, and the development of negotiations aimed at participatory decision-making and management of the fisheries sector. Enabling alliances between government authorities and local stakeholders is an important strategy for conflict resolution processes.

Implementing fisheries management practices in transboundary regions is challenging because it involves managing natural resources interdependently. An integrated fisheries management plan, articulating human needs, local economies, livelihoods, and development, planned and implemented through participatory decision-making processes, would be the best approach for the basin.

### Notes

- 1. The questionnaire used for interviews with fisher was approved by the Ethics Committee on Health Research Center CEP / NUSAU at the Federal University of Rondônia.
- Coordinated by the Laboratory of Ichthyology and Fisheries Federal University of Rondônia (UNIR), supported by Fishing Monitoring Program of the Santo Antônio Energia (SAE) and Energia Sustentável do Brasil.
- 3. *Defeso* in Portuguese.
- 4. Personal communication, Bolivian Navy Capitan from Guayaramirim.
- 5. It is important to emphasize that this work reflects the situation observed in the period of study (2012) and that Bolivia is currently implementing a new fishing law (Ley no.938, 3 de Mayo de 2017, Ley de Pesca Y Acuicultura sustainable; BOLIVIA 2013)
- 6. State and Federal Environmental Agency; Environmental Police; EMATER.
- 7. Carvajal et al. (2011) and Doria et al. (2020), report the effects of accidental introduction of piscivorous *Araipama gigas* in Mamoré river basin.
- 8. Santo Antônio and Jirau hydroelectric dams were implemented in Brazil in 2009 and 2010 respectively, with new Brazil-Bolivia bi-national dams planned (Doria et al. 2017).

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