Article

Plant composition and species use in agroforestry homegardens in the Eastern Amazon, Brazil

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Abstract: Agroforestry homegardens are integrated arrangements of common vegetable plants in areas close to residences, which follow a structure similar to that of tropical forests, with the cultivation of multiple species to meet the basic needs of families, such as the provision of food and medicine, as well as ensuring an environment for other family activities. Considering the importance of these environments, this work aimed to address the composition and use of plant species in agroforestry homegardens, in order to support society initiatives and government policies to strengthen the management of natural resources and individual and collective well-being in the region. For this, 119 homegardens were studied in the municipalities of Belterra, Mojuí dos Campos and Santarém, in the state of Pará, in the Brazilian Amazonia, comprising five different zones (periurban, urban, floodplain, indigenous land and tourist land), obtaining the data via questionnaires and guided visitation by the residents. A total of 5,323 vegetal individual plants were surveyed, distributed in 188 species and 62 botanical families. The data showed that 80.5% of the individual plants are concentrated in 18.6% of the species, with no significant difference in the average of species per homegarden in the five zones. The predominance of species for food use, primarily fruit-bearing, stands out, showing a possible direction for incentive actions and/or for the ordering of public policies and programs aimed at these spaces. Most homegardens have up to 17 plant species; less than half of homegardens have species intended for medicinal use; and there is percentage parity between native plant species and those of exotic origin, where native plants stand out for shading. Agroforestry homegardens play a crucial role in the conservation and cultivation of species for food purposes, with the cultivation or maintenance of plants based on their various purposes, showing distinct profiles of distribution and choice of species, evidencing their socioeconomic and environmental importance. Thus, it is important that these land use systems are valued, investing financial resources in actions and projects aimed at maintaining and enhancing their benefits for the region.

Keywords: agrobiodiversity; agroecosystems; polyculture; home gardens.

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1. Introduction

Agroforestry homegardens are arrangements of plants managed in traditional land-use systems in tropical countries, which may include trees, shrubs, herbaceous and sometimes animals [1], as an activity usually practiced by families in areas close to homes [2]. The structure of a homegarden can resemble that of tropical forests, with canopy strata formation, high plant diversity, and biomass and carbon storage [3, 4].

The implementation of these spaces promotes the cultivation of multiple species to ensure basic needs on the properties [5, 6] as provision of food to families [7, 8, 9]. These environments provide food options that can be enjoyed in natura with different food supply options and food shortage situations [10]. Agroforestry homegardens expand opportunities for income complementation of traditional populations [11, 12], although commercialization is not the main motivating force for homegarden maintenance [13].

These spaces, also known as backyard vegetable gardens, have great botanical richness [14, 2] and have been seen as a way to expand production alternatives, as they are types of agroforestry systems that can present agricultural and forest species in a consortium way [15] as well as presenting agrosilvopastoral characteristics [16], when the animal component is inserted in the interaction. Multistrata agroforestry systems, as in fact the homegardens are configured, stand out from other consortium systems for their greater potential of providing an ecosystem service due to the similarity with natural environments of secondary forest [17] such as homegardens in Belterra, Pará, with meliponiculture [18].

The family relationships established in these environments intensify the sharing of knowledge and interpersonal actions that accumulate knowledge, as well as strengthen crops and soil management, gradually contributing to the perpetuation of local culture [19, 20]. Both the accumulation of traditional knowledge [21], as well as the conservation of local biodiversity [2], are variable responses that indicate the consolidation of production. These land use systems are also spaces for the maintenance and conservation of important memories, associated with family life. According to [22] there is relevance for tradition, values, customs and rural habits, which confirms the need for appreciation beyond environmental and economic measurements.

The ecological and socioeconomic characteristics that are added to the homegardens, with the coexistence of numerous species in the same area, offer a variety of foods throughout the year, collaborating mainly with the food and nutritional security of the family unit [23, 24, 8] and increased family income, with the sale of surplus production [19, 25). Polyculture environments, such as homegardens, can contribute to preventing the collapse of tropical biodiversity [26], potentially towards the achievement of the Sustainable Development Goals [27]. However, despite the economic, social and ecological importance of agroforestry homegardens, few initiatives and actions have been aimed towards their valorization.

Knowing the diversity of species and understanding the breadth of the role that agroforestry homegardens play in the family environment is a key issue to encourage and expand their adoption in the Amazon region. Thus, this work evaluated the composition and use of vegetal plant species in agroforestry homegardens in three municipalities in the western region of Pará, to support initiatives by society and government policies aimed at strengthening the management of natural resources and individual and collective well-being in the region.

2. Materials and Methods

2.1 Definition and delimitation of agroforestry homegardens

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For this research, homegardens[1] were considered to be the environments where there is a combination of vegetal plants with or without animal husbandry, arranged in areas adjacent to the residence [28], where routine family, social and productive activities are commonly carried out. The research universe was based on areas under family responsibility and administration, regardless of ownership of property.

For the physical delimitation of these spaces, information from the interviewees was used, indicating the edges of the homegardens. It should be noted that in some areas surveyed, especially in peri-urban locations, floodplains and indigenous lands, these limits were established by the way activities were handled in the place, with the residents defining the places where the handling of activities is more intensified, such as the realization of sweeps, cleaning or removal of waste, disposal of spaces for the drying of clothes and for hammocks for the resting of the residents, among other activities commonly developed in these places.

2.2 Area of study

The studied area is located in the mesoregion of the Lower Amazon and in the microregion of Santarém. The survey was carried out in the municipalities of Belterra, Mojuí dos Campos and Santarém, in the west of the state of Pará, in the Brazilian Amazonia. Based on demographic density, these municipalities are classified into: predominantly urban (Santarém), adjacent rural (Belterra) and remote rural (Mojuí dos Campos), all with a population unit with moderate or low degree of urbanization [29].

