70th EAAE Seminar - May 15-17, 2019 - Montpellier, France

Governance of food chains and consumption dynamics: what are the impacts on food security and sustainability?

Biodiversity-based supply chains of the Cerrado biome: opportunities and obstacles

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Abstract

Agribusiness expansion has led to the conversion of almost half of the Brazilian Cerrado native vegetation area in monoculture, pastures and wood plantations. Although family-farming activities based on the collection of native fruits and plants could represent an alternative to the expanding high-impact agribusinesses in the Cerrado, their supply chains are poorly documented. We analyzed the obstacles that rural communities face to develop Cerrado biodiversity–based supply chains. Data was gathered in semi-structured interviews with agro-extractivists and other actors of the supply chain, during visits to farms and local markets between 2015 and 2018. The Cerrado Biodiversity-based supply chains present a high diversity of food products, but only some of them belong to a local food heritage and few generate significant cash incomes and have a high potential for trade. The development of these supply chains requires public policies that could address market access issues by focusing on marketing, legislation requirements, transportation and processes management.

Key words: supply chain; Cerrado; biodiversity-based; agroextractivism.

Introduction

Covering nearly a quarter of Brazil's territory, the Cerrado biome is the second largest biome in Latin America. Located in the Center-West region of Brazil, this mosaic of different habitats - from open dry forest and woodland savannah to shrub land and open grassland - has a remarkable biodiversity (Klink and Machado 2005).

The Cerrado has been considered, since the colonization period, as an uninhabited area, that had to be colonized by highly mechanized cash crops. From the 1960s, a deliberate policy of conquest and development of this territory was implemented through public investments and support for the migration of farmers from the South to the North of the country (Oliveira Pires 2000). These measures enabled the development of large-scale agriculture based on soybean,

cotton and maize, propelling the country as a global giant in the export of agricultural products (Leite and Wesz 2013, Hosono and Hongo 2016).

Since the 1960s, the agricultural expansion promoted by the (Federal) State has led to profound transformations of the natural landscape of this biome (Duarte 2002). So far, about half of the original 204 million hectares of the Cerrado native vegetation have been converted to monoculture, pastures and wood plantations (Ministério do Meio Ambiente 2015).

Although their demographic densities are relatively low, the remaining areas of native Cerrado vegetation are a living place and an agricultural workplace for many indigenous communities and maroon people (*quilombolas*), as well as by more recent dwellers, such as those from rural settlements (*assentamentos*) and several other traditional populations: *geraizeiros* (traditional inhabitants from the "*Sertão* backcountry"), *vazanteiros* (traditional farmers that cultivate during the ebb) and *vaqueiros*, (traditional cowboys) (Ribeiro 2008, Nogueira 2017).

These traditional communities have set up complex production systems known as "agroextractivist systems" (Nogueira and Fleischer 2005, Scariot et al. 2014), combining small-scale subsistence agriculture and poultry farming, fishing, hunting, as well as gathering fruits and other edible and medicinal plants of the biodiversity resources, and sometimes cattle farming (Eloy et al. 2018). Several scholars consider that these production systems do not create any significant disturbances in the ecosystem dynamics, thanks to their diversified production on a very small-scale (Ribeiro et al. 2008, Sawyer 2011).

The traditional populations of the Cerrado have learned from a historical interaction with the natural resources of the biome. Until today, this knowledge leads them to use various native species of the Cerrado for food consumption, traditional handicraft and medicinal purposes (Vieira, Camillo and Coradin 2016, Ribeiro et al. 2008). Many of these plant species have a high economic supply (Vieira, Camillo and Coradin 2016), while markets of a range of

biodiversity-based food products of the Cerrado biome are growing (Diniz et al. 2013, Guéneau et al. 2017). However, few studies have focused on the conditions of development as well as on the viability and capacity of the biodiversity-based food supply chains of the Cerrado to promote an alternative sustainable development path for this biome. Therefore, the objective of this article is to describe these supply chains and analyse the opportunities and obstacles to their development. The results of this research could help to reshape public policies to better address these communities' need for basic market access.

The first part of the paper presents the theoretical framework and methodology we used to achieve our research objective. In the second part, we describe the biodiversity-based products of the Cerrado biome, including the way they are processed. The third section presents a typology of the supply chains related to the Cerrado biodiversity, discussing the structure and governance of these chains and the main specificities of each product and similarities among three regions. The last part of the paper discuss the main opportunities and obstacles of the development of the biodiversity based supply chains, in particular as regards with the public policies that focus on this issue. The paper concludes with some policy considerations regarding the development of biodiversity based supply chains in the Cerrado and suggestions for future research.

1. Theoretical framework and methodology

Among the multitude of recent work on food systems, a body of research has developed, in recent years, a series of approaches to study the interrelated systems of stakeholders fulfilling complementary functions for the production of a certain product or a homogeneous group of goods. These approaches include different schools of thought, borrowing from different theories and methodologies (institutional economics, management science, economic geography, etc.) (Raikes, Jensen and Ponte 2000). If there is a relative proximity between

these approaches, each one can be distinguished by a specific angle taken to analyse these interdependencies (Temple et al. 2011).

