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Agroforestry Systems: Conservation of Biodiversity in Bahia - Brazil

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Abstract

Biodiversity agroforestry systems are characterized as an integrated land use model for the purpose of forest, agricultural and livestock production for family subsistence, strategic systems for restoration and conservation of degraded environments. These provide a variety of environmental services that directly or indirectly promote benefits to humans and the environment. In Brazil, studies on agroforestry systems are currently focused on technical, biological and social rather than economic aspects. Faced with the intensification of agriculture, agroforestry systems represent a possible solution to obtain continuous production, combining conservation practices and improving the use of natural resources, within the premises of sustainability. This study aimed to evaluate the multi-tiered commercial agroforestry systems of family farmers in an area of Atlantic Forest in the Bahia state - Brazil, identifying the plant species and their uses. The species of greatest interest to family farmers were cataloged and through a floristic inventory, productive agroforestry systems were evaluated 118 species were identified (68.4% food, 14.5% medicinal, 13.2% wood). The values of the effect on the support service showed that biodiverse agroforestry systems do not significantly differ from the preserved forests. The analysis of the application of the principles of ecologically based agriculture made it possible to assess the existence of a productive differentiation and to verify that the growing diversification of production ensured a greater number of principles of ecologically based agriculture applied in the day-to-day activities of productive activities, thus safes play an important role in the food security of family farmers. The results found bring practical implications for the discussion of those production models on the restoration of ecological processes in the Atlantic Forest and the role they can play at the multifunctional landscapes of rural properties.

Keywords: Agroforest systems, agroecological principles, tree species, biodiversity, family agriculture.

Introduction, scope and main objectives

Agriculture is practiced in Brazil through different management practices and guided by different production principles that, when applied, seek, in most cases, sustainability as a goal to be achieved. There is an evident difference in the forms of land exploitation: farmers who practice the conventional agricultural system and the ecologically-based agricultural system follow different paths in the application of these practices according to their principles, production interests and sustainability ideals to be pursued (Abreu et al., 2005; Almeida & Abreu, 2009).

Agroforestry systems (SAFs) are an alternative for agricultural production that seeks to minimize the effect of human intervention on natural systems. Mainly in the Atlantic Forest, which is considered one of the highest priority areas for the conservation of the planet due to its biological biodiversity and high degree of

threat. The intercropping of several species within an area increases ecosystem diversity, in which beneficial interactions are harnessed between plants of different cycles, sizes and functions (Feiden, 2009). SAFs combine, in an integrated manner, trees, shrubs, agricultural crops and/or animals in the same area. This occupation can be simultaneous or sequential. In this way, we seek to aggregate the factors and resources in the same area to optimize values - production, economic, social, cultural and environmental - as an alternative to a sustainable model of use and management of this system (Silveira, 2005).

Successional and biodiverse agroforestry systems (SAFs) are endowed with an intrinsic agroecological logic, as they use local knowledge and are drawn from the region's natural potentials (Gotsch, 1995). The intentional management of the forest for agricultural cultivation purposes has been shown to be a promising technique capable of reconciling production and at the same time the conservation of biodiversity and natural resources, as well as increasing rural subsistence activities; they also provide habitats for various species of fauna and increase connectivity between fragments and protected areas (Bhagwat et al., 2008).

In a new rural world, where family farming or the small rural producer takes place as protagonists in sustainable local development. The SAFs are quite appropriate to the socioeconomic and cultural conditions of these segments of society, both in terms of knowledge and available labor, as well as the diversification and integration of crops, which, in fact, contributes to the food security of families; in addition to being a system that contributes to minimizing the degradation of natural resources, such as soils and water (Rodrigues et al 2008; Scales & Marden, 2008; Siminski,2009). In addition, they need low investment, as they have a low need for external inputs (Scale & Marden, 2008).