According to [30], the increase in demographic density in the "gray" areas affects areas that are no longer strictly rural and that are not exactly urban, the so-called peri-urban areas, as they are adjacent to the urban centers of the municipalities. Thus, in the peri-urban areas of the three mapped municipalities, communities located between 1.1 and 19.2 km from each urban center were selected.

The predominant climate in the region is of the hot and humid type, with rainfall concentrated in the first half of the year, average annual temperature between 25º and 27ºC, average air humidity of 86%, average annual rainfall of 1,920 mm, varying in terms of monthly rainfall of 170 mm and 60 mm [31], falling within the climate subtype Am3 [32, 33]. The predominant soils are classified as Yellow Latosol [34, 35]. The predominant vegetation is typical of Dense Ombrophilous Forest [36]. There are two well-marked seasons in the year, one where the rains are concentrated, between December and May, and the less-rainy period, between June and November.

For the survey, five different zones were considered in the three selected municipalities, namely: i. Peri-urban – in the communities of Cidade Alta, Colônia São José, Cipoal, Garrafão, Cucurunã, Iruruma, Jacamim, Colônia São Jorge and São Raimundo; ii. Urban – in the central neighborhoods of the three municipalities; iii. Floodplain - in the Alto Jari community, where the vegetation and infrastructure of residence are subject to temporary flooding, with interaction between the aquatic and terrestrial ecosystem for about 4 months; iv. Indigenous land - in the indigenous villages of Muratuba and Paricatuba, located in the Tapajós-Arapiuns Extractive Reserve, belonging to the municipality of Santarém, and, finally, v. Tourist – in the community of Alter do Chão, where there is intense visitation and the economy has a strong influence of the tourist sector, visitation and natural leisure.

The sampling was carried out in 119 homegardens, arranged in the following zones: a) peri-urban (40); b) urban (28); c) floodplain (21); d) indigenous (20) and e) tourist (10). Homegardens in isolated rural areas were not included, due to non-compliance with the population density criterion, or because they do not minimally configure a community agglomeration, with the exception of homegardens in the floodplain area, usually with low demographic density.

2.3 Data collection and analysis

[1] To facilitate the reading of the text, the name "homegardens" was considered the summarized form of " agroforestry homegardens".

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Data were obtained from semi-structured interviews, where the quantity and vernacular name of the plants that make up the homegardens and the use indicated by the interviewees (food, medicinal, ornamental and shading) were recorded.

Sampling was carried out based on the consent of the owners, and the information was collected collaboratively with the interviewees, through observation on a guided tour [37]. To discuss and clarify the objectives of the study, meetings were held with leaders (in the case of the indigenous area) and later, with the owners, seeking verbal consent for the research to be carried out. It was decided to research two of the twenty-one villages of the Tupinambá People, since these served as a support base, facilitating the translocation of personnel, as well as the logistics of collection.

For the identification of the species, life form and origin, a consultation was carried out with specialized virtual sites for the confirmation of the botanical nomenclature [38] and the parabotanist nomenclature of the Federal University of Western Pará. The research was registered with the Genetic Heritage Management Council and with the National System for the Management of Genetic Heritage and of Traditional Knowledge, under access registers No. A6E86AF and A8E5DE0. In the case of indigenous lands, the research was authorized by the leaders, called "caciques" (chieftains).

The study design was completely randomized and the collections were carried out covering the years 2016 to 2019. The analysis in different periods does not compromise the quality of the data, since the character of the homegardens is not affected by environmental variations [39].

Data on number of species (richness) and number of individual plants in the homegardens, divided by the five zones (Peri-urban, Urban, Floodplains, Indigenous and Tourist), were submitted to the normality test through the Kolmogorov-Smirnov test, being considered with normal distribution, since they presented a non-significant p-value at the level of 0.05 for the number of species and individual plants. Thus, the linear association analysis was performed using Pearson's coefficient.

For the correlation analysis between number of species and individual plants, considering all homegardens as a single sample, the Spearman coefficient was used, as a function of non-parametric distribution.

To verify the existence of statistical differences between the areas studied, analysis of variance (ANOVA) was used, with subsequent test of comparison of means by Tukey's test, adopting a significance level of 95%. All tests and statistical inferences were performed with the aid of the Bioestat Software [40].

3. Results

The survey in the homegardens totaled 5,323 individual plants of 188 species belonging to 62 botanical families. There are 13 (thirteen) botanical families (Arecaceae, Malvaceae, Rutaceae, Musaceae, Malpighiaceae, Anacardiaceae, Amaryllidaceae, Myrtaceae, Apiaceae, Fabaceae, Euphorbiaceae, Salicaceae and Lecythidaceae, in ascending order) that represent 74.8% of the entire plant population of the sampled homegardens, corresponding to 3,984 individual plants. The remaining 25.2% of the individual plants are distributed in 49 families. Among the 188 species identified, 88.5% occur in less than 15% of the homegardens and yet, within this range of analysis, 56.6% of the species were observed in less than 2.5% of the homegardens studied.

The families Arecaceae, Malvaceae, Rutaceae and Musaceae represented 37.8% of the individual plants. These families include species of regional importance for food consumption, such as cocoa (Theobroma cacao L.), cupuaçu (Theobroma grandiflorum (Willd. ex Sprng), açaí (Euterpe oleracea Mart.), orange (Citrus sp.) and banana (Musa sp). The botanical families Malpighiaceae, Anacardiaceae, Amaryllidaceae and Myrtaceae, responsible for 21.4% of the population, present prominent species in regional feeding and domestic use such as cashew (Anacardium occidentale L.), murici (Byrsonima crassifolia (L.)), chives (Allium schoenoprasum L.), jambo (Eugenia malaccensis L.), mango (Mangifera indica L.) and acerola (Malpighia emarginata L.). It is also noted that Apiaceae, Fabaceae, Euphorbiaceae, Salicaceae and Lecythidaceae, which corresponded to 15.6% of the sampled individual plants, have important representatives such as Brazil nuts (Bertholletia excelsa Bonpl.), cumaru (Dipteryx sp.), cilantro (Coriandrum sativum L.) and rubber tree (Hevea brasiliensis (Willd.