Amid these, the concept of *filière* commonly used by the French community of agricultural economists, is defined as "the linked sequence of technical, logistical, and commercial operations necessary to produce and distribute a food or agro-industrial product, from production to consumption" (Lançon, Temple, and Biénabe 2017). This concept is close to the supply chain operational concept which was formalized and disseminated by management scientists through the supply chain management approach (Harland 1996), which focuses on the efficient flow of goods and services between a company, its suppliers, and customers in order to coordinate production chains that involve several industrial entities (Temple et al. 2011).

One interesting reference for our supply-chain biodiversity-based case studies is the anthropological tradition that focuses on markets and power, particularly in market construction for small-scale products and in the condition for the micro-chains to be successful (Raikes, Jensen and Ponte 2000). It pays special attention to the type of relation between the agents (solidarity, domination, etc.) beyond purely market transactions. This approach is similar to the "global commodity chain" (GCC) approach, which was born in the 1990s, now called "global value chain" (GVC) approach. The main innovation of GVC approaches is the introduction of the study of governance mechanisms inside the value chains (Raikes, Jensen and Ponte 2000). The seminal work of Gereffi (1994) suggests an explanatory framework of value chains governance introducing the concepts of producer-driven and buyer–driven value chain. Based on this work, the GVC approach tries to answer the following questions (Gereffi, Humphrey and Sturgeon 2005): who drives the chain? And how are they structured by dominant agents or other agents arrangements? Thus, GVC approaches

also deal with power relationships among economical agents in the production and marketing process of one product and its subproducts (Raikes, Jensen and Ponte 2000).

Taking stock of this literature, our paper aims to map out a range of biodiversity-based Cerrado product flows. In order to characterize the biodiversity-based supply chains, our analytical model pays attention to, first, agents and activities within each chain that links initial producers to markets, and second, the type of relationship between the main – private and public - players within the chain, including external players.

The methodology of the study combines socio-anthropological fieldworks through semi-structured interviews with agroextractivists and the main actors along the supply chain (consumers, middlemen and other intermediate agents[1], cooperatives, industries and local public stakeholders), as well as visit to farms and rural settlements, observation of the marketplaces as well as photographic records. This methodology has been applied in three Brazilian states: the municipalities of Mambaí and Pirenópolis, as well as Alto Paraíso and Cavalcante, in the Chapada dos Veadeiros Park area in the state of Goiás (Figure 1); an area located between the cities of Carolina and São Raimundo de Mangabeiras in the South of the State of Maranhão (Figure 2); and the northern state of Minas Gerais (Figure 3).

In the state of Goiás, fieldworks in each of the chosen municipalities were done in the occasion of different events (fairs, local festivals and seminars), between 2015 and 2017, in addition to field research that resulted in a Masters dissertation (Mendonça 2016). In the Urucuia Valley, state of Minas Gerais seven interviews were conducted with the agroextractivists and three with leaders of the main cooperative of the region. Before the interviews, a series of visits was made to six municipalities, accompanying a project from the Slow Food Movement, from where originated an analysis of strengths and opportunities,

[1] The intermediate agents of the searched supply chains differ in profile from one region to another. In section 2 we detail these differences in each supply chain category where they participate.

weaknesses and threats on baru production in the North and Northeast of Minas Gerais. In the South of Maranhão, semi-structured interviews were conducted in 2018 in two municipalities, Carolina and São Raimundo das Mangabeiras, where 14 agroextractivists were interviewed. Visits were made to the rural area of Carolina where the agroindustry of the local association and the properties of the agroextractivists were located, and in San Raimundo das Mangabeiras, an agrarian reform settlement, recognized for its work with fruits of the Cerrado, was also visited. The results of the research were followed by a content analysis, with the help of Excel, as well as the observation of the place by the researchers.

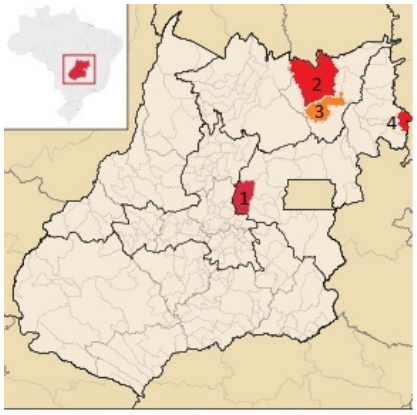

Figure 1 - Municipalities visited in the state of Goiás (1- Pirenópolis, 2- Cavalcante, 3- Alto Paraíso and 4- Mambaí). Source: Adapted from Wikipedia by the authors.

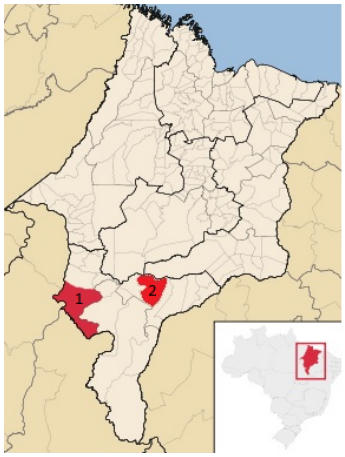

Figure 2 - Municipalities of Carolina (1) and São Raimundo das Mangabeiras (2), in the state of Maranhão. Source: Adapted from Wikipedia by the authors.

