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Seeds network and collective action for the restoration and conservation of Xingu River's springs (Mato Grosso, Brazil)

Rede de Sementes e ação coletiva para a restauração e a conservação das nascentes do rio Xingu (Mato Grosso, Brasil)

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ABSTRACT: In 2017, indigenous and non-indigenous people from the Xingu-Araguaia region met in Mato Grosso to celebrate 10 years of partnership and collective action of the Xingu Seeds Network (XSN). This network originated from the Campaign `Y Ikatu Xingu, a social phenomenon concerning conservation and protection of the Xingu spring region. The river basin of the Xingu headwaters, 17 million hectares, is the main focus of XSN and it has lost five million hectares of forests and cerrados, which were converted into grain monoculture fields, within a very short period of time. The impact on the quality of the river water caused an environmental and health problem for the indigenous peoples of the indigenous lands. XSN has promoted innovative technological alternatives for recovery of permanent preservation areas (PPAs) or gallery forest and income generation for small farmers and local communities. The goal of this study is to analyze the environmental governance in the Xingu basin, paying particular attention to institutional arrangements of the Xingu Seeds Network. This analysis is grounded on the theoretical-methodological framework, contained in the Institutional Analysis and Development (IAD), which offers tools for understanding the strengthening process of democratic institutions in the protection of common-pool resources. These are permanent preservation areas, in Brazilian case. This study provides a reflection of governance mechanisms, based on the "Commons Theory", in regions where socioeconomic dynamics drastically modify the tropical ecosystems that are fundamental to wildlife and human life.

Keywords: Amazon; Xingu River; environmental governance; restoration of permanent preservation areas; collective action.

RESUMO: Em 2017, indígenas e não indígenas das regiões do Xingu-Araguaia reuniram-se no Mato Grosso em comemoração aos 10 anos de parceria e ação coletiva da Rede de Sementes do Xingu (RSX). Esta Rede foi originada da Campanha `Y Ikatu Xingu, um fenômeno social ao redor da conservação e proteção da região das nascentes do Xingu. A bacia hidrográfica dos formadores do rio Xingu, com 17 milhões de hectares, é o principal foco de atuação da RSX e perdeu cinco milhões de hectares de florestas e cerrados, os quais foram convertidos em campos de monocultura de grãos, em um prazo muito curto de tempo. Os impactos na qualidade do rio ocasionaram problemas também na saúde dos povos das terras indígenas. A RSX promoveu alternativas tecnológicas inovadoras para a recuperação de áreas de preservação permanente e geração de renda para os pequenos agricultores e comunidades locais. O objetivo deste artigo é analisar a governança ambiental na bacia do Xingu, com atenção especial à estrutura institucional da Rede de Sementes do Xingu. A presente análise será baseada no arcabouço teórico-metodológico contido na Análise Institucional e Desenvolvimento, o qual oferece ferramentas para a compreensão do processo de fortalecimento de instituições democráticas na proteção dos recursos comuns. Estes são as áreas de preservação permanente, no caso brasileiro. Este estudo propicia uma reflexão dos mecanismos de governança, com base na "Teoria dos Comuns", em regiões onde as dinâmicas socioeconômicas modificam de forma drástica os ecossistemas tropicais que são fundamentais para a vida silvestre e humana.

Palavras-chave: Amazônia; Rio Xingu; governança ambiental; restauração de áreas de preservação permanente; ação coletiva.

1. Introduction

There is an anthological academic question around the "commons dilemma" (Ostrom, 1990) bordering a vast field of research in political ecology (Ciriacy-Wantrup & Bishop, 1975; Tucker, 2010), which is introduced in this work by the following question: Are common benefits, such as access to and use of water, the driving force to mobilize individuals or is it heterogeneous groups that collectively act on behalf of environmental conservation (or common goods)?

Common resources may be the waters and springs of rivers and vegetation that protect them, which are goods of common interest. In the Federal Constitution of Brazil, they must be protected by public power and citizens (Benjamin, 1997). The benefit of clean and healthy water should be accessible to all citizens and, ultimately, the state determines the legal duty, obligations and sanctions for its protection and balanced use. Theoretically, the common resources are shared resources and if one individual subtracts it (use) or removes it (extract) from a natural or artificial system, it will affect other users, by reducing benefits or welfare of them (Ostrom *et al*., 1997), and it might compromise the capacity of resource renewal. The second characteristic is the difficulty and high cost of establishing institutions that control or exclude new users from the management or access to common resources (Ciriacy-Wantrup & Bishop, 1975).

A theoretical and methodological path to answer this question, therefore, is to investigate and understand the evolution and role of institutions in the conservation of common resources (Tucker, 2010). Institutions contribute to structuring human actions and can be formal, such as rules, laws and constitutions, or informal, such as behaviors and codes of conduct in each family or human society (North, 1994). Some authors have demonstrated

regions in which the more robust and long-enduring the institutions, the greater the protection of natural resources and the well-being of the populations (Futemma *et al*., 2002; Brondízio *et al*., 2009). On the other hand, if institutions to govern commons are not present, are not monitored or are poorly defined, the result is open or unrestricted access to resources (Tucker, 2010). In this case, resources can be exploited until their complete degradation or extinction, as foreseen in the so-called "tragedy of the commons", by Hardin (1968). For this and other authors (Ciriacy-Wantrup & Bishop, 1975), the degradation of these resources is inevitable, unless there is some public or private control over the resources that limit their extraction.

The strengthening of institutions for the protection of common resources has also been the object of public land management and conservation policies, before the promulgation of the Brazilian 1988 Constitution. Researchers who dedicate themselves to the Amazon for decades (Nepstad *et al*., 2002; Soares-Filho *et al*., 2006; Batistella *et al*., 2008) demonstrated the importance of the creation of protected areas, by the government. However, failure of physical infrastructure for territorial control of public lands (Soares-Filho *et al*., 2006), absence of the state to properly propose and execute adequate policies aimed at conservation, and strong influence of the international marketing prices of commodities, public areas become vulnerable and open to illegal occupation and deforestation (Nepstad *et al*., 2002; Becker, 2005). Ensuring or avoiding degradation of common resources depends on both public power and active civil society who are directly engaged in the use of land and its control. It depends as well on the equilibrium of asymmetries of power among different social actors in terms of distribution, access and use of natural resources (Martinez-Alier & O'Connor, 1996).

Based on this theoretical debate and the Amazonian political-economic scenario, the present article addresses a case of environmental governance in the Xingu headwaters (Brazil), comprising 17 million hectares. The Xingu is a river of national importance, born in Mato Grosso state, crossing Pará state and reaching Amazon River. Hundreds of riparian indigenous and non-indigenous populations and regional economies depend largely upon the Xingu basin and its resources (Sanches & Villas-Bôas, 2008). The Xingu basin is also the home of the Parque Indígena do Xingu (Xingu Indigenous Park) or simply PIX (Villas Bôas & Villas Bôas, 1994).

The Xingu headwaters belong to one of the priority regions for biodiversity conservation, climatic stability and water production of the national territory, among other aspects (Nepstad *et al*., 2002; Soares Filho *et al*., 2006). The governance arrangement to be discussed refers to the Xingu Seed Network, originated from a process of social mobilization: the Campaign 'Y Ikatu Xingu (Sanches & Villas-Bôas, 2008; Malta Campos Filho *et al*., 2014). Through this campaign, indigenous leaders claimed and pointed out the increasing degradation of the water quality of the Xingu river and the loss of forests and their resources. 'Y Ikatu Xingu mobilized 340 representatives from different municipalities of Mato Grosso to discuss the future of the Xingu and the elaboration of an agreement for a common mission: the protection and recovery of springs and riparian forests, vital for the 16 indigenous peoples, the inhabitants of the region and for agricultural production (ISA, 2018).

