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Survival in the agroforestry systems of the Porto Seguro Sustainable Development Project, Marabá, PA, Brazil: biodiversity and construction of emancipatory knowledge

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Abstract - The study aims to identify the forms of use and management, conservation and commercialization of species cultivated in agroforestry systems (AFSs) developed by family subsistence farmers in the Porto Seguro Sustainable Development Project in Marabá, Pará, Brazil, evaluating the importance of this resource for the preservation of local traditions and the valorization of sociobiodiversity. Data was collected between November 2019 and October 2020 through semi-structured interviews and guided tours of eight family units, with the aid of an audio recorder, photographic records and field diary reports. The data was interpreted qualitatively and quantitatively through the systematization with Microsoft Excel. A total of 54 species belonging to 30 families were reported, distributed in three productive spaces with economic, protection and maintenance functions of biodiversity: the forest, farms and the AFS. The investigated AFSs are mostly composed of fruit trees, do not have a specific model and show a strong correlation with the factor age. The importance value of the species ranged between 0.13 and 0.50. The lack of technical assistance and support from public authorities poses several limitations to productive practices and socioeconomic reproduction. The survey data reinforce the role of AFSs in the conservation of sociobiodiversity and preserving traditional ways of life.

Keywords: Family agriculture. Sociobiodiversity. Management. Agrarian reform. Agroforestry homegarden.

Sobrevivência nos sistemas agroflorestais do Projeto de Desenvolvimento Sustentável Porto Seguro, Marabá, PA, Brasil: biodiversidade e construção do conhecimento emancipatório

Resumo - O estudo teve como objetivo identificar as formas de uso e manejo, conservação e comercialização de espécies cultivadas em sistemas agroflorestais (SAFs) desenvolvidos por agricultores familiares no Projeto de Desenvolvimento Sustentável Porto Seguro em Marabá, Pará, Brasil, avaliando a importância desse recurso para a manutenção do modo de vida tradicional e a valorização da sociobiodiversidade. A coleta de dados foi realizada entre novembro de 2019 e outubro de 2020, envolvendo entrevistas semiestruturadas e visitas guiadas a oito unidades familiares, com auxílio de gravador de áudio, registros fotográficos e relatórios em diários de campo. Os dados foram interpretados qualitativa e quantitativamente, por meio da sistematização das informações no Microsoft Excel. Foram registradas 54 espécies pertencentes a 30 famílias, distribuídas em três espaços produtivos com funções econômicas, de proteção e manutenção da biodiversidade: a floresta, a roça e sistema agroflorestal. Os SAFs estudados são compostos em sua maioria por árvores frutíferas, não possuem um modelo específico e apresentam forte correlação com o fator idade. O valor de importância das espécies variou entre 0,13 e 0,50. A falta de assistência técnica e apoio do poder público gera uma série de limitações para o alcance das práticas produtivas e de reprodução socioeconômica. Os dados da pesquisa reforçam o papel dos SAFs na conservação da sociobiodiversidade e na manutenção do modo de vida tradicional.

Palavras-chave: Agricultura familiar. Sociobiodiversidade. Gestão. Reforma agrária.Quintal agroflorestal.

Supervivencia en los sistemas agroforestales del Proyecto de Desarrollo Sostenible Porto Seguro, Marabá, PA, Brasil: biodiversidad y construcción de conocimientos emancipatorios

Resumen - El estudio tuvo como objetivo identificar las formas de uso y manejo, conservación y comercialización de especies cultivadas en sistemas agroforestales (SAFs) desarrollados por agricultores familiares en el Proyecto de Desarrollo Sostenible Porto Seguro en Marabá, Pará, Brasil, evaluando la importancia de este recurso para el mantenimiento de la forma de vida tradicional y la valorización de la sociobiodiversidad. La recolección de datos se llevó a cabo entre noviembre de 2019 y octubre de 2020, involucrando entrevistas semiestructuradas y visitas guiadas a ocho unidades familiares, con la ayuda de una grabadora de audio, registros fotográficos y reportes en diarios de campo. Los datos fueron interpretados cualitativa y cuantitativamente, a través de la sistematización de la información en Microsoft Excel. Se registraron un total de 54 especies pertenecientes a 30 familias, distribuidas en tres espacios productivos con funciones económicas, de protección y mantenimiento de la biodiversidad: el bosque, el campo y el sistema agroforestal. Los SAFs estudiados están compuestos en su mayoría por árboles frutales, no tienen un modelo específico y muestran una fuerte correlación con el factor edad. El valor de importancia de las especies varió entre 0,13 y 0,50. La falta de asistencia técnica y apoyo por parte del gobierno genera una serie de limitaciones para el alcance de las prácticas productivas y de reproducción socioeconómica. Los datos de la encuesta refuerzan el papel de los SAFs en la conservación de la sociobiodiversidad y el mantenimiento de la forma de vida tradicional.

Palabras llave: Agricultura familiar. Sociobiodiversidad. Gestión. Reforma agraria. Patio trasero agroforestal.

Introduction

The economic experiences carried out in the Amazon were developed on a basis of the productive use of natural resources, low level social capital and minimal agricultural and environmental technology, which resulted in profound socio-environmental transformations (Homma 2015). In this scenario, which is highly dependent on the depredation of biodiversity, the State of Pará continues to suffer territorial changes induced by external "development" policies that has culminated in intense agricultural expansion, with a considerable increase in large-scale grain production and agricultural and livestock management activities (Castelo and Almeida 2015). According to a study prepared by the *Núcleo de Planejamento/Estatísticas* [Center for Planning and Statistics] of the *Secretaria de Desenvolvimento Agropecuário e da Pesca* (SEDAP) [Secretariat for Agricultural Development and Fisheries], the state is among the ten largest grain exporters in Brazil, in which soy is the main agricultural export (50.13%), followed by beef (19.54%) (ASCOM SEDAP 2020).

The expansion of these activities has become increasingly worrying because it is directly related to serious social (concentration of land ownership, land grabbing, unemployment, reduction in the production capacity of traditional foods, among others) and environmental impacts, the main outcome of which is deforestation (Domingues et al. 2014). Among the nine states that comprise the Legal Amazon, Pará was first in the deforestation ranking for 2020, 42% of all registered deforestation, according to the Deforestation Alert System developed by Imazon. Among the ten municipalities that were most targeted by these actions, six are in Pará: Altamira, São Félix do Xingu, Itaituba, Novo Progresso, Portel and Pacajá (Imazon 2021).

In southeastern Pará, the forms of exploitation adopted by agricultural establishments followed this rationale, since they were based on the implementation of monoculture pastures and extensive management of beef cattle, among both large and small producers, resulting in severe damage to ecosystems and devastation of the forest that was used for Brazil nut plantations. This attracted a lot of criticism due to its predatory character and the need to promote a productive model that respects the basic principles of sustainable management of agroecosystems (Oliveira et al. 2016; Silva et al. 2019).