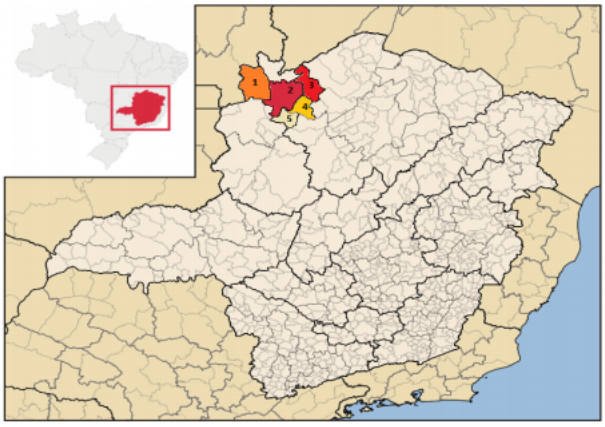

Figure 3 - Municipalities of the Urucuia Valley, in the state of Minas Gerais (1- Buritis, 2-Arinos, 3-Chapada Gaúcha, and 4-Urucuia and 5-Riachinho). Source: Adapted from Wikipedia by the authors.

2. Characterization of agroextrativism practices in the Cerrado biome

Traditional communities of the Cerrado biome are first and foremost family farmers. They displayed great variety in their crop production, including products such as cassava, corn, rice, beans, watermelon, pumpkin, bur cucumber, okra and sweet potato, together with free-range chicken raising. In addition to farming and other income generating activities (e.g. temporary jobs in nearby bigger farms, working in local restaurants, at school, hired as housekeepers, etc.), families may also engage in extractive activities of various Cerrado plant species, especially during the season when those species have higher demand and, consequently, greater potential of income generation. In some communities, particularly in the agrarian reform settlements (*assentamentos*), several farmers started gathering native fruits only 15-20 years ago, and do not consider extractivism as a traditional activity.

Therefore, in the Cerrado biome, the small-scale agriculture systems are characterized by a pluriactivity in which the collection of biodiversity resources is only one activity among others. These diversified production systems are called "agroextractivism" (Nogueira and Fleischer 2005), as they combine two of the oldest activities of humanity: vegetal extractivism and agriculture. Thus, the concept of agroextractivism differs from that of extractivism that is widely used to describe systems based on the collection of non-timber products from the Amazon rainforest for commercialization (Pinton and Emperaire 1992). Indeed, in the Amazon, extractivism is generally the core activity of some communities, which are specialized in the harvest of a specific product such as brazil-nut (*Bertholletia excelsa*) or rubber (*Hevea brasiliensis*) since the last century, or acai berry (*Euterpe oleracea*), more recently.

Unlike what is observed in the Amazon, most of the non-timber species collected by the communities are scattered throughout the Cerrado biome, even if a certain degree of regional specialization could be observed. Among the best known, the species of endemic fruits of the

Cerrado that are collected for food uses are[2]: araticum (*Annona crassifolia*), bacuri (*Platonia insignis*), baru (*Dipteryx alata*), babaçu (*Attalea speciose*), buriti (*Mauritia flexuosa*), cajá (*Spondias mombin*), cagaita (*Eugenia dysenterica*), cajuí (*Anacardium corymbosum; Anacardium humile*), coco-indaiá (*Attalea geraensis*), coquinho-azedo (*Butia capitate*), jatobá-do-Cerrado (*Hymenaea stilbocarpa*), mangaba (*Hancornia speciosa*), murici (*Byrsonima coccolobifolia*) and pequi (*Caryocar brasiliense*).

The Cerrado native fruits such as mangaba, cagaita, cajuí, buriti or cajá are highly perishable. It is one of the reasons why during the harvest period, a large part of them are self-consumed *in natura* or in the form of juice by the communities. Most of these fruits require rapid processing for conservation purposes, such as mangaba and cajuí. In southern Maranhão, the main method of processing is to use basic juice extractors to produce frozen pulp packed in 500 g. to 1 kg plastic bags. This activity complements the production of frozen fruit pulp from other non-native species such as acerola (*Malpighia emarginata*), cashew-apple (*Anacardium occidentale*) and passion-fruit (*Passiflora edulis*), among others.

Most of the fruits are used in their areas of occurrence to make liquors (baru, pequi), jams (araticum, cagaita, mangaba) and sweets (buriti). Some of them are dried and processed as chips (buriti, pequi) for conservation purposes. Various fruits are included in the recipe of special cachaça spirits made from fermented sugarcane juice (in particular murici). Other fruits like babaçu are mostly used to produce oil. Jatobá and babaçu are also processed as flours used to make pastries.

Apart from few products, the majority of the native fruits of the Cerrado are unknown to the Brazilian consumers from other regions, especially consumers from the big cities of the country. However, among all the fruits of the Cerrado, the pequi is an exception. This fruit is

[2] For a complete description of the native species of the Cerrado biome, see: RF Vieira, J Camillo & L Coradin (orgs.). *Espécies nativas da flora brasileira de valor econômico atual ou potencial - plantas para o futuro: Região Centro-Oeste*, MMA, Brasilia, 2016.

the most popular because it is part of the local culinary heritage of the Cerrado, through typical regional dishes such as “rice with pequi” or “chicken with pequi”. Freshly harvested, this green fruit is about the size of an orange. It includes a 1-4 segments of internal yellow pulpy mesocarp of 3.5 cm of diameter on average (lumps). The pulp, about 3mm thick, is rich in oil, vitamins and proteins. Internally, it also contains an edible white seed. Different products can be obtained from the fruit. The whole inner part of the fruit (lump) is frequently used within the households. The entire fresh lump is the preferred form of consumption, particularly in the traditional dishes, even if only the outer pulp is edible[3].