The goal of this study is to analyze if the Xingu Seed Network (XSN) is an effective case of environmental governance and if it has contributed to the success of the 'Y Ikatu Xingu Campaign's mission to protect and recover common resources. In order to analyze the effectiveness or success of XSN's actions, the institutional arrangements established since its incorporation were considered, based on the theoretical-methodological framework of Institutional Analysis and Development, best known as IAD. This framework is central to studies in political and economic sciences on the behavior of individuals and the regularities of human actions (Ostrom, 2011), whose elements were detailed in the methods and in the systematic description of XSN.

Elinor Ostrom (1990; 2011), awarded the 2009 Nobel in Economic Sciences, sought to respond in what way individuals are motivated to participate in collective actions in the conservation of common resources, proposing the IAD in the analysis of institutions. The IAD can incorporate the various realities to study the impacts of human actions - socio-economic, cultural, and political - in solving environmental and social problems in the Amazon (Dietz *et al*., 2003). It is intended, in the future, to follow this analysis within the comparative study of the XSN with other cases of environmental governance of the Amazon, or in regions where the institutions are not yet firmly established (Little, 2001) to balance the expansion of the agricultural frontier with the changes in the landscape (Brando *et al*., 2013).

Hence, solutions to common dilemmas can encompass studies of the ways in which civil society and its institutions are monitored and organized in decision-making processes - political, economic and social - in the protection of territories and common goods (Dietz *et al*., 2003; Soares Filho *et al*., 2006; Ostrom, 2010).

1.1. Political ecology of the Amazon and the common resources: the Xingu case.

Thus, this paper presents a case of the Xingu Seed Network as the environmental governance model for management and conservation of the Xingu River basin. Although it is among one of the regions of high importance for climate stability (Soares Filho *et al*., 2006), Xingu springs have lost more than a third of their natural areas in five decades (Sanches & Villas-Bôas, 2008). These scenario was scrutinized as one of the key questions by political ecology in the 1970s, the destruction of the Amazonian forest and its linkage with the liberal economic model of agricultural modernization (Schmink & Wood, 1992), and the industrial boom of the US and European countries (Moran, 1993; Pedlowski *et al*., 1999; Becker, 2005). This model was financed by loans at very high interest rates, which led, along with the advance of the occupation of the Amazon, to industrialization and (accelerated) economic growth in the South and Southeast of Brazil and in countries of the so called "Third World" (Schmink & Wood, 1992; Batistella *et al*., 2008). Lands, forests and minerals became the target of logging, mining and other commodities from the states of Mato Grosso, Rondônia and Pará, serving as part of the payment of those loans (Oliveira, 1997; Pedlowski *et al*., 1999; Becker, 2005; Barrozo, 2008). Thus, landscapes and its resources of importance to indigenous populations have been exhausted outside the demarcated lands and gave way to monoculture commodity in the global

market: rice, meat, corn and soybeans. However, it is worrying, to this day, that this dynamic of land use will increasingly press for protected areas (Little, 2001; Brondízio *et al*., 2009).

If the rate of deforestation in the region of the Xingu headwaters continues, it is estimated that the loss of forest areas can reach 80% of forests by 2050 (Nepstad *et al*., 2002; Soares Filho *et al*., 2006), taking into account current environmental legislation and the fact that indigenous lands protect more than a quarter of the basin. A more inclusive mode of "governance" can minimize these losses with the legitimization by the public power of local participatory processes (Soares Filho *et al*., 2006). Thus, the effectiveness of environmental policies in the Amazon biome is not solely restricted to the number and extent of legally protected areas, nor to the isolated action of the State (Nepstad *et al*., 2002). In addition, local dynamics respond differently and not always passively to the "market factors" (Batistella *et al*., 2008).

The focus is on governance and participatory management, or co-management, and on institutional arrangements at different scales (Nepstad *et al*., 2002; Brondízio *et al*., 2009). The governance term here designates a collective decision-making process, in order to promote mutual benefits or the sustainability of the system, to avoid problems that affect the welfare of social groups (Ostrom, 1990). Decision processes can take place through formal decision-making bodies, such as ethics committees, protected area management councils, union boards, public agencies (Davoudi *et al*., 2008), or through informal arrangements, such as neighborhood associations. However, it is important to include the territory and the particularities of each region in the analysis, according to Davoudi *et al*. (2008, p. 351):

> "governance is a process in which social agents (public and private) are able to build an organizational consensus between different groups, to define common objectives and tasks and to agree on each partner's contribution to a common vision for the future of their territories".

2. Methods

2.1. The study area and the phenomenon of the 'Y Ikatu Xingu Campaign, in 2004.

The Xingu headwaters region, study area, covers a size of 17 million hectares in northeast Mato Grosso (Figure 1) and it encompasses the headwaters of rivers of the Xingu basin: the Ronuro and Culuene rivers (Brasil Netto, 1964). The Xingu basin is also a home of indigenous peoples territories of the Upper Xingu, who designate a multi-ethnic political-territorial organization, currently composed of nine groups representing the Tupi, Arawak and Karib languages (Melatti, 2019). These indigenous peoples are dwellers of the PIX (Parque Indígena do Xingu). The headwaters area of the Xingu basin is also home of others indigenous groups, such as the Jê (Villas Bôas & Villas Bôas, 1994; ISA, 2018). The floodplains encompass the tributary rivers such as Manitsauá-Miçu, Rio Mosquito (or Huaiá-Miçu), Auaiá-Miçu and Suiá-Miçu. Thus, the region is an important source of common resources and goods of public interest, such as the permanent preservation areas (gallery forest), or PPAs (Benjamin, 1997; Sanches *et al*., 2012).

The focus of this study on governance is important due to conservation of biodiversity (ISA, 2018) and Xingu region's strategic position in natio-

nal geopolitics, situated between the main national highways connecting the Amazon with the rest of Brazil: the Transamazon Highway, Cuiabá-Santarém and BR-158 national roads (Nepstad *et al*., 2002). Until the 1950s, the northern region of Mato Grosso was virtually unknown to national society (Oliveira, 1997). Just over 50 years later, the region was the target of the most profound transformations in the landscape due to its definitive economic integration into the national economy and the international commodities market (Barrozo, 2008).

These changes are the results of economic incentives of the national integration policy, of opening highways and colonization projects. The expeditions of the Central Brazil Foundation, a public body created by Decree-Law, began this process in loco, in the 1940s. Led by brothers Villas Bôas, indigenists and members of Roncador Xingu's expedition, politicians and scientists discovered the basins of the rivers Araguaia and Xingu, long after the expedition of von Steinen in the nineteenth century . After that, the indigenous inhabitants were official recognized by the Brazilian State with the creation of the PIX, in the 1960s, and the lands around it were incorporated into private colonization projects (Villas Bôas & Villas Bôas, 1994).