The biggest challenge in dealing with the problematic of the environment in the Amazon, according to Silva et al. (2013), consists of balancing territorial actions in an equitable manner through the optimization of natural resources and, subsequently, containing the expansion of deforestation by making better use of deforested areas through more advanced and intensive technologies. Thus, agroforestry systems (AFSs), designated as "forms of land use and management, in which trees or shrubs are used in association with agricultural crops and/or animals, in the same area, simultaneously or in temporal sequence" (Dubois 1996, p. 3), constitute a productive alternative in previously altered landscapes, reducing the need for forest clearing, breaking the cycle of migratory agriculture and extensive cattle raising (Smith et al. 1998).

Compared with monocultures, AFSs stand out due to the synergy that occurs between the components of the ecosystem, helping to improve soil quality and fertility, water conservation, pest and disease control, carbon sequestration, biodiversity conservation and maintenance, the resilience of systems and increased multifunctionality of agriculture in many rural communities (Oliveira et al. 2018). Family farming in Pará shows experiences involving these systems are known to be viable, since in addition to contributing to essential ecosystem services, they provide the basic needs of families, generating food and income throughout the year through the sale of surplus production (Castro et al. 2017; Santos et al. 2019; Soares 2019).

The traditional peoples of the Amazon have extensive knowledge about the management of AFSs, mainly of the agroforestry homegarden, which is represented by the grouping of components in areas adjacent to the residences, requiring low management, little use of inputs or external labor, in addition to subsidize in several aspects the food security of family farmers and the conservation of genetic biodiversity in situ (Damaceno and Lobato, 2019).The adoption of this production model by family farmers expresses the importance of traditional populations in the construction and management of agrobiodiversity, in reducing deforestation, and demystifying the idea that the less favored farmers are mainly responsible for the destruction of forests (Abreu et al. 2017).

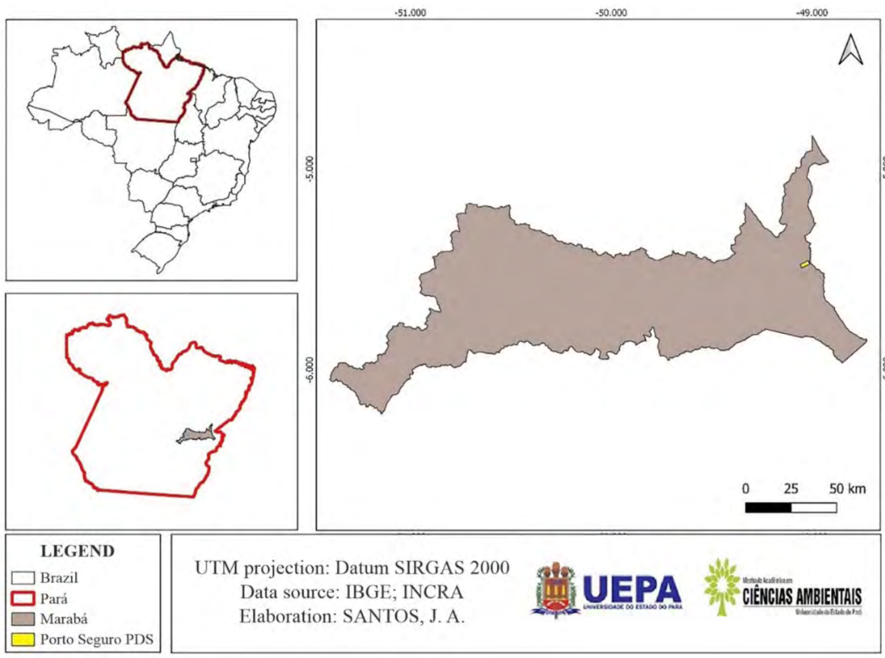
Therefore, this article aimed to identify the forms of use and management, conservation and commercialization of species grown in agroforestry systems developed by family farmers in the *Projeto de Desenvolvimento Sustentável* (PDS) [Sustainable Development Project] Porto Seguro in Marabá, southeastern Pará, Brazil, evaluating the importance of this resource for maintaining the traditional way of life and the valorization of sociobiodiversity.

Material and methods

Study Area

The study was conducted in the region comprising the area covered by the Porto Seguro PDS, located in the municipality of Marabá (5°22'12" S; 49°7'1" W) in the southeast mesoregion do Pará, Brazil (Figure 1). The municipality is located between two large rivers (Itacaiúnas and Tocantins) and has a historical evolution of urbanization linked to development policies and various economic cycles that were fundamental for population growth, such that today it is considered an important economic and administrative center in a vast region of the "Amazon agricultural frontier" (Sousa et al. 2017).

Figure 1. Map of the study area location, in the east of the municipality of Marabá, southeastern Pará, Brazil.



The Porto Seguro PDS occupies an area of 1,069 hectares located on highway BR-155, Km 14, in the rural area of Marabá, PA, Brazil. It consists of a type of settlement that is environmentally differentiated because it is an old Legal Reserve area, the second in the PDS modality created in the area covered by the Regional Superintendence of Marabá (SR – 27).

Research participants and sampling procedures

The research was conducted with family farmers settled in Porto Seguro PDS. The sample universe was defined using the "snow ball" technique (Vinuto 2015), which selected farmers through non-probabilistic sampling. This procedure consists of the indication of new participants from the network of acquaintances of the individuals already present in the sample, forming chains of reference, allowing us to evaluate the relationships between these individuals, in addition to individual information. To begin we contacted the president of the *Associação dos Pequenos Agricultores Familiares do Projeto de Assentamento Porto Seguro* [Association of Small Family Farmers of the Porto Seguro Settlement Project], Dona Maria, who helped throughout the study, playing a fundamental role in data collection and reflection, mainly because she was one of the founders of the PDS. Of the 37 family units (FUs), only eight participated in this research, as the presence of the AFS was a priority factor for inclusion.

This project was submitted to *Plataforma Brasil* under protocol CAAE 33468920.0.0000.860 and approved by the Research Ethics Council of the State University of Pará, according to specialist assessment no. 4.218.187. For ethical reasons, we used pseudonyms to preserve the farmers' identities.

Data collection and analysis

Data collection took place from November 2019 to October 2020, involving semi-structured interviews with a member of each FU who was willing to participate in the study, allowing other people from the same FU to also collaborate during dialogue if they chose to (Gonçalves and Lucas 2016). Before the new coronavirus pandemic (SARS-CoV-2) worsened, regular visits were made to the settlement to conduct these interviews and guided tours in the eight FUs, with the aid of an audio recorder, photographic records and reports in field diaries (Albuquerque et al. 2008), in which each farmer, local expert, presented the productive spaces developed in their FU. The data required to complete the study were collected remotely, without new participants.