In the region of Mambaí, families prepare pulp preserves. They insert thin slices of pulp in 1.5 liter upcycled soda bottles with brine. Packaging the pulp in the soda bottles is the simplest way for the families to preserve the fruit at lower costs, given the ease to get these bottles[4]. It is also a form of commoditization that facilitates market transactions. From the fresh pulp, the farmers also extract oil, cut shavings, make sauces, flour, dried pulp, sweets and soap. Lastly, the inner nuts are also extracted by some of them. However, most of the agroextractivists do not have the techniques to extract the pequi nuts that are little consumed locally.

Not all Cerrado’s products are used by traditional communities and some do not belong to a local food heritage. For example, the cagaita fruit can be sold in the form of jams, ice creams or juices in urban centers, but is sometimes considered by some communities as a toxic fruit[5] from which consumption is not recommended. Although bacuri is relatively abundant in Southern Maranhão, it is little consumed by local inhabitants from this region, where consumers prefer cajá juice.

[3] Eating a traditional “rice with pequi” requires a certain technique because the lump contains spines that can cause serious injuries. Thus, the tasting of the lump involves delicately gnawing the pulp around the core without the possibility of using cutlery.

[4] Although some extractivists they may need to buy soda bottles, which reach up to BRL 1.5 per unit during the peak in Pequi production

[5] The cagaita’s fruits should be eaten sparingly because when excessive, mature or fermented, have a laxative effect, according to popular wisdom (Lima et al. 2010), a fact that gave rise to the scientific name of the species (*Eugenia dysenterica*).

The baru[6] is another interesting example as it is not part of traditional uses by rural communities. The fruit of the baru is composed of a fine pulp, edible but little supplied, and a very thick shell containing a seed that is extracted by farmers for commercial purposes. The baru three was preserved from deforestation for pasture production, as the cattle appreciate the external pulp. Previously, the oleaginous seed of baru was little consumed by local communities because it was eaten raw, resulting in difficult digestion, and the communities believed that the consumption of baru nuts caused skin diseases (impetigo). In the tourist town of Pirenópolis, in the late 1980s the new inhabitants coming from big cities like São Paulo have revealed the taste qualities of the baru seed through its roasting. The roasted nut was then the subject of a social construction process leading to the requalification of the baru as a healthy and nutritious foodstuff, rich in iron, zinc, fiber and protein(Fernandes et al. 2010). From roasted nuts, several products are derived, such as flour or liquor. Nowadays, the baru nut, usually called "The Cerrado nut", is often associated by urban consumers to food heritages of the Cerrado, even if its food consumption in rural areas is far from traditional. For instance, in the northern part of the state of Minas Gerais, the agroextractivist communities hardly consume baru, although the city of Arinos organizes a Baru National Fair (FENABARU) since 2017.

3. Cerrado biodiversity-based supply chains

With some exceptions, most of the native fruits of the Cerrado biome are self-consumed or commercialized locally, in an area close to their place of harvest. It is the case of araticum, mangaba, cajuí cagaita, coco-indaiá, coquinho-azedo, jatobá and even pequi. Bacuri harvested in the South of Maranhão is mainly destined to supply the big neighboring cities, in particular Belém, Teresina and São Luís, respectively capitals of the states of Pará, Piauí and Maranhão,

[6] The baru nut belongs to the same family of the tonka beans (*Dipteryx odorata*) that recently has gained interest of chefs in many restaurants in Europe and North America due to its aromatic properties.

where they are much appreciated and can be sold at better prices. Baru nuts from Minas Gerais and Goiás states is intended to feed the growing domestic market and has fund some export markets niches in particular in United states. Babaçu is an exception as a big part of the oil production is exported to Europe.

Actually, Cerrado biodiversity based supply-chains differs a lot from Amazon fruits supply chains in terms of quantities and markets. Amazonian products are intended to supply mainly national consolidated markets in the case of fruits like açaí (*Euterpe oleracea*) or cupuaçu (*Theobroma grandiflorum*), or even international markets in the case of brazil nuts. Therefore the volumes sold are not comparable to those of Cerrado products. Nowadays, Cerrado native fruits supply chains remains micro-chains that we classify into four main categories.

a) Informal short supply chains

Most of the Cerrado biodiversity-based supply chains are very informal and unorganized. Generally, agroextractivists collect the fruits on their own plots or on open access areas. The harvest is used for self-consumption and the surplus is sold. Some of the short supply chains involve products that are little or not processed. For example, freshly harvested fruits such as bacuri and pequi are offered in bags of 5 to 10 kilos along the highways. Many agroextractivists process fruits at home to obtain greater added supply. Frozen fruit pulps, roasted nuts, jams, confectionery, oils, flours, fruit chips, liquors and homemade cakes are sold in basic packaging in local markets or by order to individuals or to local shops and restaurants (by phone or through the whatsapp app.).