After the 1990s, Xingu River headwaters were marked by a new territorial dynamic: soybean

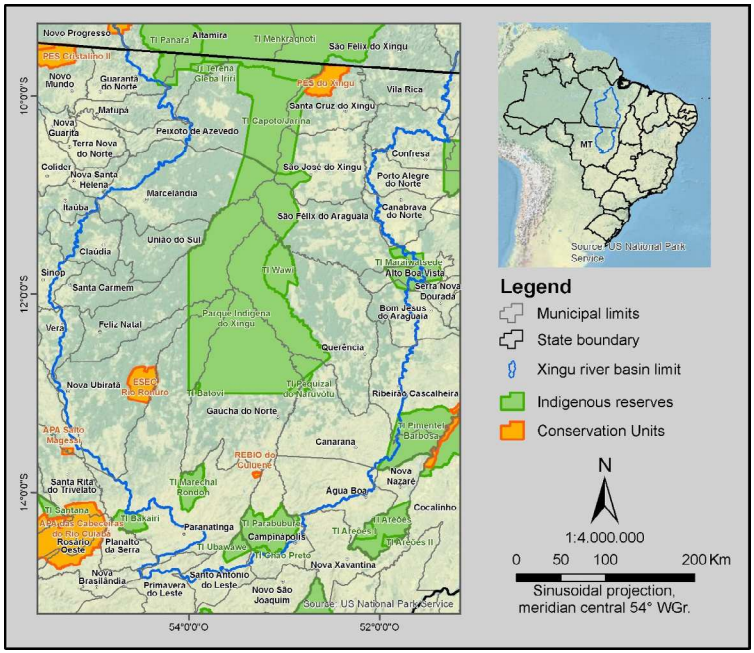

FIGURE 1 – Location of the Xingu River headwaters in Brazil and in the state of Mato Grosso.
SOURCE: Adapted from Sanches (2015). Sources: Municipal limits and State boundary: IBGE/DGC. Cartographic Base Continuing to the millionth – BCIM: version 3.0. Rio de Janeiro, 2010; Xingu river basin limit: ISA, 2009; Indigenous reserves and Conservation Units: ISA, 2012; Background image: World Physical Map. Available in: http://www.arcgis.com/home/item.html?id=c4ec722a1cd34cf0a23904aadf8923a0

and agribusiness in several municipalities around PIX. This agribusiness trend has led to the drastic transformations in the landscape and socioeconomics of the region, such as the case of Querência municipality (Figure 1), which depended economically on timber extraction and extensive livestock farming. Currently, this municipality is the regional leader among the largest soybean producers in Mato Grosso, and it has the highest rate of deforestation (Sanches *et al*., 2012). All of these changes affected the quality of the rivers and resulted in more than five million deforested hectares and 300,000 hectares of permanent preservation areas (gallery forest) degraded in the Xingu basin (Sanches & Villas-Bôas, 2008; Sanches *et al*., 2012).

Since 1994, these changes on the region have gained international visibility with the support of nongovernmental organizations such as the Rainforest Foundation and indigenous leaders like Raoni Kayapó (Sanches & Villas-Bôas, 2008). This social and political mobilization was reinforced by claims against increased deforestation of tropical forests and the demand for social participation in public policies, enactment of environmental laws to combat deforestation and illegal land appropriation, since the 1990s (Schmink & Wood, 1992; Nepstad *et al*., 2002; Brando *et al*., 2013). The Instituto Socioambiental – ISA , sought by some indigenous leaders of the PIX, initiated a process of regional political articulation with the non indigenous peoples of the Xingu (Brondízio *et al*., 2009).

After 10 years (2004), ISA met with 340 representatives of public and private organizations, ecclesiastical and indigenous grassroots associations, trade unions, researchers and official authorities in the city of Canarana (MT). The appeal of indigenous peoples materialized in the official Campaign 'Y Ikatu Xingu- or Xingu healthy water, in Kamaiurá language. The conservation dilemma about the future of the Xingu River was recognized publicly (Sanches *et al*., 2012). The Xingu headwaters region is, thus, where the three main interdependent actions of the Campaign occurred (Malta Campos Filho *et al*., 2014): (i) regeneration and restoration projects in areas of permanent preservation or PPA; (ii) the collection, sale and commercialization of native forest seeds through the Xingu Seed Network (XSN); and (iii), dissemination of knowledge and technologies to recover PPAs and improve seed marketing.

2.3. Institutional Analysis and Development (IAD) for the Xingu Seed Network case

The Xingu Seed Network - XSN, created in 2007, is a fundamental action for the Campaign's mission. It emerged because of the increasing interest in forest restoration and environmental compliance regarding the permanent protected areas and the use of native seeds to recover riparian forest (Durigan *et al*., 2013; Malta Campos Filho *et al*., 2014). In the XSN, ISA mediated the communication between these local agents (from small to large-scale farmers) and the overall network's agents, a complex task of being a bridge organization (Cash *et al*., 2006). This task is aimed at coordinating the actions of the Campaign, mediating the dialogues between indigenous and non-indigenous agents, fostering and carrying out technical and scientific studies to support projects in the field and public policies, raising financial resources and making information available to society (Brondízio *et al*., 2009). The XSN also includes researchers who dis-

cuss the viability of the agronomic techniques in the light of economic alternatives for forest restoration, family farmers, managers of large-scale farms, technicians from different institutions and indigenous people (Malta Campos Filho *et al*., 2014).

To analyze the actions of the XSN, we used the Institutional Analysis and Development (IAD) framework to understand the institutional arrangements in planning and management of this network. Ostrom (2011) proposed this theoretical-methodological framework to analyze the regularities between human actions, their interactions and the results, in cases of self-governance of commons. In the IAD (Figure 2), defining the problem, or the action-situation, is the first step of the analysis, because it allows the analyst to isolate the immediate structure that affects the process (object or phenomenon) of interest to the analyst. The action-situation represents the social spaces, where the individuals and representatives of organizations interact, exchange goods and services or solve problems, conflicts and decision making (Ostrom, 2011). The action-situation in the IAD framework is influenced or modified by external variables related to biophysical conditions, community attributes and rules-in-use. Among some variables that comprises it, there are: (i) the characteristics and numbers of staff, (ii) the specific positions to be filled by the participants, (iii) the set of allowable actions and its links with the results, (iv) the potential results, (v) the level of control each participant exercises over a decision, (vi) information available to participants on the structure of the action-situation, and (vii) costs and benefits-incentives and deterrents-assigned to actions and results. Rules-in-use define the relationships between social agents within a specific context, i.e. who should (by obligation) or should not (by prohibition), who can or cannot (by permission) exercise certain actions. From a set of interactions - which can be (i) information sharing among users, (ii) deliberative processes, (iii) conflicts between users, (iv) investment activities, and (v) lobbying activity - it is possible to predict potential results or to analyze existing ones with evaluation criteria (measures of efficiency, equity, or ecological or social indicators), according to Ostrom (2011).

Figure 2 represents the constituent elements of IAD framework: the external variables, the action-situation, the interactions, the results and the evaluation criteria.

This framework can be used in different spatial and temporal scales and to prescribe the potential results from changes in the action or in the variables that affect a certain action-situation. The evaluation of these results can contribute to the review of the actions, or to verify the influence of external factors on them. Each element is equivalent in terms of importance in the IAD. Thus, the planning of a particular action should not be limited to results, as a measure of "success" or "failure" of governance.

The data of each element of the IAD were obtained in field research from 2011 to 2015, participation in meetings and expeditions of the XSN, and visits to 20 areas of riparian forest restoration projects within the Suiá-Miçu basin (between 2016-2017). During fieldwork, 63 semi-structured interviews with representatives of organizations, rural producers and indigenous leaders, who were linked in the structuring of the actions of the Campaign, or are still in XSN were conducted (Sanches, 2015).