The interviews were conducted using previously prepared forms consisting of open and closed questions. The questions addressed the profile of the farmer and the agricultural establishment, traditional knowledges and understanding, the productive spaces they developed, and the description of AFSs. An inventory of the species existing in the farmers' AFSs was prepared, including details of the origin of the seeds and/or seedlings, their forms of use and commercialization. At the beginning of the interview, the free listing technique was used (Albuquerque et al. 2010), where each farmer was encouraged to mention the species considered important regardless of the type of use. These data supported the determination of the importance values (IVs) of the species present in the AFSs, which was calculated according to Silva et al. (2010). This value measures the proportion of informants who cited a species as the most important in values ranging from 0 to 1, using the following formula (Veiga and Scudeller, 2011):

$$IVs = nis / n$$

Where:
nis is the number of informants who consider a plant the most important species; and
n is the total number of informants.

To illustrate the typologies found in the settlement AFSs, including the biological and non-biological components of the landscape, approximate batch size, organization of crops, a schematic sketch was drawn representing the grouping of the composition of plants preserved in different spaces of the FU (Silva and Lucas, 2019). This organization followed that observed *in loco*, and the choice of graphic elements respected the largest number of citations by the families interviewed.

Analysis of the qualitative-quantitative data was performed through the interpretation of information from the forms, field notes and photographs (Albuquerque et al. 2008), all systematized in Microsoft Excel spreadsheets to group and determine patterns of absolute and relative frequency, produce graphs, tables and flowcharts.

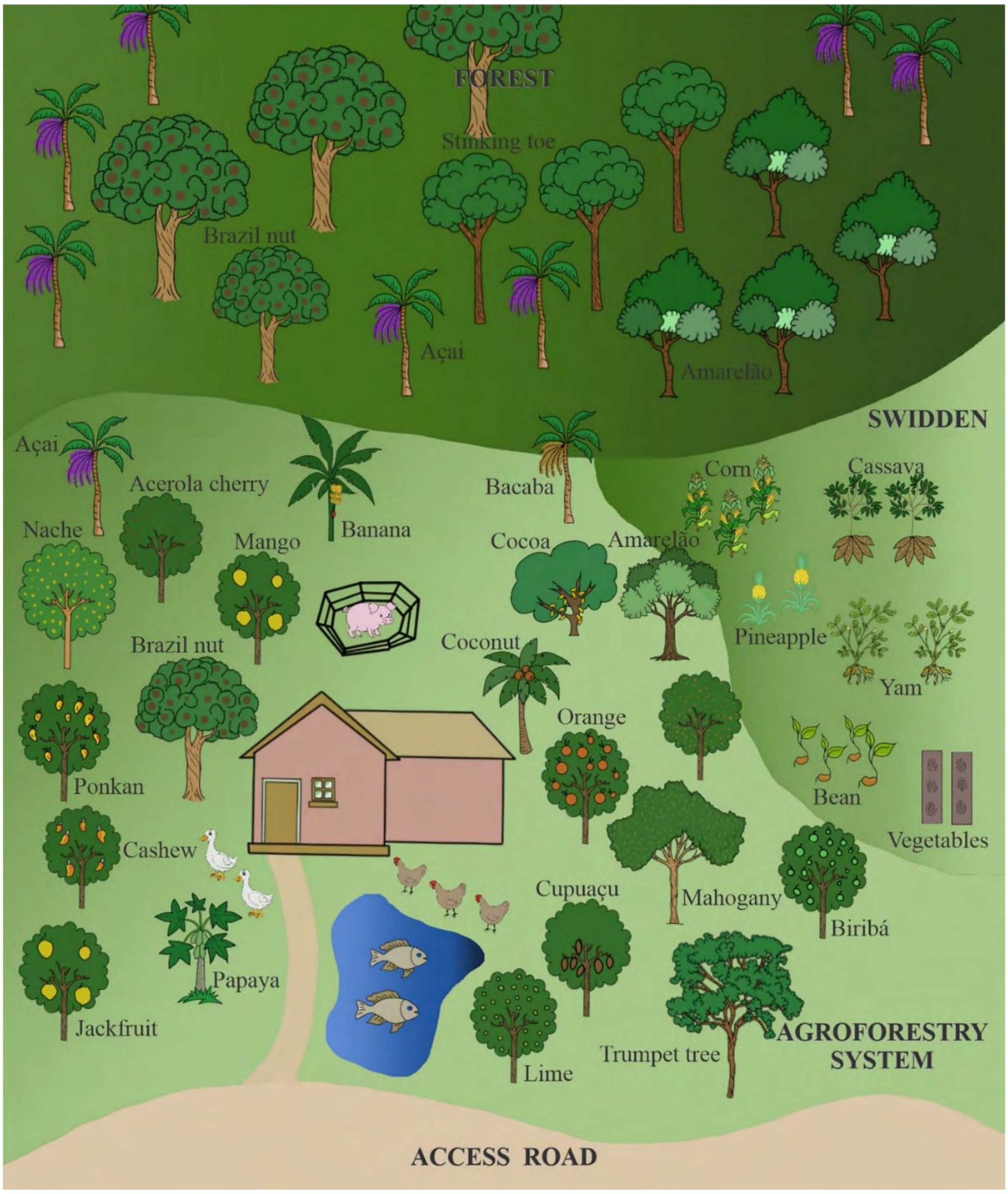
Results and discussion

Eight family farmers took part in the research, six women and two men, aged between 35 and 70 years old, from Pará (37.5%), Maranhão (37.5%), Goiás (12.5%) and Tocantins (12.5%). Most respondents (75%) gained access to their lot through the struggle for land, collective actions of occupations and encampments that resulted in the families being benefited by the National Agrarian Reform Program (PNRA/INCRA); the remainder obtained their lots by purchasing them from former settlers. These families cultivate both native and introduced species in peridomicile homegardens, swiddens, and the forest, demonstrating ample knowledge acquired through family transmission and the exchange of experiences with neighbors.

Cultivation systems and spatial organization of AFSs

In all the FUs visited, three productive spaces were identified that had economic, protective and biodiversity maintenance functions: the forest, the swidden and the AFS. Altogether, 54 species were registered, distributed among 30 families, cultivated and managed in the three productive spaces. The main components of these three systems demonstrate the great diversity of species available, mainly of fruit trees (Figure 2).

Figure 2. A diagram of the organization of production systems (the forest, swidden and agroforestry system) developed by family farmers in the area covered by the Porto Seguro Sustainable Development Project (Marabá, PA, Brazil).



In the forestry area, only eight species (12.1%) were mentioned, being directly related to local knowledge about the use of these resources (shade, wood, food). Despite the recognized diversity in the forest area of the settlement, only the species mentioned by the farmers were kept in this study. In the swidden were 14 species (21.3%), and in the agroforestry homegardens, 44 (66.6%). Some species appear in more than one space (Table 1).