In the South of Maranhão, for example, the fruits are mostly sold as frozen pulp to individuals, on order. The two most popular fruit pulps are cajá and buriti, which are sold at average prices of R$ 10.00/kg (US$ 2.80/kg) and R$ 8.00/kg (US$ 2.00/kg) respectively. The frozen bacuri pulp is proposed at R$ 15,00/kg (US$ 4.00/kg) but finds few clients. The selling price of the sweet of buriti is quite attractive since it reaches R$ 25.00/kg (US$ 6.80/kg). The

main cooperative in the region, Coopevida, located in São Raimundo de Mangabeiras, has a small outlet in the city center where a variety of Cerrado products from members of the cooperative are offered: frozen fruit pulp, soaps, oils, sweets and liquors. This shop is also a place were members of the cooperative can barter some Cerrado biodiversity-based products for other food goods like coffee or sugar.

Where the production sites are relatively close to urban or tourist centers, short chains without intermediaries have been organized between agroextractivists and certain shops. This is the case around the city of Brasilia, including the tourist towns of Pirenópolis, and Cavalvante and Alto Paraíso in the region of Chapada dos Veadeiros. Some agroextractivists have established a privileged commercial relationship with their customers, restaurants, hostels or specialized shops. For example, during the period of harvest of fresh fruits such as mangaba or cajuí, agroextractivists contact some restaurants to deliver their harvest directly. In the tourist towns of Cerrado, some micro-enterprises market their products directly in hotels, restaurants and hostels. For example, the baru is sold in the form of small samples of 50 grams of roasted nuts, biscuits or cereal bars, allowing the discovery of this product by tourists. The packaging often emphasizes the environmental and healthy attributes of these products.

b) Informal supply chains driven by downstream processing industries

Fresh fruits are also sold to middlemen who come directly to pick them up in trucks at the collection points. The agroextractivists deal directly by telephone with the intermediaries with whom they are used to do business[7]. In general, the sales unit is the thousand fruits (*milheiro*) and selling prices are very low: in the south of Maranhão, the thousand bacuri was sold between R $ 60.00 and R $ 70.00 last year (US $ 16.00-19.00 the thousand fruits, or US $

[7] However, there are situations where the intermediares are truck drivers who travel from these regions to urban centers and take advantage to take the collected products for not returning with empty load.

0.03-0, 05 / kg), and pequi prices can reach less than R $ 30.00 per thousand (US $ 8.00, or US $ 0.05-0.10 / kg) when the harvest is plentiful. These prices are very low in relation to the collection work that is usually done at dawn, with the family, and often requires walking for tens of kilometers carrying bags of several tens of kilograms.

In some cases, processing units located in large cities contact local intermediaries to organize collection and transport, and sometimes the processing of fresh fruits. This is the case of the bacuri supply chain in southern Maranhão. Intermediaries do some sort of outsourcing by contracting local farmers who are paid by the task to gather the fruits.

The extraction of the pulp is carried out by women, who perform this operation in a processing unit in the city of Carolina. The product obtained is a non-standardized raw fruit pulp, packed in plastic without specific labeling, and frozen until a sufficient volume is reached to be transported in a refrigerated truck chartered by a distant processing industry located in big cities.

The pequi pulp preserves that are processed at home in the Mambaí region are sold to intermediaries at relatively low prices, in the range of R$ 3,00 to 8,00 (US$ 0.80 to 2.00) per bottle, depending on the quantities available on the market. At some point after the harvest begins, the resellers will start passing by the extractivists' houses and will usually buy the entire production of each family. Although some families do mention difficulties to deal with intermediaries (i.e. not being paid, uncertainty in the sale, low payments, delays, etc.), they prefer this kind of transaction because the traders will take large quantities (which can reach 500 bottles of pequi preserves). Selling the raw or processed pequi fruits to middlemen provides significant cash income in a very short period to the agroextractivist families, often coming in times of need. It is complementary to the income obtained more evenly from the sale of products of family farming. In some cases, the intermediary is a member of the community which has an informal agreement with a remote industry, paying him R$ 0,20 per

liter of pulp preserves on average in order to collect a determined quantity at a fixed price. In other cases, the intermediaries work independently and negotiate directly with remote industries and cooperatives or sell directly to final consumers at fairs or on the sideline of the main marketplaces of the big cities. Remote industries will recondition the pulp or process it into canned food, sauces, pastes, liquors, etc., a range of products that can be found in supermarkets or delicatessens, especially in the Cerrado region.

c) Supply chains driven by public procurement

A large part of family farming products find their markets through public policies of food acquisition (Grisa and Schneider 2014). Two programs play a crucial role in supporting the Cerrado agroextractivist chains. The first one is the Food Acquisition Program (PAA) created in 2003. The purpose of the PAA is to develop the purchase of food by the Federal Government to meet social or collective needs, for example to feed people in situations of social vulnerability. This federal program has some local variations, especially in the state of Maranhão where a Family Farming Purchasing Program (Procaf) is implemented. The second Federal Program is the National School Feeding Program (PNAE), which aims to purchase family farming products, by the government to ensure the school feeding of the public education network.