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ex A.Juss.) Müll.Arg.). It should be noted that 23.6% of the plants (1,255) are distributed in the remaining 22 botanical families, with 22 to 106 individual plants per family.

On the other hand, evidencing the peculiarity of these homegardens, 2.9% of the population was distributed into 30 families that had less than 20 individual plants in the sum of the areas evaluated, reinforcing the importance of these spaces in the conservation of biodiversity. The maintenance and inclusion of unique, endemic or little-known species may indicate a reserve of key species that still reach future markets in addition to being configured as a stock of genetic materials [41, 42, 8], in addition to the need for a systematic effort to improve the conservation and availability of wild relatives of crops for use in plant breeding [43].

The distribution of individual plants and species in the survey confirmed the Pareto Principle, which predicts that about 80% of the consequences are produced by 20% of the causes [44]. Also called the Power Law, this concept was observed in real data and is considered as an auxiliary tool to understand the behavior and parameters of distributions, with potential application in several natural situations [45]. In the inventory of homegardens, it was found that 80.5% of the individual plants (4,284) are concentrated in 18.6% of the species (36). Likewise, for the number of species and botanical families, the rule was also valid, with 81.0% of the individual plants (4,311) concentrated in 25.8% of the families (16).

Data in the five different zones revealed that the range of species in the environments ranged from 3 to 30 and the number of individual plants showed great variation (5 to 140), resulting in mean and standard deviation of 12.9 ± 5.3 species per homegarden and 44.7 ± 29.1 individual plants in each property. Both variables with high heterogeneity, indicated by the value of the coefficient of variation (41.3 to 65.1%). Figure 1 shows the arrangement of the data illustrating the number of plants and species for all the homegardens evaluated.

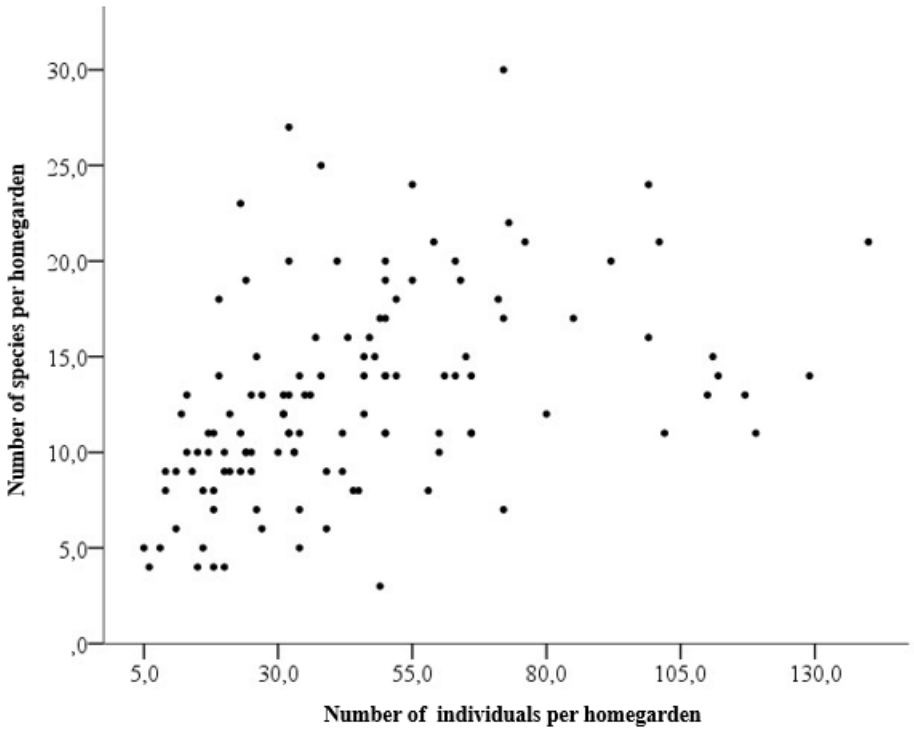

Figure 1. Distribution of plant species and individual plants in agroforestry homegardens in Western Pará, Brazilian Amazon.

Considering all the homegardens evaluated, the Spearman correlation test indicated that there is significance (p-value = <0.0001) with a weak relationship (r: 0.438) between the number of species

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and the number of individual plants in the homegardens. Considering the different zones studied, moderate (r: 0.50 to 0.67) and significant (p-value < 0.05) correlations (Pearson's coefficient) were identified for these two variables.

These inferences suggest that despite the existence of a linear and partial relationship between the number of species and individual plants in the homegardens, factors related to space management, family dynamics of area use and unit management affect the composition of the homegardens. The conditions described show that each homegarden has particularities, compositions and structures distinct from each other and between the different localities [41]. In the context of homegardens in Santarém/PA, the circulation of plants and plant material maintains a high agrobiodiversity in the gardens [45], thus evidencing an intense dynamic of modification. In addition, the origin of people who manage homegardens can also influence the composition of these land use systems in the Amazonia [47].

The range expressed in Table 1 shows that even in the different study zones, the minimum (4 to 6) and maximum (up to 30) values for the number of species are similar, with the exception of the floodplain area where the maximum value was lower (16), revealing greater species richness in urban and peri-urban areas. The characteristic of annual flooding of floodplain areas determines that, according to reports from residents, many crops are limited because they do not withstand flooding for several months.

Table 1. Number of species (richness) and sum of number of vegetal individual plants in agroforestry homegardens, in different zones, in the western region of Pará, Brazilian Amazonia.