Another aspect, analyzed in the XSN, is the presence of design principles, which helps to explain the probability of robustness of institutions (Ostrom 1990, p. 58). There are eight principles

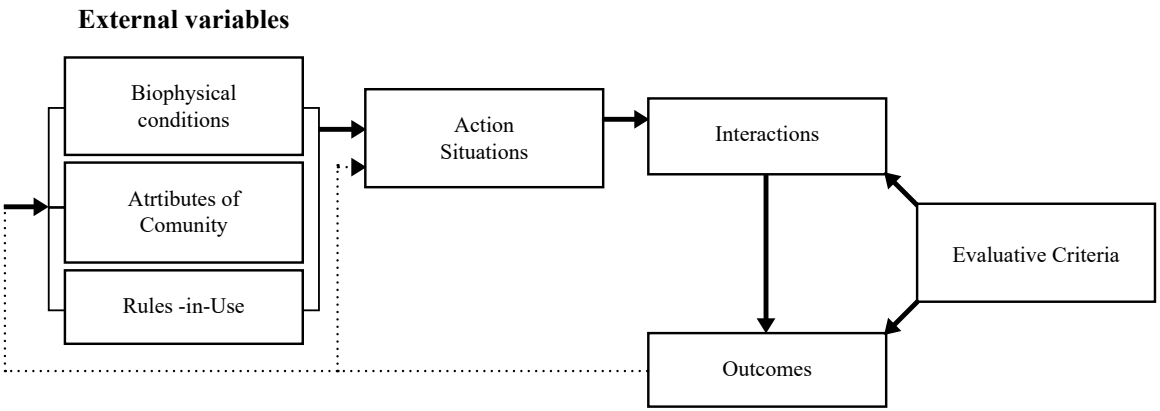

FIGURE 2 – Theoretical-methodological framework representation of Institutional Analysis and Development.
SOURCE: Adapted from Ostrom (2011, p. 10).

verified by Ostrom (2010), among more than 100 cases of self-governing systems and institutions with up to 100 years of existence, that have survived extreme environmental stress situations. Of these principles, three were disaggregated from the analyses performed by Cox *et al*. (2010), as in Table 1.

Thus, Ostrom (1990) found in these systems the principles that allow robust institutions, such as the presence of well-defined boundaries (P1A e P1B) and rules and duties agreed upon by the participants and recognized by a public authority (P7), as being fundamental to good governance and long-term success in conserving common-pool resources. The design principles can occur together or independently in each case (Dietz *et al*., 2003; Ostrom 2007; Cundill & Fabricius, 2010). Ostrom (1990) and Cox *et al*. (2010) demonstrated that the presence or absence of these principles may explain the success or failure of institutions; and principles 1A, 2 and 4 have had a greater effect (effect-size) between cases of governance success than the other principles.

3. Results and discussion

3.1. Who are the social agents of the Xingu Seed Network?

Since its creation in 2007, the XSN has become an important action linked to the 'Y Ikatu Xingu Campaign. During 10 years of work, it has developed projects and expanded its activities in the region. Practitioners and researchers tested the use of different techniques of forest restoration. They systematized the first results on direct planting of seeds in permanent preservation areas - PPAs, at a much lower cost compared to planting of seedlings (Durigan *et al*., 2013). In the so-called muvuca system, they tried to mix a certain quantity of forest seeds of different species, with forage species, in the no-tillage of degraded PPAs (Malta Campos Filho *et al*., 2014). This system was initially applied to rural settlement lots of the National Institute of Colonization and Agrarian Reform - INCRA and to large-scale farms of the Xingu basin. Positive results

promoted an increase in the interest and demand of rural producers in the region, through the technical assistance for the recovery of new PPAs and the legal adequacy of their lands (Malta Campos Filho *et al*., 2014).

Currently, the XSN consists of 450 collectors (individual or family) belonging to 16 Mato Grosso municipalities, 16 indigenous villages and 15 rural settlements, in and outside of the Xingu river basin . It is organized on basis of mutual support of its participants, regarding the supply and commercialization of forest seeds in restoration areas in riparian forests (Durigan *et al*., 2013). They are agents of different socio-cultural origins and relations with the land, some of them are linked to social and grassroots organizations. These organizations vary in their legal nature, their mission and objectives,

TABLE 1 – Principles of planning for robust institutions.

Principle	Description
1A. Clear defined boundaries (among users).	The rights of those [individuals or family groups] to extract or not certain resources must be clear and locally defined.
1B. Clear defined boundaries (of the system).	Limits of the system where the resources are inserted and will be directly used by certain communities.
2A. Congruence between appropriation and provision rules with local conditions.	The rules of appropriation establish restrictions of time, place, and technology and / or the number of resource units is related to local socio-environmental conditions.
2B. Congruence between rules of appropriation and provision.	The benefits acquired by the users are proportional to the amount of investments required [labor, materials or money], according to the rules of provision and appropriation.
3. Collective arrangements.	Most individuals affected by daily rules or operational ones are allowed to participate in drafting or changing rules.
4A. Monitoring by users.	Presence of individuals among users who are responsible for monitoring / auditing actions.
4B. Monitoring of resources.	Presence of individuals among resource users who are responsible for monitoring resource conditions.
5. Gradual sanctions.	Establishment of sanctions by the users themselves, in case of violations of the rules. Sanctions increase according to the type and frequency of offenses.
6. Mechanisms for conflict resolution.	Presence of fast and inexpensive means to resolve conflicts between users.
7. Minimal recognition of rights to organize.	The rights of users to define their rules and organize themselves are recognized by the government.
8. Nested enterprises.	Local institutions [rules of appropriation, provision, monitoring, sanction and conflict resolution mechanisms] are organized at multiple levels and scales.

SOURCE: Adapted from Ostrom (2010, p. 653) and Cox *et al*. (2010, p. 38).

their form of organization and their scope of action (Sanches, 2015; Urzedo *et al*., 2016).

Between 2004 and 2015, 88 organizations participated directly in the Campaign, with the majority (53.4%) belonging to nongovernmental organizations; 28.4% public, 15.9% private sector and only 2.3% informal organizations (Sanches, 2015), as the Mato-Grossense Forum on Environment and Development (Formad) , which worked with ISA in structuring the 'Y Ikatu Xingu Campaign. More than 60 percent of these organizations have been created since 1990; a decade marked by global debates on environmental sustainability politics. The majority of the organizations (84%) is of national origin with strong local or regional performance (66%), while 16% are of international origin.

Social agents played a variety of roles in structuring the network and occupied specific positions in relation to common resources. Table 2 synthesizes these aspects, position and function in the XSN, and the relation with the common resources (springs and riparian forests). A rural producer, for example, who had a obligation to adapt his property to the environmental law, could be both a seed collector and a participant in the XSN decisions. A bridge organization could make decisions and monitor results or perform varied functions within the XSN, such as participating in the collection, and being responsible for communication between participants and administrative staffs. A funding organization, in turn, could be one that would buy and sell seeds, but it did not participate in the decisions or even be a direct user of the sources of the Xingu.

Therefore, the social agents who participated in the XSN have assumed different skills and responsibilities - seed collectors, farmers, traders, buyers, technical assistants, financiers - and had different relationships with common resources (river water and gallery forest/PPA), as follows:

a) Users: are those who used it directly from the common resources, such as water for consumption, or irrigation destined to the agricultural production, practiced the extraction and the collection of seed from the forest or from their territories, and who were the direct responsible for the protection of the PPAs. They were those who made indirect use of resources, as in the case of buyers of native seeds from the Xingu Seed Network, or who lived outside the region of the Xingu headwaters.

b) Providers: are the facilitators, who provided the physical, financial or technical support for restoration activities in degraded PPAs. They also promoted communication among participants to ensure the flow of activities, for example, from obtaining, transporting, storing, marketing the seeds to their final destination. The providers were also responsible for enabling the means for monitoring the PPAs.

c) Producers: are the ones who built, repaired or led actions to the sustainability of the system. The producers were directly responsible for the assistance in the restoration of the riparian forests to guarantee the quality of the seeds and to contribute to the conservation of the sources of production, in the case of the seed suppliers.