Table 1. The use and occurrence of species and the varieties cultivated and managed in productive spaces in the family units that were visited during fieldwork in the catchment area of the Porto Seguro Sustainable Development Project (Marabá, PA, Brazil).

FAMILY **species/variety** Portuguese (English if available)	**Scientific name**	**Occurrence (productive space)**	**Use**
ANACARDIACEAE			
Caju (Cashew)	*Anacardium occidentale* L.	HA	F+C
Cajá (Spondias mombin)	*Spondias* sp.	HA	F+C
Manga rachadinha	*Mangifera indica* L. (var. Mangarita)	HA	F+C
Manga rosa	*Mangifera indica* L. (var. Rosa)	HA	F+C
Manga fiapo	*Mangifera indica* L. (var. Fiapo)	HA	F+C
ANNONACEAE			
Ata (Sugar apple)	*Annona squamosa* L.	HA	
Biribá	*Annona mucosa* Jacq.	HA	F
Graviola (Soursop)	*Annona muricata* L.	HA	F
APIACEAE			
Chero verde (Parsley)	*Petroselinum crispum* (Mill.) Fuss	S	F+C
Chicória (Coriander)	*Eryngium foetidum* L.	S	F+C
ARECACEAE			
Açaí precoce (Açai)	*Euterpe oleracea* Mart.	HA/F	F
Bacaba	*Oenocarpus bacaba* Mart.	HA	F
Coco (Coconut)	*Cocos nucifera* L.	HA	F
Coco babaçu (Babassu palm)	*Attalea speciosa* Mart. ex Spreng.	HA	NU
Pupunha (Peach palm)	*Bactris gasipaes* Kunth.	HA	F+C
ASTERACEAE			
Alface (Lettuce)	*Lactuca sativa* L.	S	F+C
BIGNONIACEAE			
Ipê rosa (Pink Trumpet tree)	*Tabebuia heptaphylla* (Vell.) Toledo	HA	NU
Ipê amarelo (Yellow Trumpet tree)	*Tabebuia serratifolia* (Vahl) Nicholson	HA/Fr	NU
BRASSICACEAE			
Couve (Wild cabbage)	*Brassica oleracea* L.	S	F+C
BROMELIACEAE			
Abacaxi (Pineapple)	*Ananas comosus* (L.) Merril	HA/S	F+C

FAMILY species/variety Portuguese (English if available)	**Scientific name**	**Occurrence (productive space)**	**Use**
CARICACEAE			
Mamão (Papaya)	*Carica papaya* L.	HA	F+C
CUCURBITACEAE			
Abóbora (Butternut squash	*Cucurbita moschata* Duchesne	S	F+C
Melancia (Water melon)	*Citrullus vulgaris* Schrad.	S	F
DIOSCOREACEAE			
Cará (Yam)	*Dioscorea guianensis* R. Knuth	HA/S	F+C
EUPHORBIACEAE			
Mandioca branca (Cassava white)	*Manihot* sp. (cv. Branca)	HA/S	F+C
Mandioca cacau (Cassava cocoa)	*Manihot* sp. (cv. Cacau)	HA/S	F+C
FABACEAE - CAES.			
Amarelão	*Apuleia leiocarpa* (Vogel) J.F. Macbr.	HA/Fr	M
Jatobá (Stinking toe)	*Hymenaea courbaril* L.	HA/Fr	M
FABACEAE			
Amendoim (Peanut)	*Arachis hypogaea* L.	HA	F
Copaíba (Copaiba)	*Copaifera multijuga* Hayne	HA/Fr	M
Cumaru (Tonka bean)	*Dipteryx odorata* (Aubl.) Willd.	HA	F
Fava (Lima bean)	*Phaseolus lunatus* L.	HA/R	F+C
FABACEAE - MIM.			
Ingá cipó torcido (Ice cream bean)	*Inga edulis* Mart.	HA	F
Ingá do mato	*Inga heterophylla* Willd.	HA	F
FABACEAE - PAP.			
Feijão de corda (Black-eyed pea)	*Vigna unguiculata* L. Walp	HA/S	F+C
LECYTHIDACEAE			
Castanha do Pará (Brazil nut)	*Bertholletia excelsa* Bonpl.	HA/Fr	F+C
MALPIGHIACEAE			
Acerola (Acerola cherry)	*Malpighia punicifolia* L.	HA	F+C
Murici amarelo (Nache)	*Byrsonima crassifolia* (L.) Kunth	HA	F+C
Murici Vermelho	*Byrsonima ligustrifolia* A. Juss.	HA	F+C

FAMILY **species/variety** Portuguese (English if available)	**Scientific name**	**Occurrence (productive space)**	**Use**
MALVACEAE			
Cacau verde (Cocoa bean green)	*Theobroma cacao* L. (var. Forasteiro)	HA	F+C
Cacau comum (Cocoa bean common)	*Theobroma cacao* L. (var. Forasteiro)	HA	F+C
Cacau nativo (Cocoa bean criollo)	*Theobroma cacao* L. (var. Criollo)	HA	F+C
Cupuaçu nativo (Cupuaçu native)	*Theobroma grandiflorum* (Willd. ex Spreng.) K. Schum.	HA	F+C
Cupuaçu melhorado (Cupuaçu improved)	*Theobroma grandiflorum* (Willd. ex Spreng.) K. Schum.	HA	F+C
MELIACEAE			
Mogno (Mahogany)	*Swietenia macrophylla* King.	HA/Fr	NU
MORACEAE			
Jaca mole (Jackfruit soft)	*Artocarpus heterophyllus* Lam.	HA	F
Jaca dura (Jackfruit hard)	*Artocarpus heterophyllus* Lam.	HA	F
MUSACEAE			
Banana chifre de boi	*Musa paradisiaca* L.	HA	F+C
Banana conquista	*Musa* sp. (var. BRS Conquista)	HA	F+C
Banana de fritar	*Musa paradisiaca* L.	HA	F+C
Banana maçã (Apple banana)	*Musa* sp. (var. BRS Maçã)	HA	F+C
Banana pratinha	*Musa* sp. (var. BRS Pratinha)	HA	F+C
Banana Vitoria	*Musa* sp. (var. BRS Vitória)	HA	F+C
MYRTACEAE			
Ameixa (Java plum)	*Syzygium cumini* (L.) Skeels	HA	F
Goiaba branca (Guava common)	*Psidium guajava* L. (cv. Kumagai)	HA	F
Goiaba vermelha (Guava red)	*Psidium guajava* L. (var. Paluma)	HA	F
Goiaba amarela (Guava yellow)	*Psidium guajava* L. (cv. Kumagai)	HA	F
Jambo (Rose apple)	*Syzygium malaccense* (L.) Merr. & L.M. Perr	HA	F
PASSIFLORACEAE			
Maracujá melão (Passion fruit)	*Passiflora edulis* Sims	HA	F
PIPERACEAE			
Pimenta do reino (Black pepper)	*Piper nigru* L.	S	F
POACEAE			
Milho (Corn)	*Zea mays* L.	S	F+C