Variable	Zone	Amplitude (min. and max.)	Average*	Standard deviation	CV (%)
Number of species	Peri-urban	4 a 30	13,9a	± 5,5	40,8
	Urban	4 a 30	11,9a	± 5,1	42,6
	Floodplain	4 a 16	10,5a	± 3,7	34,7
	Indigenous	4 a 24	14,5a	± 5,3	36,8
	Tourist	6 a 27	13,5a	± 6,8	50,3
Number of individual plants	Peri-urban	5 a 167	33,8B	± 23,0	68,2
	Urban	5 a 99	42,5AB	± 22,4	52,8
	Floodplain	8 a 119	58,2AC	± 32,7	56,1
	Indigenous	6 a 140	62,5A	± 37,1	59,4
	Tourist	11 a 55	30,9BC	± 12,2	39,5

*Average values followed by same letters, in the same column, indicate that no statistical differences were identified by Tukey's test at the level of 95% significance. CV (%): coefficient of variation.

The average number of species per homegarden ranged from 10.5 to 14.5 and showed no statistically significant difference (p-value = 0.06; F= 2.2770 and GL = 4), in the five zones evaluated. For the number of individual plants, the average was distinct between the areas, with values between 30.9 and 62.5, reflected in a statistically significant difference (p-value = 0.0005; F= 5.8099 and GL = 4), with emphasis on the floodplain and indigenous areas that differed from two other zones (Peri-urban and tourist, respectively) and from each other.

It is noteworthy that the indigenous homegardens were superior to the peri-urban ones in terms of number of individual plants. This may be due to the fact that indigenous areas are larger than peri-urban areas. Even in such a distinct environment, as to the location and environmental characteristics, the maintenance and cultivation of vegetable individual plants in homegardens is maintained in the familiar environments. Floristic composition and selection of species in homegardens is strongly influenced by the decisions of the owners aiming at food security [13].

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Evaluating the size of the homegarden, information not available for all zones in this analysis, and its relations with the number of individual plants and species could bring more effective answers about the relationships established in these spaces and the choices for cultivation and maintenance, since it is likely that in indigenous areas, due to the availability of space, there would be a greater total number of plants in the homegardens. In the floodplain, despite being a rural area, with large extensions, there is limitation of cultivated area for reasons of the flood regime that occurs annually. A study published with data from the indigenous zone showed that among 20 homegardens evaluated, there is a great diversity of use of the areas (ten categories of use), where the average size of the homegardens was 6,049.3 ± 5,295.8 m² [48] and also, that these places are intended for productive practices, with greater frequency of fruit species and, thus, are of great importance for family food sovereignty and income promotion. As for data from the flooding zone, the average size of homegardens was 3,300 m², with a marked presence of native tree species typical of this environment [49].

The research also made it possible to identify homegardens in different environments in the municipalities, so that the five zones evaluated have evident distinction between themselves in occupation, demonstrated by the statistically significant differences for the number of individual plants. Differences in agrobiodiversity in homegardens arise through the interaction of human action, plant responses and the unique soil properties in relation to socioeconomic and historical trajectories over time [50]. These differences were also expressed by the coefficient of variation between the areas (Table 1), which ranged from 34.7 to 50.3% for the number of species and from 39.5 to 68.2% for the number of individual plants, which according to [51] indicates high heterogeneity (CV> 30%) in the samples.

The distribution of absolute and relative frequency for the number of species per homegarden (Figure 2A) showed that the highest concentration (67.2%) occurs in units with 6.8 to 16.5 species, observed in 70 of the 119 homegardens sampled, expressing that environments with greater diversity predominate in the sampling universe of this research. As for the sum of individual plants, it is noted that 39 homegardens have from 5 to 26.8 individual plants (Figure 2B), being the most expressive class (32.8%) in the distribution of the study. The next class of this variable (26.8 to 49.7) is also relevant, covering 31.1% of the sampled homegardens, thus demonstrating that more than half of the sampled areas contain less than 49 plants in the environment.

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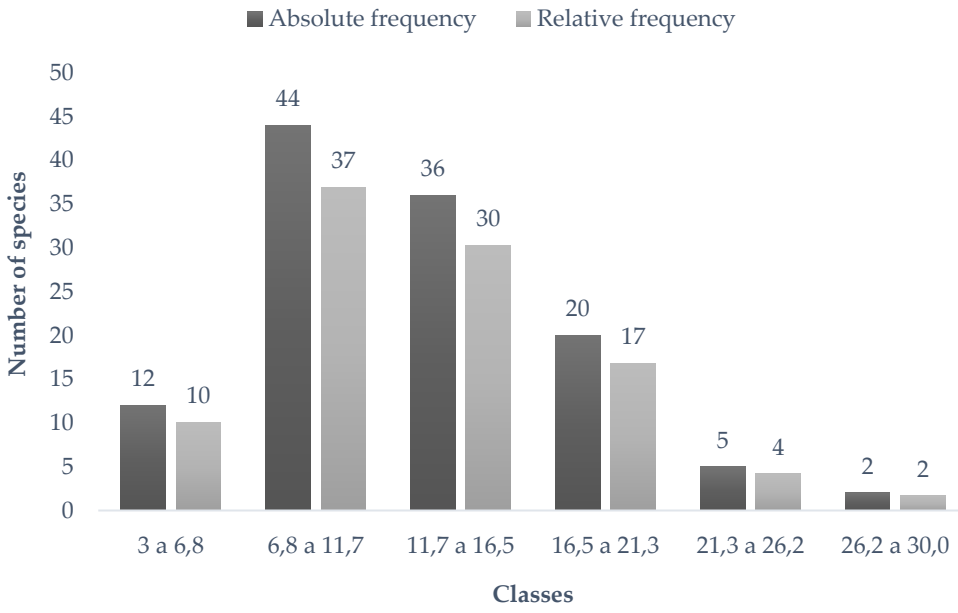
A