The term Agroforestry System (SAF) corresponds to a form of land use and management of natural resources, in which woody species (trees, shrubs, palm trees) are used in association with agricultural or animal crops, in the same area, simultaneously or in a temporal sequence. This one of deliberate introduction or retention of trees in association with other perennial or annual crops and/or animals, presents mutual benefit and comparative advantages to other agricultural systems resulting from ecological and economic interactions. It can have various arrangements in space and time, and must use management practices compatible with the producer. These systems advocate a series of advantages over monocultures. Among the advantages is the fact that there is a greater use of space and also a better use of resources. Thus, knowledge of sustainable production systems appears as an alternative to the use of these areas.

In these agroecosystems there is a more intensive use of resources such as water, solar radiation and soil nutrients, by recycling the foliage, thus requiring the use of low inputs, in addition to causing less damage to the environment. Thus, the SAFs represent an agroecological alternative of production, under a sustainable regime, for family farmers, in which the cultivated plants are introduced in a consortium, in order to fill all niches, including, considering in this combination, remaining native species, regeneration species or reintroduced. In addition to combining species in space, consortia are combined in time as in the process of natural succession of species, in which consortia follow one another, in a dynamic process, depending on the life cycle of the species. The trees used in SAFs can have several functions: afforestation of pastures and crops, living barriers, living fences, windbreaks, revegetation of degraded areas, protein source for animals, green manure, protection forest, supply of energy matrix for obtaining biofuels, beekeeping, forage, feed and cellulose (Maneschy et al.; 2009).

It is still possible to emphasize the use of these species to obtain resins, essential oils, use of medicinal active principles, commercial production of fruits, etc. Management interventions demand knowledge about the species, requiring observation and precision on the part of farmers. Planting trees on the property can reduce agricultural production costs due to lower expenditures on soil conservation and combating pests and

diseases, replacing material for fences and buildings, an alternative source for energy supply and alternative income from harvested wood and by-products. This situation also leads to less pressure on the use of native forests as a source of raw material, mainly for energy.

Agroecological systems are defined by Worster (2003) as systems reorganized for agricultural practices, a domesticated system, but keeping in mind a restructuring of the trophic processes of nature, that is, the energy flow processes and elements in the economy of living organisms, but that they can serve conscious purposes of nourishment and prosperity of human groups. Biodiversity has been increasingly recognized as one of the central elements for the development and well-being of humanity, although only a small part of its components has been adequately studied and its future benefits are not yet fully known, each has been valued. increasingly its ability to generate socioeconomic benefits (Ferro et al., 2006). Based on these considerations, the present study aimed to evaluate the multi-tiered commercial Agroforestry Systems - SAF of family farmers in an area of Atlantic Forest in the state of Bahia - Brazil, identifying plant species and their uses. From interviews, the species of greatest interest to family farmers were catalogued and the productive AFS were evaluated through a floristic inventory.

In these studies it is possible to find many species that are used in various forms, producing food, wood for constructions and handicrafts, fibers, raw material for herbal medicines and pharmaceutical or cosmetic industries. When they have several of these uses in a single species, they are considered multipurpose species, as they present diversified production, contributing to and improving the planning and obtaining of income in the SAFs; and being native species, they also contribute to qualify the forestry production area.

Methodology/approach

The study was carried out in the municipalities of Cruz das Almas (20 owners), Muritiba (10 owners), São Felipe (10 owners), Amargosa (10 owners), Conceição do Almeida (14 owners) and Taperoá (18 owners), located in Microregion Recôncavo and Recôncavo Sul da Bahia, approximately 160 km from the capital Salvador, BA. The evaluation of productive commercial multi-stratified FAS in the studied municipalities was carried out with the aid of semi-structured interviews. From interviews, the species of greatest interest to family farmers were catalogued and the productive AFS were evaluated through a floristic inventory. The method used was the case study with application of questionnaires, interviews and participant observation.