FAMILY species/variety Portuguese (English if available)	Scientific name	Occurrence (productive space)	Use
RUTACEAE			
Laranja (Orange)	*Citrus sinensis* L. Osbeck (var. Pera-rio)	HA	F+C
Laranja tanja (Mandarin orange)	*Citrus reticulata* Blanco	HA	F+C
Laranja da terra (Seville orange)	*Citrus x aurantium* L.	HA	F
Limão caipira (Rangpur)	*Citrus* L.	HA	F+C
Limão Tahiti (Sweet lime)	*Citrus* L. Tanaka	HA	F+C
Tanja pocãn (Ponkan)	*Citrus reticulata* Blanco	HA	F+C
SAPOTACEAE			
Maçaranduba (Manilkara huberi)	*Manilkara huberi* Chevalier	HA/Fr	NU
SAPINDACEAE			
Pitomba	*Talisia* sp.	HA	F
SOLANACEAE			
Pimenta de cheiro (Chili pepper)	*Capsicum annuum* L.	S	F+C
Pimentão (Pepper)	*Capsicum* sp.	HA	F+C
Pimenta malagueta (Tabasco pepper)	*Capsicum frutescens* L.	HA	F+C

HA, Homegarden Agroforestry; S, Swidden; Fr, Forest; F, Food; C, Commercialization; M, Medicinal; NU, No defined use.

In the forest system, farmers (100%) extract açaí (*Euterpe oleracea* Mart.) and *Castanha do Pará* (*Bertholletia* excelsa Bonpl.), which are primarily intended to feed the family, though any surplus is sold. Species like *jatobá* (*Hymenaea courbaril* L.), *Amarelão* (*Apuleia leiocarpa* (Vogel) J.F. Macbr.) and *Copaiba* (*Copaifera multijuga* Hayne) have medicinal uses; the others, not mentioned in a specific category, are maintained used as components of the landscape and for the comfort of shade. In contrast, vegetables and herbs are cultivated in ground beds fertilized with cattle manure, and all the species present in the swidden area are intended for family food and commercialization. Corn (*Zea mays* L.) and *mandioca* (*Manihot* sp.) are also used as feed for the animals (pigs, chickens and ducks) raised in the homegarden.

The implementation of the AFSs range between 6 and 16 years, they occupy a small area of land (on average 0.8 ha) and are located close to the families' homes, using a spatial and temporal structure of a type of agroforestry homegarden (Dubois 1996; Silva et al. 2018). Damaceno et al. (2019) describe this model of AFS as common among family farmers due to the possibility of exploiting a high diversity of plant species that are reserved for subsistence feeding and income generation, contributing to food security (Garcia et al. 2015) and more efficient use of natural resources (Altieri 2012).

However, there were variations in arrangements that broke with the "common model," such as AFS (P7) developed by Dona Ana, a 65-year-old widow and the only resident on her lot, which has uniform, minimally diversified production with a predominance of one species: cupuaçu (*Theobroma grandiflorum* (Willd. ex Spreng.) K. Schum.). Due to its wide acceptance for consumption and commercialization, cupuaçu is the most cited fruit (42%) in publications on AFSs in the Brazilian Amazon from 1980 to 2005, according to the bibliographic database cataloged by Brienza Júnior et al. (2010), which reinforces the viability and importance of this species for the region.

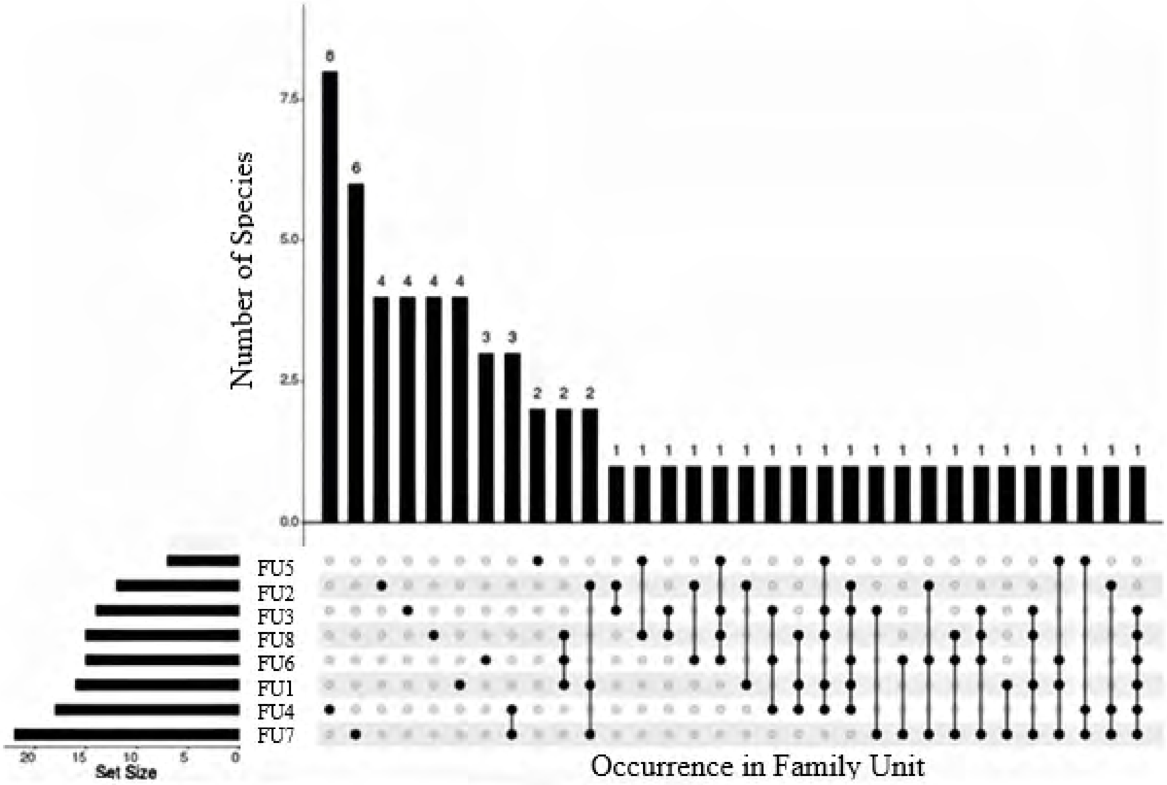
In the AFSs investigated, fruit trees were the most frequent specie, and of these the most common were: *cupuaçu*, *banana* (*Musa* sp.), *cacau* (*Theobroma cacao* L.), *açai*, *papaya* (*Carica papaya* L.) and *goiaba* (*Psidium guajava* L.). These and other fruits form part of the daily diet of the families and are consumed both *in natura* and processed as juices and sweets. Added to this is the use of agroecological transition strategies by extensionists of this group, prioritizing species known to farmers as a viable and solid way to increase the resilience of the system (Caporal, 2020). According to Vieira et al. (2012), this preference is quite common in the Amazon and is related to the food security of the families and the demands of local markets.