In order to fulfill the mission of protection and recovery of the Xingu springs, the challenge is also to balance this socioeconomic heterogeneity among the XSN participants during decision-making processes, which may be intrinsically related to the success of any collective action aimed at the conservation of common resources. Thus, it is crucial to establish well-planned and agreed institutional

arrangements among social agents over time (Ostrom, 2007; Cundill & Fabricius, 2010).

Robust institutions stem from situations where rules have been well defined, between sufficiently informed participants (user, producer and provider). They increase the likelihood of transferring these institutions across generations (Ostrom, 1990). As it will be discussed below, the success of the pact for protection and conservation of the Xingu springs also depends on the institutional arrangements (taking into consideration the function and position) agreed over time and among the XSN participants, to accommodate this socio-economic and cultural heterogeneity and the relation (user, producer and provider) of common resources.

3.2. The institutional arrangements and results of the Xingu Seed Network

The XSN consists of a functional system, composed of several processes to meet the demands of a specific market, the ecological restoration sector for the environmental compliance of rural properties (Urzedo *et al*., 2016). In this characterization, a large number and the heterogeneity of participants of diverse socioeconomic realities and great physical distances are implicit. The proximity to the problem of the springs and the interest in environmental, economic and social benefit, resulting from the protection of these resources, sharing of technical and scientific knowledge, are some of the reasons why the XSN was able to accommodate such socio-cultural heterogeneity. In this sense, most of the participants are users, producers and providers. However, for other scholars, this heterogeneity may turn the decision-making process and monitoring of this system more complex (Chuenpagdee & Jentoft, 2009).

In order to organize the actions of such a heterogeneity of collaborators, the initial meetings of members of the Campaign organizations allowed them to define the technical and financial support to some pilot projects in the field and to reach an agreement about the tasks in order to guarantee the quality, the supply and the commercialization of native seeds, in accordance with current legislation (Malta Campos Filho *et al*., 2014).

A motivating factor in the formalization of the XSN was the voluntary desire and individual interest of rural producers to recover the PPA in their properties, and to disclose the common benefits with the protection of water resources and forests for agricultural production (Malta Campos Filho *et al*., 2014). Because of this motivation and because of the demand for seeds, the need for agreed planning and the definition of the rules in regard to the XSN (Urzedo *et al*., 2016), this network has guaranteed the production and supply of seeds in the restoration of PPAs. One of the direct results was the increase of areas with PPAs to be restored, but in the long-run these areas may suffer from external pressures, such as biophysical conditions (prolonged droughts and out-of-control forest fires), which affect seed production and, thus recovery of PPAs. Another factor

[5] Source: http://sementesdoxingu.org.br/site/wpcontent/uploads/2017/11/Boletim-Remento-de-Xingu-10-anos_edi%C3%A3o-julho- 2017.pdf. Access: Dec. 2017.

[6] Formad is a forum in the State of Mato Grosso, whose "objective is to democratize information and social-environmental debate and propose alternatives for sustainable development to improve conditions of population life ". Available at: http://www.formad.org.br/sobre-o-formad. Access: Jan. 2018.

TABLE 2 – Social agents in relation to common resources, in the position and function in the Xingu Seed Network (XSN).

Relation with resources*	Function in XSN	Position in XSN
User, producer and provider	Facilitate communication between members, provide physical and financial support.	Organization-bridge, third sector, occupies different positions. S/he participates in decisions and in monitoring results.
User, producer and provider	Responsible for the collection, processing or marketing of seeds. It also uses restoration in the PPAs, inside or outside the community.	Representative of the indigenous community. It depends on the river for physical and cultural survival. Collecting and marketing seeds, aid in physical and financial management. S/he participates in decisions and in monitoring results.
User, producer and provider	Responsible for the collection, processing or marketing of seeds. It also uses them in the restoration of PPAs inside or outside its lots or properties.	Smallholders or private producer. Depends on the river for subsistence and agricultural production. Collecting and marketing seeds, aid in physical and financial management. S/he participates in decisions and in monitoring results.
User and producer	Purchase or receive seeds from the network to use in restoring the PPAs in your lot or property.	Smallholders or private producer. Depends on the river for subsistence and agricultural production. S/he does not participate in decisions, but contributes to the monitoring of results
Provider	Promote activities with technical and financial support. Identify technical and financial criteria for monitoring.	Supporting organization. S/he may or may not participate in the decisions, but s/he contributes to the monitoring of the results.
Provider	Support or participate in the educational activities of the network, based on scientific researches and professional training, in addition to contributing to the quality of the seeds used.	Supporting organization (public sector). S/he may or may not participate in the decisions, but s/he contributes to the monitoring of the results (i.e. the quality of the seeds, extension of restored PPAs).
User	Purchase or use of XSN seeds for the restoration of PPAs in other regions.	Merchant or rural producer outside the region. S/he does not participate in decisions.

* Adapted from Ostrom (1990).

that influenced the results was changes in constitutional rules, the new Forest Law (year of 2012). One example was the reduction of the extension of PPA to be recovered, according to this new law. The economic incentives for the commercialization of cultivated seeds (e.g., agroforestry) also contributed to improve the results and can, along with the other factors, restrict or increase the actions of the XSN, influencing the decisions among its members.

In addition to the different roles and functions, the XSN's technical and financial management is based on a set of criteria (Table 3), defined by the members of the network at annual meetings that were taken place since 2007, for example: the management of seed collection, processing and marketing activities, the entry of new collectors, the exchange of seed varieties, the improvement of collection and handling techniques, transportation and the price of kilogram of marketable seeds, among others aspects. The regularity of these meetings, together with the interactions in the intermediate meetings and the collection expeditions, guarantee the basic

communication and exchange of information among collectors. These meetings allow them to make decisions and monitor the results of the XSN. The opportunity, therefore, of face-to-face meetings contributed to constant revision or modification of these criteria and contributed to improvement of the final results and governance in the long term (Ostrom, 2011).

Table 3 summarizes 11 of the 36 criteria in the first column. These criteria were agreed upon during the first XSN expedition in May 2014 and these criteria prescribe conditions for being a member of the XSN (Sanches, 2015). Based on these criteria, we identified and highlighted, for each one the categories, "sanction" (as non-compliance), "duties" (for collectors in the seed collection and marketing activity), and "monitoring" or "doing the homework", as an individual activity of taking care of the lots' PPAs or properties of the XSN members.

The everyday experiences and technological innovations were shared, and participants made decisions over the quantity and species of seeds that would be offered to the market. This aspect was also observed by Urzedo *et al*. (2016), who show how the operation of the XSN legitimizes decisions and generates shared responsibilities over final results and the entire production and marketing chain.

To the extent that results were monitored and technical information was made available and published, the XSN attracted new interests from collectors, researchers or buyers from this and other regions of Brazil. Table 4 illustrates some of these results, with the evolution of the number of collectors and the number and quantity of species traded and yield, between 2007-2016.

There was an increase in collectors (from 10 to 450) and the quantity of seeds offered (from five to 23 tons), totaling 153.5 tons traded. Table 4 also shows the amount of seeds processed within the XSN (extraction of fruit seeds of varying sizes, hard or soft coat, etc.), from 120 to 214 species, mostly from native forest. This whole seed marketing generated a total of two million reais (US$ 630,000) between 2007-2016, with a minimum income of R$ 9,000 (US$ 4,000) and a maximum income of R$ 414,000 (US$ 241,000) per year.