Due to the administrative difficulties and the bureaucracy generated by this program, few agroextractivists manage to access individually this institutional market. Most transactions take place through cooperatives or producer associations. Much of the output of these producer organizations is marketed under the PNAE to supply rural schools. This is the case, for example, in the São Raimundo de Mangabeiras region, in southern Maranhão, where about 90% of the production of Coopevida, the main cooperative of the region, is intended for the school feeding of the villages of the region through the PNAE. The Coopevida produces about 30 tons of fruit pulp a year from twelve different types of fruit, including three fruits

native to the Cerrado: buriti, cajá and cajuí. Coopevida sells thus pequi frozen pulp for school feeding. In northern Minas Gerais, the Copabase also markets a large part of its production through this institutional channel.

In the opinion of those responsible for family farming support policies in these two regions, the PNAE is a fundamental instrument for maintaining quality short supply chains (fresh and healthy products), and reduce the costs of logistics, transportation and storage of food for schools.

The PAA is less used, especially because of the sharp drop in the budget devoted to it by the federal administration. Nevertheless, in Maranhão, the agroextractivist supply chains benefit from the local family farming purchasing program (Procaf).

d) Conventional supply chains supported by international cooperation and NGOs

In many cases, conventional biodiversity-based supply chains have been structured through international cooperation programs. For example, through the Small Grants Program of the Global Environment Facility (GEF), known in Brazil under the name of PPP-Ecos, 318 civil society projects were supported in the Cerrado since 1994. These PPP-Ecos projects were largely related to the sustainable use of biodiversity.

A large part of the agroextractivist communities of the Cerrado are included in conventional supply chains through producer organizations, cooperatives or associations. This is the case of the Copabase, whose development stems strongly from a project of the Bank of Brazil Foundation and, subsequently, from other projects supporting the agroextractivist supply chains.

Originally, the mission of the Copabase is the sustainable production and marketing of handicrafts and cultural products of the region Urucuia Grande Sertão in the Northwest of the state of Minas Gerais. One of the main projects funded by the Brazilian Bank Foundation was to set up a technical assistance for the management and good practices for collecting

Cerrado's products, as well as ecological and fair certification of products. This technical assistance allowed the cooperative to develop its production capacity, to comply with technical and sanitary standards and to commercialize its products in the formal markets. However, in some situations the intermediaries[8] pay better prices than Copabase and don't require good practices, distributing these baru nuts in conventional markets.

Cooperatives of the Cerrado also receive support from the *Central do Cerrado*, a second degree cooperative created in 2005, as a collective of community organizations (cooperatives and associations), whose main objective is to promote the insertion of eco-friendly products of the Cerrado in national and international markets. The *Central do Cerrado* helps member cooperatives to market their products through various initiatives such as a sales shop located in the Brasilia region, the setting up of a website for online ordering of the products of member cooperatives, the organization of cocktails and the participation in fairs and exhibitions to make known the products of the Cerrado.

Cerrado's range of products in the formal markets is very limited. Among others, ice cream made from Cerrado fruits, oils (babaçu, pequi), flours (babaçu, pequi and jatobá), cereal bars or biscuits made from baru nuts are available on the formal market, on the Central do Cerrado sales site, in specialized shops, and much more rarely in conventional supermarkets. In the latter, the most common products are pequi preserves and roasted baru nuts.

The main markets are located in major cities such as São Paulo, Rio de Janeiro and Brasilia. The bag of one kilogram of roasted baru nuts is sold at a price of R $ 80,00 (US$ 21.00) by the Copabase on the online sales-platform of the cooperative Central do Cerrado. But in some specialized delicatessens in Sao Paulo, baru nuts packed in 100-150 gram packets have market values of over R $ 200/kg (US $ 54.00/kg).

[8] Usually the intermediaries are not covered by the technical assistance and training agencies, especially if they are not comming from an agroextractivist community.

Baru nut sales have developed strongly and have recently been of growing interest for some major agrifood groups. The company Mãe Terra, one of the leaders of the trade of cereals and organic biscuits in Brazil offers two kinds of cookies containing roasted nuts of baru in its range of products. Copabase is one of the suppliers of this company, which was recently bought by the giant of food industry Unilever.

Although the volumes traded on the international markets are still relatively small, some foreign buyers have shown a growing interest in the exotic side and the sustainable origin of some products of the Cerrado. The enterprise Barukas, headquartered in the United States, has also signed a large purchase contract for several tons of baru at Copabase in 2018 to develop the baru trade in the United States. The pequi market also made breakthrough into Europe, Japan and Canada, extending the observations that had already been made some years ago (Afonso and Ângelo 2009).

Yet, it remains difficult to maintain formal supply-chains over a long period, as shown by the fruit pulp supply chain in the South of the Maranhão. In this area, few years ago, the agroextractive activities were mainly organized through a network created by FrutaSã, a fruit pulp company founded in 1993 following a project coordinated by the NGO CTI (Centro de Trabalho Indigenista – Indigenist Work Center), in partnership with the local indigenous association Wyty-Cate (Carvalho and Silveira-Junior 2005). In 2012, FrutaSã produced tens of tons of fruit pulp, in particular of bacuri and cajá, involving more than one hundred agroextractivist families from the Carolina area. Internal conflicts involving members of the board (in particular Wity-Cate indigenous association and family farmers) has slowed down the development process of the company. Recently, the company had to face serious management problems that lead to closure of activities in 2016.