Agroforestry homegardens play an important role in the food security of family farmers, as the abundance of species found (mainly food species) provides a healthy diet that provides vitamins and minerals for the maintenance or nutritional improvement of the organism. In addition, the diversification of this production system results in safe food throughout the year, since there are productive seasonalities, that is, several crops throughout the year free of agrochemicals and healthier (Garcia et al., 2015).

Species cultivated in AFSs and their correlations

Among the species cultivated in the AFSs (Figure 3), the most frequent was cupuaçu, occurring in six of the eight areas visited, followed by apple banana (*Musa* sp. var. BRS maça) and *castanha do Pará*, which occur in five areas. The more frequent occurrence of these species is due to regional cultural traditions, since they form part of the daily food of the farmers, conferring commercial value and high market demand, while the incentives of the Pastoral Land Commission technicians, who consider the opinion and prior knowledge of farmers concerning their management, have encouraged their use in the arrangements of the AFSs, providing support with seedling donations, trainings and courses. Regarding the frequency of Brazil nuts (*castanheiras*), the fact that the settlement was created in a Legal Reserve area predominantly consisting of native Brazil nut trees influenced its high use by the farmers.

Figure 3. Distribution of the number of species cultivated in the agroforestry systems of the family units studied in the area covered by the Porto Seguro Sustainable Development Project (Marabá, PA, Brazil). The bars on the left indicate the total number of species recorded in each of the family units (FU) studied. The upper bars indicate the number of unique species in each of the family units. The connected dark dots in the bottom panel indicate which family units (FU) share a particular set of species.



Of the species and varieties cultivated, 35 (48.6%) occur in at least one of the eight areas visited, indicating that there is no pre-established pattern among farmers in the choice of components that integrate these systems. The plant diversity found is distributed in different arrangements, such that their priority is based on the preferences and needs of the families. No species was common to all the areas.

This result demonstrates the importance of conserving the diversity of species, the individual potential of each system to have different styles and combinations, and the autonomy of the settlers over the selection of species, without necessarily serving only the market, but in compliance with food security and ecological value. This distinction is due to the different motivations observed in the research data: a) family interests (food and/or economic); b) usable size of the area; c) available workforce; d) productive strategies; and e) knowledge of the farmer in the management of the species and expected agroecological benefits. In the AFSs developed in FU1, FU2 and FU3 where labor availability is low, the species cultivated are those that meet the food options of the families, the regulation of air temperature and soil conservation, while in the remainder, the farmers have given greater consideration to the management practices involved and the economic potential of the species.

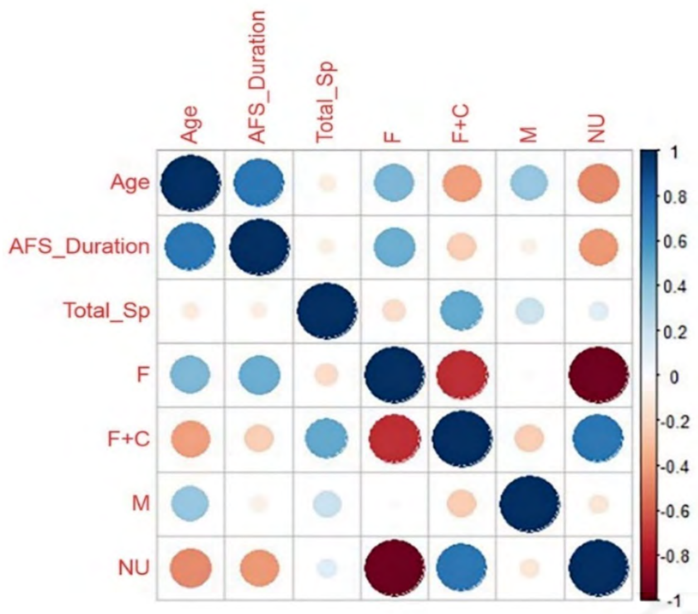
However, the intersections between the sets of species identified in the graphic also indicate the lack of organization and difficulty in carrying out collective work, which is one of the main obstacles to accessing commercialization channels due to low production, which leads most to use intermediary agents, so that the prices charged end up not covering the costs, resulting in indebtedness, a reason for dissatisfaction for many of them. Even though the farmers maintain collaborative ties among themselves, the exercise of the activities of the AFSs is best characterized as "everyone for themselves…" eliminating the possibility of joint actions that, if well organized, could expand market options and minimize production and technological difficulties, particularly because this is a relatively small group.

The interaction and collaboration between family farmers were analyzed by Santos et al. (2017) and Schwab et al. (2020), who determined them to be essential qualities that enable alternative systems for the commercialization of products of agroecological origin, that strengthen interpersonal relationships and improve living conditions, providing autonomy and food sovereignty to rural families, allowing for a new local dynamic through the enrichment of productive activities from a social, environmental and economic viewpoint.

According to the farmers, 80% of the cultivated species come from seeds and seedlings donated by the Municipal Secretariat of Agriculture (SEAGRI) and by the Pastoral Land Commission; of the remaining 20%, 15% are native and only 5% were purchased. The diversity of species is satisfactory, since it meets food demands throughout the year and also generates surpluses that are destined for commercialization. In agreement with these statements, Gonçalves et al. (2017) and Mayer et al. (2018) pointed out that diversified production, in addition to enabling different food options and ensuring a continuous income, also exerts positive effects on the microclimate and thermal regulation in the lots, contributing to the thermal comfort and well-being of families, harmonious coexistence with nature, and a reduction in the risk of frustrations resulting from climatic adversities.

Another fact worth mentioning is that the correlations between the age of the interviewees and the duration of the AFS and the percentages of types of use of these species, while not significant, show that the consumption of species as food increases with age and the duration of the AFS, while the percentage of species without some type of use decreases (Figure 4). In addition, the older the respondent is, the lower the commercial use of the species and the greater the medicinal use. Those with the highest number of species in the AFS are those that make the most commercial use of these species.

Figure 4. Correlation between the age of the farmers interviewed and the AFS duration with the percentages of types of use of plant species. **Note:** Positive relationship: blue dot; Negative relationship: red dot. The darker the dot, the stronger the relationship. (F, food; F+C, food and commercialization; M, medicinal; NU, no defined use).