The income per collector per year varied according to the number of collectors and quantity of seeds traded, from US$ 229.00 to US$ 1160.00, in the period between 2007 and 2015 (Table 4). According to Malta Campos Filho *et al*. (2014), another direct impact of this commercialization was the recovery of five thousand hectares of degraded areas, mainly in the Xingu and Araguaia basins. This result, sought by the `Y Ikatu Xingu Campaign, is one of the aspects that deserve to be further deepened in the IAD analysis, since it implies changes in behaviors among collectors and also in the relation to the areas where the matrices are located for collection and which involves other agents.

3.3. Attributes of IAD to Xingu environmental governance analysis.

The elements described in the XSN can now be observed by the conceptual diagram of the IAD (Figure 3), in which the variables that interfere (modify or not) in the XSN are highlighted. In the future, an increase in demand for seeds and an increase in interest of being a XSN collector might affect and become a challenge to the sustainability of the XSN. The important aspect is to ensure that the criteria are fulfilled and that, at the same time, the entry of

TABLE 3 – Criteria to become and remain as a Xingu Seed Network seed collector.

	Criteria (rules in use)	Function in XSN	Position in XSN
1	**Preserve the riparian forests on own property or lot. Recover 0.5 ha /year in PPASs or legal degraded reserves.**	Cases of non-compliance need justification to the administrative board of XSN.	From the commission, formed by collectors: monitor once a year on each property and/or in the group.
	Those who have already recovered or have no degraded areas or land of their own should assist in the recovery of areas of collective use, donate seeds for restoration, or assist in the work of XSN.	The collector will remain seedless for one year and may be excluded from XSN.	
2	**Make responsible use of fire in own property or lot.**	Responsible for the collection, processing or marketing of seeds. It also uses restoration in the PPAs, inside or outside the community.	
3	**Ensure seed quality, identification and use of processing and storage techniques. Identify, collect and preserve seed matrices, leaving at least 30% of the fruits.**	Cases of non-compliance need justification to XSN's board of directors	From collector: register the flowering season, disseminate forms of collection and processing. Meetings every three months to exchange experiences.
4	**Always maintain contact through your links (commercial, core, local) or XSN administrative board.**		From the collector
5	**Responsibility for any losses that may occur due to the loss of seeds.**		From the collector
6	**Responsibility for the collection, processing, storage, identification and transportation to the "seed house".**		From the collector
7	**Reserve 10% of the seeds collected and sold, being 5% for the XSN association and at least 5% for the nucleus or group to which the collector belongs.**	If you remove the tax invoice and the collector does not pass the 5%, you will be prevented from issuing new tax invoices. Defaults cases will not receive the order list.	From the nucleus or collection group: collect the percentages at the time of payment of the seeds. From the collector: Sharing the benefits.
8	**Inform XSN of any change or difficulty in meeting the commitments made.**		From the collector
9	**Collect on private properties when you have the consent of the owner. Wear an ID badge and declare the purpose of the collection and XSN organizations.**		
10	**Deliver a prior list of available seeds by the end of February each year.**	If you do not submit the list, the collector can only send the request the following year.	
11	**Deliver the seeds only to order, whose maximum term is December.**	If you do not deliver by the deadline, the seeds will only appear on the list next year.	

* SOURCE: Adapted from Sanches (2015).

potential buyers and current buyers, without losing quality in production, will be secured.

The XSN outcomes, such as increased forest seed production, restoration of PPAs and family income, combined with reduced forest restoration costs, have moved more collective interest in participating in the XSN. Thus, the annual meetings represent the action-situation, in the process of mobilization of participants, who live in different municipalities of Mato Grosso. The action-situation represents the social spaces where the seed collectors or practitioners of organizations interact, exchange goods and services, solve eventual problems or conflicts, or exercise their leadership and control over others (Ostrom, 2011). They also facilitate the exchange of knowledge about the biophysical conditions, for example, where the PPAs to be restored are located, or about forest matrices that will serve as seed source.

In addition, the criteria for including XSN new participants, the common goals and expected results discussed and reviewed in the annual meetings, make up the action-situation, according to Ostrom (1990; 2010; 2011). Participants have the authority to determine, modify or establish new operating rules that define, for example, who can participate in the XSN, which duties and sanctions (for those who do not comply with the rules), which types of species to collect and the way of transporting and storing the seeds in order to reach their final destination and, most of all, participants has the authority to define the main mission of the Campaign: the forest restoration of degraded PPAs. The collectors acted independently, but were guided by the decisions of the annual meetings (Table 3), and

TABLE 4 – Criteria to become and remain as a Xingu Seed Network seed collector.

Year (1)	Seeds (Kg) (1)	Number of collectors (1)	Number of species (1)	Total resources (.1000)		Resources by collector *	
				R$ (1)	US$*	R$	US$*
2007	5,000	10	120	9,00	4,00	900,00	429,00
2008	8,000	50	125	20,00	11,00	400,00	229,00
2009	15,000	240	207	142,00	63,00	591,67	261,00
2010	25,000	300	214	220,00	118,00	733,33	393,00
2011	19,000	300	185	213,00	128,00	710,00	426,00
2012	25,000	350	159	414,00	241, 00	1.182,86	689,00
2013	22,000	350	177	326,00	166,00	1.841,00	936,00
2014	17,500	421	124	344,00	144,00	2.774,00	1160,00
2015	17,000	421	120	311,00	110,00	2591,00	913,00
2016	23,000	450	120	-		-	
TOTAL	**153.500**			1.999,00	630, 00**		

(1) SOURCE: http://sementesdoxingu.org.br/site/publicacoes.
(*) Calculated by the authors on February 14 of each year, based on the exchange rate of the Central Bank of Brazil. Available at: http://www4.bcb.gov.br/pec/conversao/conversao.asp. Accessed on: Feb. 2018.
(**) Total until February 1, 2018, without 2016 data.

were responsible for the collection and commercialization of the seeds.

The attributes of the community in the diagram of Figure 3 represent the socioeconomic characteristics of the XSN participants, the history of the land use of the region, participants' relation with the common resources (Table 2) and their roles in the network. This heterogeneity of agents is contemplated in the decision structure of the XSN, from the positions and functions defined for each one. The rules represent the result of individual and collective efforts, implicit and explicit, to acquire order and predictability among users and to use and manage the XSN, in relation to what is required, allowed or prohibited (Ostrom & Basurto, 2011). Among the rules-in-use of the XSN, 36 criteria were identified, from which the ones that establish the conditions to be a collector of the network (11 criteria) were analyzed. The other 25 criteria return the functions of the link, or the individual, responsible for the articulation of collection groups in their locality (eight criteria); the conditions for joining the network (seven criteria) and; the functions of those responsible for the "Seed Houses", i.e. the places for storage (10 criteria).

Once the criteria were reviewed and agreed at the annual meeting of the XSN, the rules were valid for all participants. Failing to do so could lead to the exclusion of the infringer or other type of penalty (Table 3). The sale of spoiled seeds, for example, from an individual collector, could end up affecting everyone who was collectively responsible for the loss of the raw material. It could affect the quality of riparian restoration and the reliability of the information generated. Providing seeds to supply the demand was not enough for the XSN's success: compliance, i.e., following agreements and monitoring of the whole process, which generates shared responsibility. Another example, when the collectors failed to recover their own PPAs (mandatory), did not protect the environment or let down the environments where the seed matrices were located; attitudes that can generate conflicts in the governance of the XSN (Chuenpagdee & Jentoft, 2009).