4. Opportunities and obstacles for the development of Cerrado biodiversity-based supply chains

The national market for Cerrado agroextractive products is expanding. This growth is driven by urban consumers looking for differentiated food products with strong ecological and health attributes. Several authors consider that extractivist systems are beneficial for the environment, particularly as regards the conservation of biodiversity, because of a very diversified production on a very small scale, based on a great diversity of native species, thus creating small disturbances in ecosystem dynamics (Scariot *et al.* 2005; Ribeiro *et al.* 2008; Sawyer 2011; Lima *et al.* 2013). In addition, by using little or no inputs to the production unit, these systems generate little waste and pollutants. The commercial valorization of extractivist native biodiversity products of Cerrado is therefore generally considered one of the means to ensure the conservation of the native vegetation of the biome and provide alternative income generation for traditional communities.

In a context of challenging the industrial food systems and damaging colonization of monoculture crops in the Center-west region of Brazil, the social construction of Cerrado biodiversity-based markets is also part of a movement that seeks to consolidate new relationships between urban consumers and traditional rural communities. For example, in the city of Brasília, the demand for food that comes from diversified and local agricultural systems is becoming stronger. It is why a large number of institutionalized initiatives connecting the producer and consumers more closely, such as Community-supported agriculture (CSA), are emerging in Brasilia (Penereiro and Silva 2018).

This growth in the demand for Cerrado biodiversity-based products is also driven by some chefs of restaurants, an observation already reported by Zaneti (2017). In São Paulo or Brasilia, and in small touristic towns like Pirenópolis, some menus mention dishes containing biodiversity-based products of the Cerrado. Television programs often led by chefs or

gastronomic critics focus on these products, prompting the Brazilian consumers to buy them. Finally, some famous chefs go much further by carrying out projects to support Cerrado biodiversity-based supply chains. For example, in partnership with the City Council of São-Paulo, the ATA institute created by chef Alex Atala decided to open a commercial space dedicated to the marketing of biodiversity–based products from five Brazilian biomes (Amazon, Atlantic Forest, Caatinga, Cerrado and Pampa) inside the municipal market of Pinheiros, in the center of the economic capital of Brazil, where several products such as roasted baru nuts or pequi preserves are available.

Although Cerrado biodiversity-based supply-chains offer various benefits in terms of sustainability and show interesting development prospects, few public policies have supported the development of these chains. A national plan for the promotion of socio-biodiversity chains[9] (Plano Nacional de Promoção das Cadeias de Produtos da Sociobiodiversidade - PNPPS) was adopted in 2009, but it is more adapted to the Amazon biome and has been elaborated from a top-down approach. It has not been fully designed taking into account the particularities of the Cerrado, which are quite different from the Amazon context in terms of production systems and organization of the supply chains.

Public purchasing policies remains important to create institutional markets. For instance, the traditional communities who supplied the Fruta Sã Company in the South of the Maranhão have lost their main market, yet they maintained an extractivist activity thanks to the PNAE and PROCAF programs. But these programs do not focus on bacuri pulp, especially because of its higher price. It is why the activity related to the extractivism of bacuri has been taken

[9] The concept of socio-biodiversity refers to the integration of cultural diversity of traditional populations into biodiversity conservation policies. It has been institutionalized as a result of the strong interaction between lifestyles and the socio-economic activities of many indigenous peoples and communities and the conservation of the biodiversity of their territories, giving rise to a current of socio-environmental thought (Santilli 2005).

over by distant companies employing middlemen, generating little revenue for the local communities.

Public policies implemented by the municipalities are also quite limited, generally focusing on the support to the organization of local fairs: provision of sale equipment for the farmers (tables, stands, etc.), transport of agroextractivists from their villages to the marketplace. In fact, local public policies mainly focus on the support for the agricultural production of family farmers (provision of tractors, field clearings, etc.) rather than on their extractivist activities, such as gathering of fruits, seeds, straws and leaves.

The obstacles to the development of Cerrado biodiversity-based supply chains are numerous. Upstream, the main problem is the limited access to biodiversity resources. For example, in the case of the baru, few years ago, extractivists had free access to collecting areas on private property, but the commercial success of the baru nuts has led some owners (*fazendeiros*) to limit the access to their properties, or even to charge the agroextractivist for the access to the baru resource. Some conflicts started to appear, following invasions of private properties by frustrated family farmers, leading to an unorganized and risky activity of baru gathering. This is the reason why some agroextractivist families have started to plants trees on their own plots, for example in the Arinos region, where Copabase is developing a large-scale baru plantation project.

The rapid development of the baru nuts supply chain could also lead to a specialization of productive systems and a reduction in subsistence agriculture, leading to food security risks, as has been the case for other species that had a great commercial success, such as açaí (Cialdella and Alves, 2014). The commercial valorization of extractivist products requires questioning the kind of market that has to be reached, and what relations between producers and consumers would maintain the biodiversity and the social inclusion of traditional communities.

In the South of the Maranhão, the access to the collecting areas of bacuri fruits is also complex, because the resource is mostly concentrated in two integral protected areas, the National Park of Chapada das Mesas and the Maranhão State Park of Mirador. It is forbidden to enter into the Parks without any authorization, and even considered a serious environmental crime to pick bacuri fruits inside the protected areas. In addition, the bacuri trees that were abundant outside the protected areas 10-20 years ago have almost disappeared due to the conversion of native vegetation to monocultures of soybeans over a large part of the territory.