Age has been a preponderant factor in the adoption and the form of use of species in rural areas, given that, as the farmer gets older, their productive capacity for working in the field is reduced, which requires less physically demanding activities. Furthermore, Pompey et al. (2011) observed that the receipt of retirement and/or old-age pensions has an influence on the exploitation of species and, consequently, their lower commercial use, since the AFSs are no longer the main source of income for the families. This situation does not reduce the potential benefits of the systems, as they provide a variety of environmental and ecosystem services, contributing directly to the environment.

In addition, this combination of retirement and exclusively subsistence production has been essential to reducing rural exodus, according to studies by Boscardin and Spanevello (2019), since it ensures that older farmers remain on the lots, have better conditions of life and access to better quality food options. As for young people, the low quality of education, combined with many other difficulties, lead them to migrate to urban centers in search of better living conditions through non-agricultural activities. It is young people who often experience social and economic problems in a dramatic way that expose them to the need to choose between leaving or staying in the countryside, with the need to create strategies for permanence to guarantee labor and production with surplus for commercialization.

Importance value

In terms of biodiversity and socioeconomic factors, the importance value (IVs) can be used as an ecological indicator, significantly assisting decision-making related to the planning and maintenance of production systems that take into account priority species for the community or some part of it (Oliveira and Amaral 2003). Thus, the IVs was calculated for the species of the AFSs cited as the most important in the FUs we visited: it ranged between 0.13 and 0.50 (Table 2). Fruit trees were frequently listed, with cupuaçu (0.50) and banana (0.38) showing the highest values, because they are highly productive and have a great influence on the family's diet and income since they are species that have commercial value and a viable cost/benefit ratio in the region. *Abacaxi* (Ananas comosus (L.) Merril), *açaí, castanha do Pará, goiaba* and *mogno* (*Swietenia macrophylla* King.) had the lowest index (0.13).

Table 2. List of the most important species cited within the AFSs studied and their respective importance values (IVs).

Species Portuguese (English if available)	**Scientific name**	**IVI**
Cupuaçu	*Theobroma grandiflorum* (Willd. ex Spreng.) K. Schum.	0.50
Banana	*Musa* sp.	0.38
Mandioca (Cassava)	*Manihot* sp.	0.25
Limão (Lime)	*Citrus* sp.	0.25
Laranja (Orange)	*Citrus sinensis* L. Osbeck	0.25
Cacau (Cocoa)	*Theobroma cacao* L.	0.25
Acerola (Acerola cherry)	*Malpighia punicifolia* L.	0.25
Abacaxi (Pineapple)	*Ananas comosus* (L.) Merril	0.13
Açaí	*Euterpe oleracea* Mart.	0.13
Castanha do Pará (Brazil nut)	*Bertholletia excelsa* Bonpl.	0.13
Goiaba (Guava)	*Psidium guajava* L.	0.13
Mogno (Mahogany)	*Swietenia macrophylla* King.	0.13

Results similar to these were obtained by Pereira et al. (2018) in agroforestry homegardens in southwestern Pará, where the category "food plants" had the highest commercial value, and *cupuaçu* and *banana*, due to the food safety factor and sale of surplus, obtained importance indices of 0.54 and 0.35, respectively. According to the farmers' reports, both *cupuaçu* and *banana* have shown satisfactory results in the development of AFSs, and from an environmental viewpoint, by improving the use of the soil with rapid deposition of biomass and due to the low dependence on labor. In the Amazon, experiences with socioeconomic and environmental analysis of AFSs confirm the benefits of including these species on the stability of the activity (Bentes-Gama et al. 2005; Lacerda et al. 2013).

Regarding the pattern and low values observed for the remaining species, the absence of a specific model among the AFSs evaluated seems to have influenced this result, since each farmer expresses their particular identity, in which the choices of species are modeled accordingly the needs and preferences of the family. This fact is evidenced by the biodiversity encountered and by the different degrees of importance, not necessarily reflecting the low valuation of these vegetables by the community, since traditional knowledge, management that respects the conditions of the ecosystem, and the inclusion of these resources in the daily food of the families is also an effective way of conserving cultural and biological diversity (Silva and Lucas 2019).

The results obtained highlight the traditional dynamics of land use in family farming, and can serve as elements of public policies that respect the singularities of each system. From the perspective of ethnobotanical and ethnoecological studies, as knowledge is directed to species of greater significance, the potential and limitations for the maintenance of these systems, together with traditional customs and knowledge, are elements fundamental to educational and management actions that aim to increase the value of knowledge for the conservation of local biocultural diversity (Pereira et al. 2018).

Management and conservation of species present in AFSs

AFSs are managed through traditional practices using simple, low-cost technologies. Planting and replanting are done manually due to the lack of machinery, without prior preparation of the area and by directly seeding and/or transplanting seedlings. There is no fertilization and irrigation, and the main cultivation treatment is the clearing of spontaneous and undesirable plants by manual removal. According to that reported by 46.1% of respondents, species like cocoa and cupuaçu require regular pruning, which helps provide larger and better fruit production and avoids competition for nutrients, water and lighting (Sousa 2005).

In general, AFSs present a plant diversity capable of directly contributing to the reduction of pests and diseases (Coelho et al. 2017). However, the imbalance of external factors, such as climate, management, soil and nutrition, can provide an opening for the emergence of phytosanitary problems with severe economic damage (Gadelha 2018;). In the different AFSs arrangements, the occurrence of insect-pests and diseases in species with significant socioeconomic relevance was common (Table 3).

Table 3. The most frequently occurring pests and diseases in the agroforestry systems visited in the Porto Seguro Sustainable Development Project (Marabá, PA, Brazil).

Insect-pests or disease	**Species affected** Portuguese (English if available)	**Treatment adopted by local farmers**
Ants	Cacau (Cocoa)	Eliminate the plants
Moths	Tanja Pocãn (Tanja Ponkan)	Light traps
Fruit fly	Manga (Mango)	More resistant plants
Fruit mummification	Goiaba (Guava)	Alternative defenses (insecticide
Witches' broom disease	Cupuaçu	solutions and plants)

The control strategies adopted by farmers follow the assumptions of agroecology and consist of eliminating the plants attacked, installing light traps, cultivating more resistant species, and spraying alternative defenses, such as Bordeaux mixture and aqueous extract of Neem (*Azadirachta indica* A. Juss), garlic and smoke. These methods are accepted by organic agriculture, however, Lopes et al. (2019) highlighted that the best option to maintain plant health in the medium and long term is to prioritize the dynamic balance of agroecosystems through the redesign of production units and the rural landscape, with a focus on increasing agrobiodiversity, ecological complexity and environmental adaptation.