The regularities of the annual meetings, collection expeditions and the technical and financial support of the organizations, guaranteed collective learning by sharing experiences, techniques and local and scientific knowledge, as well as communication between collectors, who lived far apart. This set of interactions involving all activities, selection of new areas of matrices and evaluation of the risks and benefits of the decisions taken allowed communication across social agents, as well as to resolve small conflicts between users. This whole process of working together on a regular basis provides a feeling of shared responsibility and determines the success or failure of the results and the costs and benefits that affect peoples. Evaluation criteria (i.e., seed quality or restored PPAs) were defined with the XSN collectors and contracts with funding organizations, audited annually. Although not discussed in this paper, efficiency indicators should be addressed in IAD, according to Ostrom *et al*. (1997), such as: the use of resources (the investment made in the collection, storage and sale of the seeds and the financial return to the collectors); the equity in the distribution of the results (collectors receive proportionally the amount of seeds produced) and legitimacy and transparency in decision-making via participation (Chuenpagdee & Jentoft, 2009).

In addition, the conceptual governance diagram (Figure 3) also takes into account the influence

of the external variables. The "deforestation moratorium" or Federal Decree No. 6,321, of December 21, 2007, in turn, is a result of environmental policy and local and international pressures to combat illegal deforestation. This law has imposed restrictions on the soybeans farming from deforested areas, blocking loans and marketing on international markets, obligating farmers to restore the PPAs.

Thus, criteria defined and legitimized by users over time can increase trust among individuals, which is fundamental to the long-term success of governance (Tucker, 2010). From the 11 criteria to be a collector in the XSN (Table 4), evidence of one or more design principles was/were verified, which can indicate the stability or duration of long-term governance institutions (Ostrom, 1990).

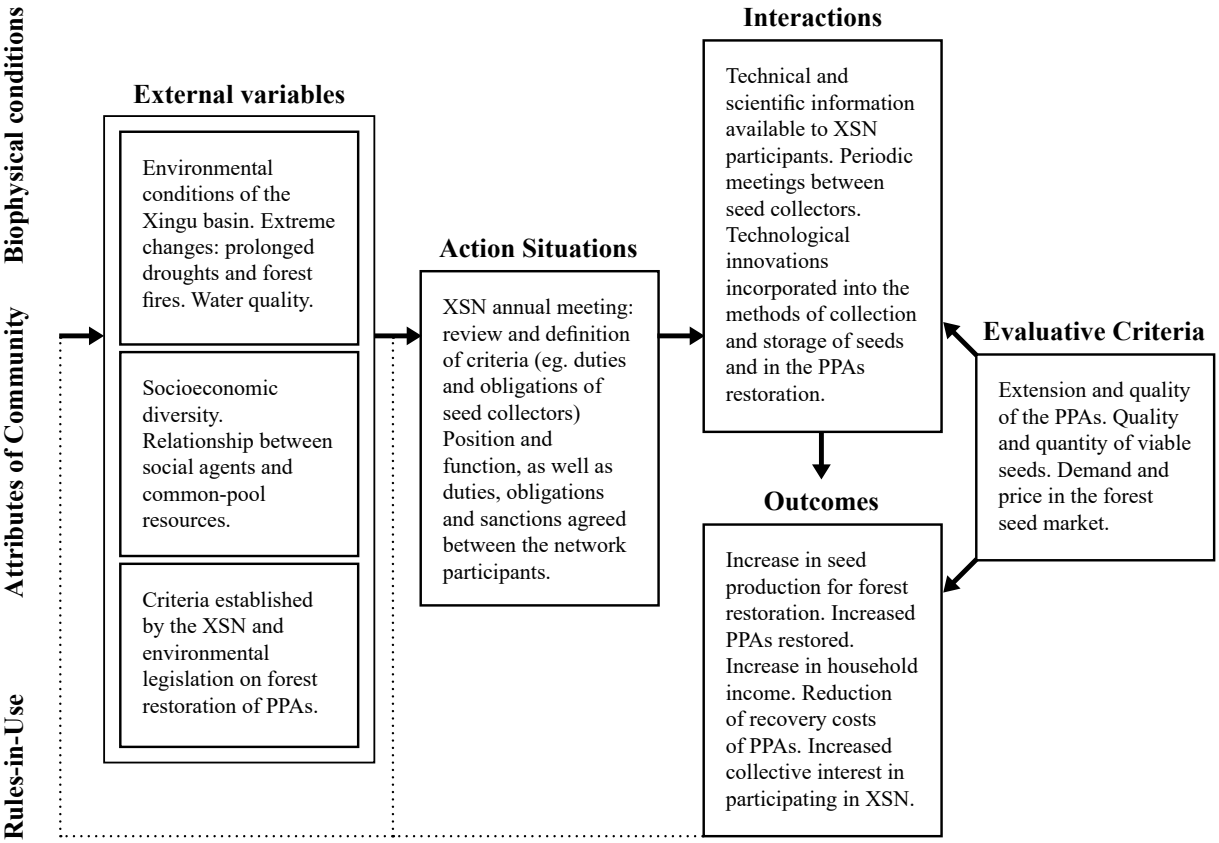

FIGURE 3 – **Conceptual governance diagram of the Xingu Seed Network**. Continuous dashes with the arrows indicate the direction of the relationship and the direct influence among a set of variables, as in the case of biophysical, sociocultural conditions and the rules in use on the "action-situation". This is represented by the decisions taken at the annual meetings of the Xingu Seed Network (XSN). The outcomes can also indirectly (dotted lines) modify the conditions of degradation of the water resources and permanent preservation areas, as a result of the results, improve water quality.

The absence of the last principle (P8, "nested enterprises") applies to all XSN criteria (total of 36), as shown in Figure 4. Still, there is more evidence of the first four principles (P1, "clearly defined boundaries "; P2, "congruence between the rules of use and provision"; P3, "collective arrangements" and; P4, "monitoring") in all XSN criteria. The presence of these principles is frequent in cases of success in governance, according to other studies analyzed by Ostrom (1990).

Cox *et al*. (2010) demonstrated that the effect of principles such as P4 ("monitoring") is present in the success cases, among the (91) cases analyzed by the authors. The cases of Cox and collaborators also showed those principles 1, 3, 4 and 6, 7 and 8 exerted greater effect (size-effect). Among the XSN's institutional arrangements, however, the last three principles are less obvious.

The results summarized in Table 5 and in Figure 4 allow us to infer some assumptions for the governance analysis of XSN. By incorporating into their arrangements rules that contemplate principles that are not evident until at least in the present study, such as the organization of actions at different scales, the XSN can increase the chances of success in the long run. Principles such as P6, "mechanisms for conflict resolution" and, P7, "minimal recognition of rights to organize", are also fundamental, considering the land use dynamics in regions where asymmetries occur with regard to land ownership and use of natural resources.

Despite of increasing in forest restoration as a result of XSN' actions, changes in legislation - federal, state or municipal level - might constrain this type of local initiative and dismantle all the work done thus far by the XSN collective effort. The government and society should legitimate these local institutions, which contribute to the use and protection of commons (principle 7), increase the chances of preservation of riparian (gallery) forests. In sum, governance should depend less on the state and more on self-organization of social agents at multiple scales to manage and govern common resources (Brondízio *et al*., 2009; Ostrom, 2010).