A second problem in the Cerrado biodiversity-based supply chains concerns the processing, storage and delivery of agroextractivists' products. The intermediaries own most of the transport and storage infrastructure, as well as contacts needed to reach distant markets. In most cases all these operations are still very rudimentary, a situation that reflects the real low developmental context of the remote regions of the Cerrado. Processing and packaging activities are often done manually, without any equipment or machinery that would reduce these time-consuming activities and the production costs of the products. For example, in the Pirenópolis area, many agroextractivists extract the baru nuts one by one with an artisanal device made of a machete fixed on a wooden block. In regions where the potential of fruit pulp supply is high, as in the South of Maranhão, few communities have individual and collective freezers and cold rooms in their settlements or villages. The lack of electricity is not uncommon and power cuts are recurrent. Water often comes from artesian wells, while treated water is required for formal food processing activities. Roads in poor conditions are common, causing troubles when it comes to carrying fragile and highly perishable fruits such as mangaba or cagaita. In a great majority of cases, frozen fruit pulps are carried out using Styrofoam cool boxes in common vehicles, whereas the transport must be carried out in refrigerated trucks to not interrupt the cold chain.

The lack of collective organization of agroextractivists communities is another issue of concerns. Indeed, some agroextractivists have little interest in the forms of institutionalized mutual organization, such as producer associations or cooperatives. It is the case of the agroextractivist communities of Mambaí area or in Pirenópolis, where the family remains the production unit. Yet, collecting and processing agroextractivist products are time-consuming activities that require economies of scale in order to lower production costs. Collective organization also makes it possible to better negotiate the prices with the middlemen and share the costs associated with the marketing of products.

Downstream, market access for Cerrado biodiversity-based products is constrained by the lack of administrative authorization. Many agroextractivists, even among those who are organized in a cooperative, fail to reach the minimum requirements to access the formal market, both in terms of product quality (health, visual appearance, caliber) and packaging (lack of labeling or rudimentary labeling). The sale of agroextractivists' products to supermarkets or other kind of commercial or industrial establishment requires a seal of the Federal Inspection Services of the Ministry of Agriculture (SIF - Selo de inspeção Federal) for the commercialization in the whole country, or a seal of the State Inspection Services (SIE - Selo de inspeção estadual) for a commercialization limited to the territory of the State. For example, in the South of the Maranhão, Coopevida has not yet obtained these seals, compelling the cooperative to limit its sales to authorized institutional purchasing programs.

Finally, it should be pointed out that Cerrado biodiversity-based supply chains have never been the priority of any federal government, whatever their political affiliation, once the main projects of the Federal government for this region are more related to agribusiness productive chains. Actually, agroextractivism in the Cerrado biome has mostly been supported by international cooperation. Cooperation programs could be considered as an advantage, but also as an inconvenient as regards to the relationship of dependence between agroextractivists

organizations and donors, in particular in the current context of reduction of international cooperation programs in Brazil.

Conclusions

The emergence of biodiversity-based supply chains represents a valuable option for the sustainable development of the Cerrado biome. These chains have significant development potential but are poorly structured and remain characterized by a still high level of informality. Agroextractivists communities of the Cerrado have to face various challenges to access the growing market of biodiversity-based products. Many of these supply chains remain informal. In general, production processes are rudimentary and do not meet the standards required by formal markets. Many supply chains are poorly structured, which means that agroextractivists are often dependent on intermediaries or public procurement programs to sell their products. Intermediaries occupy an important place by exerting certain dominance over agroextractivists, controlling the quantity purchased and setting up the market prices. Once usually there are few buyers (like in an oligopsone) for the products of the almost isolated agroextractivists, the intermediaries can decide the prices they will pay, and not the producers.

Although agroextractivists perform most of the work of harvesting and processing the fruits, the intermediate actors still capture the most part of the value-added, especially in the informal short supply chains and in the informal supply chains driven by downstream processing industries.

The dependence of agroextractivists on public purchasing policies is also very fragile as regards to the drastic cuts in the federal programs of assistance to family farming that took place in recent years. Many associations of producers and agroextractivist cooperatives could

be strongly affected by this disinterest and lack of support. Moreover, political pressure from agribusiness interests to maintain the invisibility of agroextractivist sectors remains strong. The rural elites disseminate a widespread preconceived vision of traditional populations that are seen as unhelpful for the national development. Several recent public statements of the new federal government demonstrate the political will to extend agribusiness activities to the territories of traditional communities. Without a strong social mobilization, the social and environmental state of the Cerrado biome could be even worse in the near future.

Further work has to be done in order to better understand how to address basic market access needs. Analysis of marketing devices that could help to better identify the 'Cerrado socio-biodiversity attribute' of the products (e.g. certification and labels), and analysis of public policies options that could help to sustain the pequi supply chain (e.g. public purchases, minimum prices) are two avenues of future work. As technical assistance has focused mainly on the processing techniques, we also suggest public policies to better target the needs that could help the agroextractivists to better organize themselves to access markets: legislation requirements (regarding sanitary regulation, etc.), transportation, and entrepreneurial management for the youth, integrating the basic concepts of accounting and management. Local institutions (technical and higher education) could also have their courses and training more based on the context of agro-extractivism, in order to integrate innovation and traditional practices, promoting a development from the valorization of the natural and human resources of the region, more sustainable in socio-environmental aspects, preserving, thus, the socio-biodiversity of the biome.

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