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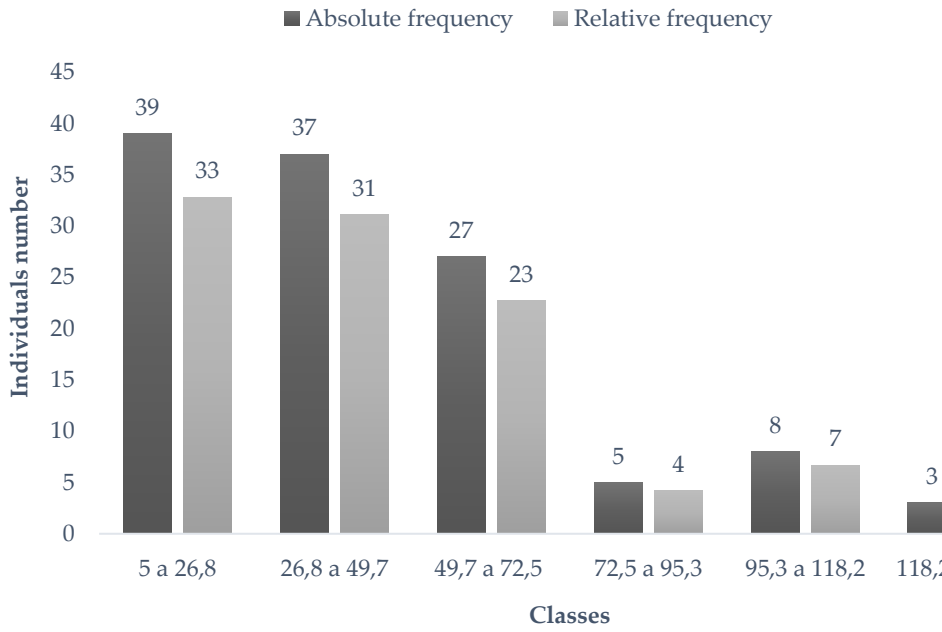

Figure 2. Distribution by frequency classes for number of species (A) and sum of vegetal individual plants (B) in agroforestry homegardens in Western Pará, Brazilian Amazon.

3.1 Sociocultural use of species in homegardens

The species found in homegardens have diverse purposes, and can be food, medicinal, shading, ornamental, or even have dual use (food and medicinal). The cultivation of species mentioned solely for food purposes represented 84.5% of the individual plants found (4,497), distributed in 104 species, while 4.5% (41 species) have medicinal and medicinal/food uses (2.9% and 1.6%, respectively), indicating that, mostly, the maintenance of plants in homegardens, in the study areas, is intended to meet

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the demands of self-consumption, food security, immediate health care, which shows the multifunctionality of these environments.

The emphasis on the food use of products from homegardens may indicate an economic impact on the income of keepers, through the reduction of costs with the acquisition of external products, due to the supplies provided. The cultivation of food species in homegardens is an important feature of this type of production system, since it is characterized as an accessible and safe source of food and inputs, contributing to a more diverse and healthy family diet [15, 52], expressing the direct and indirect relationships between homegardens and food security through evidence of a supplementary source of food [53].

The fact that food use stands out in this analysis reinforces the importance and the relationship between the human being and the diversity and periodicity of food supply. The act of eating is also developed according to social rules, individual trajectory and group values [54]. This connection is also expressed in literature, such as the example of the work of Rubem Alves that discusses food as affection and identity [55]. Thus, food, as a cultural product, is surrounded by traditions, rituals and affective relationships that preserve traditional elements [56], highlighting the importance of homegardens in the identity of communities.

Another aspect inherent is the discussion of the food use of plant species in homegardens, since from the beginning of the twenty-first century, about 400,000 species from biodiversity and agrobiodiversity could serve as human food in the world [57], and Amazonian tree communities have been influenced by a long history of plant domestication [58], and some species have been domesticated in homegardens [59]. However, currently, about 15 species account for 90% of the world's human diet [60] and some species account for more than 50% of the global supply of calories [61].

For the Brazilian conditions,[62] highlight that despite the richness and potential of Brazilian biodiversity, its use as food is still neglected and little known. In this regard, homegardens can be constituted as a space of resistance or a barrier, as opposed to the tendency to simplify food, as they concentrate countless individual plants who provide biomass of human interest (mainly food), which in natural environments, would have a lower density of plants for use through extractivism.

On the other hand, with regard to the Brazilian production of non-timber forest products, the food category corresponds to 96% of all production [63]. As an example, species such as bacaba (Oenocarpus bacaba Mart.), pupunha (Bactris gasipaes Mart.), sapucaia chestnut (Lecythis pisonis Cambess.), tucumã (Astrocaryum aculeatum G.Mey.), açaí (Euterpe oleracea Mart.) and uxi (Endopleura uchi) (Huber) Cuatrec), were identified in the homegardens studied and have acceptance and preference in the local daily life, peculiar flavors and are fruit-bearing plants maintained or cultivated to supplement household food. It should be noted that the frequency of food consumption in 10 years (2008 to 2018) showed an increase in the consumption of açaí in Brazil, in urban and rural areas, especially in the Northern region, with an increase from 9.0% to 12.4% [64], covering all income groups. Still considering this report, in the Northern region there was a reduction in the consumption of fruits such as banana, mango and orange, and in the national scenario, the consumption of fruits, vegetables and legumes showed a reduction, being below the recommended level.

At the same time, data from the Food and Nutrition Surveillance System [65] show that for adults in the municipalities of Santarém and Mojuí dos Campos, fruit consumption in 2021 was 43 to 79%, while the consumption of vegetables was more emphatic, with 71 to 83%. This same source also indicates that 58 to 63% of the adults evaluated in the three municipalities of this study are overweight or have some degree of obesity. These findings point to the importance of maintaining homegardens to contribute to the improvement of nutrition, as a possible strategy of diversification and alternation in the availability of fruits, mainly. Since food sovereignty is associated with sustainable systems as a way to reduce hunger and malnutrition [66], homegardens could play a leading role given their richness of species and food potential.