The evaluated SAF belong to 82 family farmers in the six municipalities. To identify the species, botanical material was collected. The exsiccates of this material are incorporated in the Herbarium of the Federal University of Viçosa (VIC). Families and specimens were identified using the Tropicos website (www.tropicos.org).

Results

The floristic composition and distribution of species in the SAFs are determined by external and internal factors, such as area function and size, as well as socioeconomic and cultural factors, in addition to the direct influence of the family that selects the species according to their needs (Nair 1986). In the SAF's of Recôncavo da Bahia, 76 species were registered, belonging to 68 genera and 35 families (Table 1). The most representative families in terms of diversity were Myrtaceae (10 spp.), Fabaceae (10 spp.), Anacardiaceae (6 spp.), Mimosaceae (4 spp.) and Arecaceae (4 spp.), with species common to tropical safs, such as *Musa paradisiaca, Cocos nucifera, Psidium guajava, Mangifera indica*, *Carica papaya, Citrus* sp. (Clerck & Negrero-Castillo 2000; Wezel & Bender 2003; Kehlenbeck & Mass 2004; Albuquerque et al. 2005).

A high richness and abundance of species was recorded, accounting for 3,282 individuals in the 82 agroforestry systems evaluated, when compared with similar studies in the Atlantic Forest of Bahia (Albuquerque et al. 2005). From this universe, 3,282 individuals correspond to the introduced plants, which total 56 species, the most frequent being Spondias

In the agroforestry systems occurring in the six municipalities studied, species with multiple uses, such as medicinal, ornamental and wood, were observed. Regarding this last category, Shavanas & Kumar (2003) found in the safs of Kerala (India) a great diversity of native and exotic plants cultivated for fuel, species selected by the local population for their energy potential. For the author, the safs can be areas of continuous cultivation of species for this purpose, constituting a solution for reducing the environmental impact and contributing to the conservation of local diversity. Backyards are areas with continuous resources and have several functions, the main one being, in all regions, the production of food, as shown by Wezel & Bender (2003) for backyards in Cuba, which constitute an important factor for the local economy and the self-sufficiency for many families. Occurring plants are used for different purposes, reflecting the same situation pointed out in other studies (Nair 1986; Lamont et al. 1999; Wezel & Bender 2003; Albuquerque et al. 2005). However, the main purpose of the Recôncavo systems is to promote the food supplementation of family units, with the exception of one backyard, whose owner sells the excess of fruits produced in the open market, mainly *Anacardium occidentale* and Citrus spp (predominant species).

Table 1: Species present in agroforestry systems and forest yards in the municipalities of Cruz das Almas, Muritiba, São Felipe, Amargosa, Conceição do Almeida and Taperoá – Bahia (Northeast of Brazil). Categories of use: 1 = food; 2 = fruitful; 3 = medicinal; 4 = ornamental; 5 = timber; 6 = shadow production; 7 = Other uses. Ab.= Abundance, N = number of individuals, P = Percentage. Status: N = Native; E = exotic.

Common Name	Scientific Name	Family	N	P	Status	Uses
Abacateiro	*Persea americana* Mill.	Lauraceae	64	28,19	N	1, 2 , 3 e 6
Abil	*Lucuma caimito* (Ruiz & Pav.) Roem. & Schult.	Sapotaceae	16	4,1	N	1 e 2
Açaí	*Euterpe oleracea L.*	Arecaceae	30	13,22	N	1
Acerola	*Malpighia punicifolia* L.	Malpighiaceae	74	40,2	E	2
Alfavaca-Louro	*Ocimum gratissimum* L. alfavaca-louro	Lamiaceae	21	11,4	N	3
Algaroba	*Prosopis juliflora* (Sw.) DC.	Mimosaceae	10	5,4	N	5 e 6
Algodão	*Gossypium hirsutum* L	Malvaceae	12	6,5	E	3 e 4
Amora	*Morus alba* L.	Moraceae	56	24,67	N	1 e 3
Angico	*Anadenanthera colubrina* (Vell.) Brenan var. cebil	Mimosaceae	21	9,25	N	5
Apara-raio	*Nicotiana glauca* Grah.	Solanaceae	4	1,76	N	3
Araça	*Psidium araca Raddi.*	Myrtaceae	37	9,4	N	1, 4, 5,
Aroeirinha	*Schinus molle* L	Anacardiacae	19	8,8	N	2,3