4. Can the Xingu Seed Network be a form of environmental governance?

The 'Y Ikatu Xingu Campaign has become a social phenomenon and has triggered a process of collaborative action and governance on a regional scale, through the establishment of a wide network of organizations. Its mission of protecting and conserving the Xingu River headwaters, which are common resources, is publicly and widely recognized. The governance structure, based on the Xingu Seed Network, consisted of the main action of the Campaign, which mobilizes common interests for forest restoration. The theoretical components of the IAD were used to analyze the XSN and describe the factors that affect or are modified by the network. The XSN accommodates different social agents in positions and defined functions, through its planning and management criteria. From the framework of the IAD and based on the Theory of Commons, one can analyze the success of institutions focused on the conservation of common resources. The results confirm this assertion, considering the criteria to participate in the XSN and coordinate the interactions among collectors, and prescribe who should (by obligation) or should not (by prohibition), who may or may not (by permission) carry out actions within the XSN structure. The planning principles

TABLE 5 – Identification of design principles among the criteria to be collector of XSN.

Principle*	Criteria verified**
1A. Clearly defined boundaries (among users)	1, 4,
1B. Clearly defined boundaries (of the system).	1, 4, 9
2A. Congruence between appropriation and provision rules with local conditions.	1,2,3, 6, 8, 9, 10, 11
2B. Congruence between rules of appropriation and provision.	1,2, 3, 6, 7, 8, 10, 11
3. Collective arrangements.	1, 2,3,4,5,6,7,8,9,10,11
4A. Monitoring by users.	1,2,11
4B. Monitoring of resources.	1,2,3,11
5. Gradual sanctions.	1,2,10,11
6. Mechanisms for conflict resolution.	1
7. Minimal recognition of rights to organize.	1
8. Nested enterprises	-

* Ostrom (1990); Cox *et al*. (2010).
** Source: Adapted from Sanches (2015).

are equally important for the governance success. These arrangements show that when rules are jointly endorsed, participants are confident in making decisions of common interest for the restoration and conservation of PPAs. The results also show the opportunity to include innovative techniques and mobilize interests for environmental governance in the Xingu headwaters, even under unfavorable conditions of uncertainty and socioeconomic and political complexity.

Systems of governance should be established jointly with administrative reforms and adapted to new environmental policies. To curb the process of land speculation and deforestation in the region, the support of civil society organizations is fundamental, along with the local presence of organizations-bridges, such as ISA and Formad among others. The XSN provides not only a cure for an unwanted scenario, but also proposes a new paradigm for governance of common resources in the Amazon region, with changes in behavior among social agents from different production systems, spaces conquered by different social groups, of diverse knowledge and learning. The XSN actions has contributed to restore PPAs (gallery forest), thus working together on a regular basis and providing a feeling of shared responsibility. Also, the XSN has promoted an increase in the interest and demand of rural producers in the region, through the technical assistance for the recovery of new PPAs and the legal adequacy of their lands.

This study shows that the common dilemma in the region of the Xingu is not circumscribed, or has never been, only to the interests of indigenous peoples or to the problems of a local community. In regions of great socio-environmental complexity, such as the Xingu, which is the target of development-oriented public policies and land use intensification, which spatially guide the course of the region's land use history, dialogue is the basis

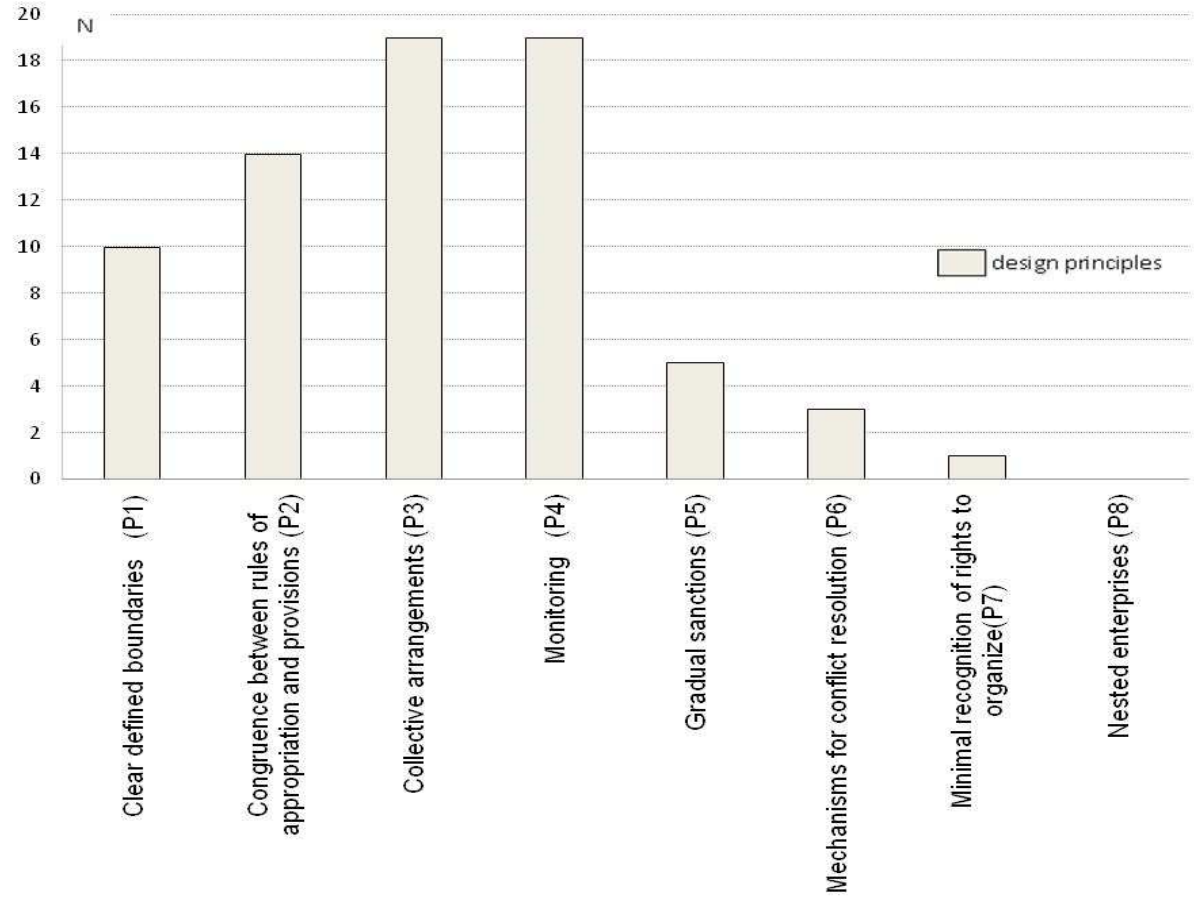

FIGURE 4 – Evidence of the design principles (P1 to P8) in each one of the 36 criteria (N) of the Xingu Seed Network. The first four principles are most frequent between the criteria.

for balance of interests in the protection of natural resources.

The collective action of the XSN, therefore, supported by innovative institutional arrangements, contributed to the conservation of the springs of the Xingu River. It will be necessary to study the other elements of the IAD, as well as incorporating the financial contributions and resources that have been mobilized during almost two decades in this and other actions of the 'Y Ikatu Xingu Campaign. The IAD allows the revision of the actions of the XSN and the prescription of new arrangements that enable development of effective institutions in the management of common resources. Further studies on the influence of market factors and political circumstances are needed, which may increase the inequality among social agents (Tucker, 2010). The legitimacy and longer continuity of the actions of the 'Y Ikatu Xingu Campaign and its materialization in the Xingu Seed Network require the stability of

its institutions and their greater articulation with the public authorities at different scales.

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