On the other hand, a report on food and nutrition security (2018 to 2020) in Latin America [67] indicated that in 23.5% of the Brazilian population, there is a prevalence of moderate or severe food insecurity and that 7.5 million people face severe food insecurity. Food and nutritional security, as

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expressed in Law No. 11,346/2006, consists in the realization of the right of all to regular and permanent access to quality food, in sufficient quantity [68]. Studies with adolescents in the urban area of municipalities in the Brazilian Amazonia showed that there was a prevalence of food and nutritional insecurity in households and low consumption of vegetables, fruits and legumes [54].

Regarding the medicinal use, species were found for this destination in 42.8% of the homegardens inventoried, with emphasis on six species - Ocimum basilicum L. (alfavaca), Carapa sp. (andiroba), Dipteryx sp. (cumaru), Crescentia cujete L. (cuieira), Zingiber officinale Roscoe. (ginger) and Jatropha gossypifolia L. (purple pawn) - which had higher abundance. This quantity indicates an accentuated importance of popular medicine in the daily life and well-being of the populations of the studied areas, expressed by the cultivation of medicinal plants. Other studies with homegardens in the Amazonia have also shown the predominance of plants intended for medicinal use [41], where the choice and maintenance of species are usually assumed by the woman [69, 70].

In this context, the commercial production at the national level of medicinal products is not very expressive and presents a low variety of product supply [63]. Thus, the cultivation of species for medicinal purposes in homegardens holds great importance for the health of maintainers. Added to this, the distance between the areas surveyed and the urban centers, which are commonly sources of access to conventional medicines, originating in pharmacies. In the case of floodplain areas, the dynamics of flooding and drought impose additional difficulties to move to urban centers, making the use of medicinal products a necessary measure and that is sometimes reinforced by the traditional practices of riverside populations [71, 72].

Still addressing the use indicated for plants in homegardens, the cultivation/maintenance for shading stands out, pointed to 9.4% (29 species – 502 individual plants). The shaded areas in homegardens are often used for activities such as leisure, rest and work [8], also providing an important microclimate to the development of different plant and animal species [73] where they constitute as the places of preference for coexistence by families, due to the sensations of environmental comfort [74], including strengthening more resilient green cities [75].

3.2 Form of life and origin of plants

Regarding the form of life or habit of the inventoried vegetal plants, there was a predominance (Figure 3) of arboreal individual plants (trees), which were distributed in 85 species. Next, the plants of the herb/herbaceous category dominated with 50 species, palm trees with 11 species and shrubs with 8,3% of the individual plants distributed in 22 species. The plants listed in the categories of life form bamboo, liana and tree/shrub were responsible, together, for 0,7% of the total individual plants and 20 species.

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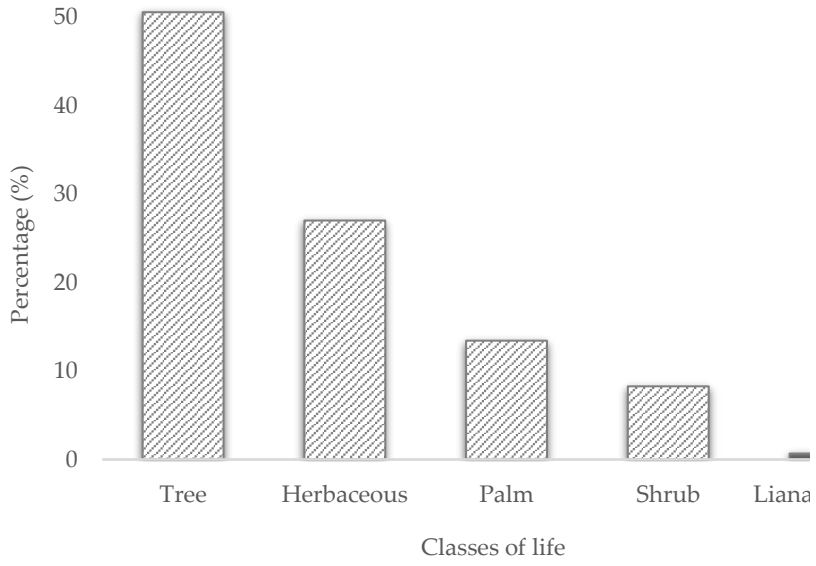

Figure 3. Percentage of plants distributed classes of life form or habit in agroforestry homegardens in the West of Pará, Brazilian Amazonia

Regarding the total number of plants found, approximately half of them have native origin in Brazil (49.5%), while the others (50.5%) are of exotic origin, with 40.4% cultivated and 10.1% naturalized, according to the classification of the Reflora program (Flora and Funga do Brasil, 2022). When considering the number of species, this proportion is maintained, with 103 species of native origin (54.8%) and 85 of exotic origin, subdivided into cultivated (31.4%) and naturalized (26.0%).

Still addressing the origin of the plants, it is noteworthy that for shading was identified exclusive use of native (100%), possibly by the maintenance of forest species when creating homegardens or even by the management of local natural regeneration. This result is opposite to that found for species with dual purpose (food/medicinal), in which all individual plants were of exotic origin (88.2% - cultivated and 11.8% - naturalized). It is pointed out, however, that species indicated for other uses, other than shading, also result in shade in homegardens, which, however, was not considered in this work where the criterion for inference is the main use pointed out by the maintainers of the homegardens. For ornamental use, plants of exotic origin stood out (57.3%), while for medicinal use evidences are that 60.5% are of native origin. The food use category was the only one that presented a relatively equitable distribution for origin, where 44.3% are considered native, while 55.9% are classified as exotic (cultivated 44.1% and naturalized 11.6%).