Arruda	*Ruta graveolens* L	Rutaceae	29	13,5	N	3
Banana	*Musa paradisiaca* L.	Musaceae	62	28,8	E	1
Cacaueiro	*Theobroma cacao* L.	Malvaceae	82	36,12	N	1,2
Cajá	*Spondias mombin* L.	Anacardiacae	96	44,7	N	1,
Cajueiro	*Anacardium occidentale* L.	Anacardiacae	73	18,6	N	1
Calumbi	*Piptadenia stipulacea* (Benth.) Ducke	Mimosaceae	18	4,6	N	5
Camboatá	*Cupania vernalis* Cambess.	Sapindaceae	15	6,61	N	5,7
Carambola	*Averrhoa carambola* L.	Oxalidaceae	28	9,9	E	2,3
Cereja	*Prunus avium* (L.) L.	Rosaceae	21	7,4	N	5
Chuva de ouro	*Cassia fistula* L.	Fabaceae	41	19,1	N	5,6
Coqueiro	*Cocos nucifera* L.	Arecaceae	95	41,85	N	2
Cravo-da-india	*Syzygium aromaticum L.*	Myrtaceae	87	38,33	N	3
Cupuaçu	*Theobroma grandiflorum L.*	Malvaceae	119	52,42	N	2
Embaúba	*Cecropia pachystachya* Trécul	Urticaceae	26	14,1	N	3,5,7
Erva-cidreira	*Lippia alba* (Mill.) N.E. Br.	Verbenaceae	57	31,0	N	3
Eucalipto	*Eucalyptus* sp.	Myrtaceae	7	3,8	E	5
Flamboyant	*Delonix regia* (Bojer ex Hook.) Raf.	Fabaceae	36	15,86	E	4
Flamboyanzinho	*Caesalpinia pulcherrima L*	Caesalpinaceae	16	7,05	E	5,4
Fruta-pão	*Artocarpus altilis* (Parkinson) Fosberg	*Moraceae*	34	12,0	N	2,5
Goiabeira	*Psidium guajava* L.	Myrtaceae	68	29,96	N	2,3
Gonçalo-alves	*Astronium fraxinifolium* Schott ex Spreng.	Anacardiaceae	6	3,3	N	
Gonçalinho	*Casearia sylvestris*	Anacardiacea	3	1,6	N	
Graviola	*Annona muricata* L.	Annonaceae	45	24,5	E	
Graxa-de-estudante	*Hibiscus rosa-sinensis* L.	Malvaceae	32	17,4	E	
Guaraná	*Paullinia cupana* Kunth	Sapindaceae	96	52,2	N	
Hortelã da folha graúda	*Plectranthus* sp. 2	Lamiaceae	29	15,8	N	
Hortelã-grosso	*Plectranthus* sp. 1	Lamiaceae	35	19,0	N	
Ingá	*Inga sessilis* (Vell.) Mart.	Fabaceae	38	20,7	N	
Jabuticaba	Myrciaria cauliflora (Mart.) O. Berg	Myrtaceae	8	4,3	N	
Jaca-mole	*Artocarpus integrifolia L.*	Moracea	27	11,89	N	
Jacarandá da Bahia	*Dalbergia nigra* (Vell.) Allemão ex Benth.	Fabaceae	11	5,1	N	
Jambeiro	*Eugenia malaccensis* L.	Myrtaceae	47	20,70	N	
Jamelão	*Syzygium cumini* (L.) Skeels	Myrtaceae	13	4,6	E	
Jaqueira	*Artocarpus heterophyllus* Lam.	Moraceae	88	38,77	E	
Jenipapo	*Genipa americana* L.	Rubiaceae	58	25,55	N	
Juazeiro	*Ziziphus joazeiro* Mart.	Rhamnaceae	6	2,64	N	
Jurema	*Mimosa tenuiflora* (Willd.) Poir.	Fabaceae	26	9,2	N	
Laranja	*Citrus sinensis* (L.) Osbek	Rutaceae	266	8,10	E	
Leucena	*Leucaena leucocephala* (Lam.) De Wit.	Mimosaceae	13	0,40	E	
Licuri	*Syagrus coronata (Mart.) Becc.*	Arecaceae	38	16,74	N	
Limão	*Citrus limon* (L.) Osbeck	Rutaceae	114	62,0	E	
Mamão	*Carica papaya* L.	Caricaceae	85	30,0	N	
Mangueira	*Mangifera indica* L.	Anacardiaceae	109	48,02	E	
Mela-bode	*Solanum stipulaceum* Roem. e Schult.	Solanaceae	15	6,61	N	
Mororo	*Bauhinia cheilantha* (Bong.) Steud.	Caesalpinaceae	6	2,64	N	