Regarding the frequency of management, 62.5% do so only when necessary, 12.5% monthly, 12.5% every three months, and another 12.5% once a year. Farmers showed great concern with regard to the management techniques used to conserve biodiversity and use natural resources, since they understand that these factors are priorities for the good performance of ecosystems and, consequently, for the optimization of productive capacity and income generation. However, through rapid diagnosis of the soil structure, Almeida et al. (2018) observed that the soil in the settlement presents regular structural quality, which demonstrates that the cultivation practices adopted by farmers are not sustainable. However, one fact that may have contributed to this result is related to annual fire invasions from neighboring properties, since the settlement is surrounded by farms that use fire as a technique for pasture cleaning and renewal.

The fire episodes promoted by the external invasion of agro-pastoral fires are implicated in the continuous change in the socio-spatial environment and in the production structure, resulting in significant losses of forest and cultivated areas, making the presence and effectiveness of public agencies necessary in the inspection of such activity, as well as conducting courses, training and talks on preventing and fighting forest fires for the farmers.

Regarding the conservation of plant resources, only 11.7% of the seeds and seedlings of the aforementioned species are selected, stored and shared among the group. Emperaire and Peroni (2007) stated that the circulation of varieties without individual appropriation is a key element in the diversity and conservation of local varieties. Of the eight FUs visited, only one showed a direct contribution to the maintenance of variability within species through the use of the grafting technique (Lopes et al. 2016).

The low incidence of practices aimed at protecting these resources among farmers contradicts the principle underlying the role of the farmer, that of an agent active in the conservation of local genetic resources, and signals the need for awareness and greater encouragement in the propagation of activities that address participatory improvement (Machado 2014) through the sharing, protection and maintenance of species. Noda et al. (2003) reflected that this practice benefits traditional populations in terms of the use of readily available resources, maintains the system functioning permanently and promotes access to, allocation and regularization of the land and other ecosystems.

Production schedule and chain of commercialization

The production calendar that guides the activities of farmers is determined by the municipality's climatic conditions. Cultivation takes place throughout the year; however, the largest part (86.6%) is concentrated in the rainy season from October to March. Regarding the harvest, the fact that the plantations are diversified allows the farmer to obtain production throughout the year, with 39.8% harvested between January and March, 30.5% between April and June, 16.6% between October and December and 12.9% between July and September. This stage is done manually, in the early morning or late afternoon, periods when the temperatures are milder.

In the post-harvest period, the production obtained goes through a number of stages before being consumed or commercialized: cleaning, selection, transformation, storage and transportation. During cleaning, impurities from the field are removed by washing in running water; next comes the selection of products that will be part of the family diet and those that will be sold. During selection, appearance and ripening phase are verified. The transformation step is only performed on some fruit (*cupuaçu*, *maracujá melão* (*Passiflora edulis* Sims), *acerola* (*Malpighia punicifolia* L.), and *goiaba*) and on *mandioca*, from which pulp, flour, tapioca and *puba* (a dough extracted from fermented cassava) are obtained. Subsequently, both the processed and the *in natura* products are stored in freezers and/or wooden boxes until they are transported to the points of sale. For commercialization, farmers sell their production through conventional short production chains that depend on intermediaries, or through direct sales to the consumer in organized open-air markets.

According to Amador (2017), family farmers' markets in Marabá originate from socio-territorial struggles and play a strategic role in the local economy, in the sociocultural empowerment of the small farmer and in the consumption of healthy foods, both in the rural area and in the city. The PDS goods are sold at three markets in the city: the "farmers' market," a weekly market subsidized by the Municipal Secretariat of Agriculture (SEAGRI) that provides logistical support to the farmers, including stalls, tables and transport; the monthly "university market," located on the campuses of the Federal University of South and Southeast of Pará and the State University of Pará, which has raised the visibility of sales and stimulated encounters between the knowledges of the rural and academic communities. In these times of the COVID-19 pandemic, the farmers sought alternatives to maintain their sales routines and, with the support of the Pastoral Land Commission, began to work with an "online market," in which sales are made via cell phone and delivered to family residences.

Conclusion

The productive dynamics of Porto Seguro PDS family farmers are organized in three areas: the forest, the swidden and the agroforestry system. The AFSs occupy a small amount of land in a spatial and temporal structure of the agroforestry homegarden that play an important role in the food security of family farmers, since the richness of species belonging to 30 families provide healthy food, in addition to generating income with the surplus sale. Among the species, fruit were frequently listed, with cupuaçu and banana showing the highest values, because they are highly productive and have a great influence on the family's diet.

Potential areas of land use and management with immense biodiversity and capable of consolidating local farmers were observed, providing food resources, medicines, creating opportunities for the employment of labor and ensuring financial stability. Agroforestry systems are mostly composed of fruit trees and do not follow a specific model, since the species are selected according to the particularities of each family. Management is based on traditional knowledge, practices using simple, low-cost technologies, supported with few financial resources, being carried out only when necessary, and the circulation of products depends mainly on open-air markets.

Although the AFSs evaluated are promoting income, food and biodiversity conservation, farmers reported a series of difficulties and individual aspirations, which become obstacles to the full development of these activities. The scarcity of water during the dry period, the drop in productivity over the years, difficulties in the outflow of production due to price fluctuations, lack of labor and lack of technical knowledge for managing the AFSs, are some of the limiting factors to the farmers risking investment in the property.

In the current conjuncture, the PDS farmers cannot access public policies specific to family farming, through free technical assistance and credit lines, which makes the challenge of rural workers even greater. If properly managed, the AFSs would bring economic prosperity and environmental balance. Therefore, it is essential that the state fulfill its role and ensure the effective execution of the agrarian reform policy, defining actions so that these farmers are able to live and produce with greater autonomy, especially in the case of a settlement that stands out among others in the region for making sustainable use of natural resources with a view to protecting biodiversity and traditional knowledge.

Moreover, the biodiversity found in agroforestry patterns convey optimistic scenarios for the diversification of landscapes and maintenance of ecosystem services (nutrient cycling, climate and water regulation, carbon sequestration, among others), in addition to the conservation of different species. Through the benefits derived in the environmental, social and economic fields, the AFSs provide conditions for farmers to reach a state of physical and mental well-being that is expressed in a series of feelings (joy, gratitude, hope, belonging, pleasure in living) and values (solidarity, generosity, friendship, patience) that could only be constructed through an intimate relationship with nature, with the community, and with working on the land.

In a micro-region whose economic dynamics are based on the historical depredation of natural resources, the AFSs are configured as a strategic path to minimize the socio-environmental impacts caused mainly by extensive cattle raising. When we consider the strong connections with the land and the harmony of the interviewees with nature, the AFSs emerge as a suitable alternative to the promotion of *good living*, since it guarantees survival, work and quality of life without dominion over what is esteemed as a common good.

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