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3.3 Characteristics of homegardens in the five zones

Evaluating the categories of plant use in the different zones/areas of the study, it is noted that in all of them the use of plants for food use predominated (68.4 to 92.4% per area). In second place, shading plants stood out in indigenous and floodplain areas (8.3% and 26.7%, respectively), while in peri-urban and urban areas this place belonged to plants for medicinal use (2.9 to 3.9%). In the tourist area, ornamental plants (15.2%) appeared as the second prominence in the homegardens. It is noteworthy that ornamental use was indicated for 1.5% of all inventoried plants (89 individual plants distributed in 19 species).

It is also noted that, in the indigenous, peri-urban and urban areas, there was a dominance of the tree component (trees), corresponding to 45.6% to 65.6% of the individual plants. Palm trees stood out in the indigenous and peri-urban areas, occupying the second place in the number of individual plants (12.8 to 28.2%). In the tourist area, this dynamic was different, and all plants had a similar distribution between trees and herbs (35.9 to 38.9%).

Still on this analysis, the floodplain area was the one that showed the most differentiated performance in relation to the others, with a predominance of individual plants of herbaceous size (52.6%), stimulated by the use of suspended flower beds for the cultivation of vegetables and medicinal herbs, mainly. In this environment, potted cultivation is recurrent due to the ease of transportation between homes, a common activity carried out due to periodic floods.

For the floodplain, it was reported during the research that there are difficulties in the cultivation of tree species in the areas subjected to flooding, which restricts the insertion of the tree component. Thus, native species with the capacity to adapt to the seasonal regime are prioritized [76], where homegarden owners demand less efforts to insert perennial crop species in their homegardens, opting instead to resort to spontaneous species of native origin [75].

In the peri-urban, urban and tourist areas, plants of exotic origin predominate (53.8%, 57.9% and 60.5%, respectively). In the peri-urban area, exotic species are mainly used for food purposes, while in the tourist zone they are intended for both food and ornamental use. In the indigenous area, the highest percentage is of native origin (62.0%), driven by plants for food use and shading. Finally, in the floodplain area, the distribution was mathematically similar (50.1% and 49.9%) for this approach.

3.4 Featured species in homegardens

The twenty most frequent species in the homegardens have food purposes (Table 2), with a major emphasis on the fruit-bearing trees of permanent cultivation, such as mango, cupuaçu and orange, present in more than half of the areas, evidencing an essentiality for the production of fruits in homegardens. Diagnosis with more than 500 families of farmers in the Santarém plateau showed that 70% of farmers have expanded their crops with a focus on fruit production [76]. This pattern was also observed in the evaluation of homegardens in several places in the country [78] and in studies in homegardens in the Amazonia [79, 80, 25], where fruit-bearing trees such as açaí, cupuaçu and banana are the more frequent species. Among the 10 most frequent species (34.5 to 54.6%) there is a predominance of exotic species. The most abundant, but not the most frequent, were the meracurua species (Laetia corymbulosa Spruce ex Benth.), chicory (Eryngium sp.), sapucaia chestnut (Lecythis pisonis Cambess.), rubber tree (Hevea brasiliensis (Willd. ex A.Juss.) Müll.Arg), pineapple (Ananas sp.) and cilantro (Coriandrum sativum L.).

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Table 2. Popular name, percentage of frequency and abundance of the twenty species with the highest frequency value in agroforestry homegardens in the West of Pará, Brazilian Amazonia.

Order	Popular name	Scientific name	Frequency (%)	Abundance (%)
1	Mango*	*Mangifera indica* L.	54,6	3,3
2	Cupuaçu*	*Theobroma grandiflorum* (Willd. ex Sprng)	53,8	7,8
3	Orange*	*Citrus* sp.	50,4	4,8
4	Coconut*	*Cocos nucifera* L.	47,1	3,6
5	Banana*	*Heavenly Muse* L.	44,5	6,6
6	Guava	*Psidium* sp.	42,0	2,4
7	Acai*	*Euterpe oleracea* Mart.	38,7	5,8
8	Avocado	*Persea* sp	37,8	1,5
9	Lemon*	*Citrus latifolia*	36,1	1,7
10	Acerola	*Malpighia emarginata* L.	34,5	1,3
11	Cashew*	*Anacardium occidentale* sp.	33,6	1,9
12	Murici*	*Byrsonima crassifolia* (L.)	32,8	4,6
13	Pupunha*	*Bactris gasipaes* Kunth.	31,9	3,2
14	Papaya*	*Load* sp.	27,7	1,6
15	Jambo	*Eugenia malaccensis* L.	23,5	0,8
16	Tangerine*	*Citrus nobilis* Lour.	23,5	1,7
17	Bacaba	*Oenocarpus bacaba* Mart.	19,3	0,8
18	Chives*	*Allium schoenoprasum* L.	19,3	5,4
19	Soursop	*Annona muricata* L.	18,5	0,6
20	Ata	*Annona squamosa* L.	17,6	1,0

*Indicates that the species is among the twenty most abundant in the survey.

Among the twenty most frequent species, fourteen - mango, cupuaçu, orange, coconut, banana, açaí, lemon, cashew, murici, pupunha, papaya, tangerine and chives - stand out, in ascending order, with 55 to 178 individual plants. The prominence, in this ranking, for chives can be attributed to the wide use of this species as a spice in regional cuisine in the daily eating routine. Chives, as well as several tropical spices, have numerous nutritional properties [81]. Considering the possibility of the formation of vegetal gardens in these spaces, it is noteworthy that this practice can serve as an indication of food security, being this an important item of agrobiodiversity [59]. The inclusion of new species in the diet will certainly increase the food security of Brazilians [62].

The twenty most abundant species represented 66.5% of all inventoried individual plants while the 10 most abundant represented 47.9%. Cupuaçu, banana and açaí stand out with the highest sum

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of individual plants (414, 352 and 308, respectively). Cupuaçu, occurring in 53.8% of the homegardens, has regional productive prominence in the municipalities of the West of Pará. Data from the Agricultural Census indicated a production of 109 tons of cupuaçu fruits in the Lower Amazonia region in 2016, from a planted area of 54 hectares, which corresponded to 2,096 kg per hectare that year [82]. In the urban area of Belterra, great potential for commercialization of cupuaçu pulp from homegardens was estimated [83].

This study also revealed that the production of fruits such as banana, coconut, guava, lemon, papaya and pupunha stood out for having at least one specimen in each area evaluated. However, most of the species (42.1%) were counted in only one of the studied areas, reflecting the unique behavior and reflecting the diversity in the cultivation of the homegardens. This fact shows that these environments are distinct and peculiar, which is probably due to the circumstantial introduction or cultivation of species not commonly found in most homegardens. These findings reveal that the conservation of these spaces will indicate conservation of species of little occurrence in the environments, which can contribute to the local biodiversity. The promotion and expansion of these environments can result in a strategy to increase diversity and genetic exchanges, as well as to favor local wildlife.

3.5 Importance and perspectives for agroforestry homegardens

The local dynamics, stimulated by small crops such as those carried out in homegardens, is altered and has an interface with the national and international dynamics of food distribution. In this sense, a document from the Pan American Health Organization, in an approach to Brazilian strategies to combat hunger and poverty, indicated the implementation of productive homegardens as a strategy to minimize food shortages

Homegardens, with their diversity of species and purposes, pointed out in this study, can be a source of autonomy and contribute to the sovereignty and food security of families, by assisting mainly in the availability and variety of food. This entails providing year-round food security at low cost, while sustaining numerous ecosystem services [10]. A study in municipalities of the Legal Amazonia indicated that, due to the situation of food and nutritional insecurity, policies should encourage administrators, media and civil society to include in their agenda and seek actions of the public power related to the greater supply of healthy foods [54].

The results reveal that in the homegardens evaluated, there is a predominance of species of food use, primarily fruit-bearing, showing a direction for incentive actions and/or for the ordering of public policies and programs aimed at these family spaces. The sale of manufactured products obtained from these homegardens, such as pulps, jellies, sweets, handicrafts, among others, could mean a form of exploitation and income generation. Local productive initiatives already recognize the potential of these environments, such as, for example, the Agroecological fair for the commercialization of products from urban productive homegardens [84], in the Pérola do Maicá neighborhood, in Santarém (85). A study in this region also showed that homegardens managed by women generate income and produce food to ensure food security [86] and because they are a small-scale system, they can facilitate the participation of women and other marginalized groups [27].

The commercialization of products or surpluses from these homegardens, mainly due to the potential expressed in this survey for fruit species, could strengthen the so-called short commercialization chains or alternative food circuits, that are based on an agri-food system that aim to strengthen the relationship between consumer and producer, promoting the reconnection between those involved and incorporating collective social and cultural values [87, 88, 89].

The cultivation or maintenance of vegetal plants in homegardens has varied dynamics, and this inclusion is done in order of opportunity and experiences, stimulated by exchanges, visits and social interactions. In this sense homegardens promote agrobiodiversity, which is understood as the processes of natural selection and the careful selection and inventive developments of farmers over time [59]. Thus, the homegardens addressed in this analysis were shown as mixed agroecosystems, with species that express the cultural and local knowledge of diversity.

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The homegardens denoted complex structures, with interconnection between the elements that make up the environment, which despite the quantitative similarities identified in the evaluated areas, it becomes clear that these environments have a dependent dynamic based on the influence of different social, economic and ecological factors. The diversity expressed in homegardens shows possible resilience to facing economic and climate cycles.

Despite the aforementioned relevance, there are no records of policies or projects aimed at managing the organic waste generated by these homegardens, such as leaves, fruits and branches. The municipal law of Santarém (17,894/2004) does not allow the outdoor burning of materials that compromise the environment [90] and, however, the practice is still widely used, being evidenced by statistics of fires and urban occurrences [91], which can lead to conflict and inconveniences in the community coexistence. In this sense, payment for environmental services could be an alternative to reward service providers [92], if it were linked, for example, to the proper disposal of waste as strategies for the valuing homegardens. The transformation of organic materials from these environments, via composting, with integrated and synchronized collections by the government could also result in the maintenance of tree individual plants in the homegardens.

Carrying out a qualitative analysis of a complex system, such as homegardens, involving different levels, such as the areas selected in this study, requires admitting that the inferences are limited to the "cuts" produced by the data presented. Thus, in order to represent, in a more in-depth way, the complexity of the insertion or maintenance of vegetal plants in these environments, a multidisciplinary weighting would be necessary to point out the direction and causality for the choices made by the owners of the homegardens.

5. Conclusions

Homegardens play an important role in the conservation and cultivation of species for food, nutritional and phytotherapeutic purposes, with fruit-bearing trees being the most common, highlighting the importance of valuing and maintaining these environments in the region. These spaces present a great diversity of cultivated species, with similar distribution between exotic and native species, but with variations in composition according to the environment in which they are inserted. The contribution of these homegardens is evident as holders of a high richness of species, with the most diverse purposes and with different profiles of distribution and choice of species, even in places located in the same region. The promotion and expansion of these environments could, in this way, result in strategies to increase diversity, genetic exchanges and the conservation of local fauna.

The analysis of homegardens can bring visibility to these spaces, reducing vulnerability and neglect in relation to the recognition of their socioeconomic and environmental importance, to which they are subject, to meet the demands of real estate expansion. Since homegardens are seen as important and socially relevant ecosystems, and not on the margins of conservation policies and actions, these environments could expand and improve their conditions.

Considering the data from this study, it is encouraging to state that, for conservation projects and/or technical assistance, the species that represent 80% of the individual vegetal plants and the most frequent in the study should be prioritized, especially the native ones. In this way, efforts can be concentrated on crops that are already the domain and affinity of the residents, so that production can gain scale and not be limited to isolated productions. Likewise, it is believed to be convenient that efforts for social or cooperative organization, destined to the production or aggregation of value, consider the species highlighted in this study as priorities to direct actions or projects.

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