Mulungu	*Erythrina velutina* Willd.	Fabaceae	4	1,76	N	4 e 6
Nim	*Azadirachta indica* A. Juss.	*Meliaceae*	19	6,7	E	
Pau-brasil	*Caesalpinia echinata* Lam.	Fabaceae	9	4,9	N	
Piaçava	*Attalea funifera L*	Arecaceae	67	36,4	N	
Pimenta	*Solanum* sp.	Solanaceae	49	26,6	N	
Pimenta-da-jamaica	*Pimenta dioica* L.	Myrtaceae	99	53,8	E	
Pinha	*Annona squamosa* L.	Annonaceae	31	13,66	E	
Pinhão-manso	*Jatropha curcas* L	Euphorbiaceae	32	14,10	N	
Pitangueira	*Eugenia uniflora* L.	Myrtaceae	24	10,57	N	
Romã	*Punica granatum* L	Punicaceae	7	3,08	E	
Sabiá	*Mimosa caesalpiniifolia* Benth.	Fabaceae	28	12,33	E	
Seriguela	*Spondias purpurea* L.	Anacardiaceae	45	19,82	N	
Seriguela	*Spondias venulosa* var. venulosa (Engl.) Engl.	Anacardeaceae	31	13,66	N	
Seringueira	*Hevea brasiliensis L.*	Euphorbiaceae	106	46,70	N	
Sombreiro mexicano	*Terminalia catappa* L.	Combretaceae	6	3,3	E	
Tamarindo	*Tamarindus indica* L	Caesalpinaceae	16	8,7	N	
Teca	*Tectona grandis* L. f.	Lamiaceae	9	4,9	E	
Terminalia	*Terminalia catappa* L.	Moraceae	2	0,5	E	
Umbu	*Spondias tuberosa* Arruda	*Myrtaceae*	32	11,3	N	
Urucum	*Bixa orellana* L.	Bixaceae	76	33,48	N	
	Indeterminada 1	Fabaceae	1	0,44		
	Indeterminada 2	Fabaceae	1			

Discussion

Food species are represented by fruit trees, tubers and spices, but only fruit (woody) remain in the SAF continuously. Some species, such as *C. papaya*, *A. occidentale* and *M. paradisiaca*, have a high frequency in the AFS, due to their great importance in the food supplementation of the local population.

Although all species are considered useful, it is observed that only a small number is used for more than one purpose, which does not corroborate data from other authors such as Angel-Perez & Martin (2004) who work with Backyards in Veracruz, Mexico, found a high diversity of species with multiple uses. For some species, more than one type of use, as occurs with foodstuf*fs also used as medicinal products, such as*: *Anacardium occidentale*, *Eugenia uniflora*, *Musa paradisiaca*, *Citrus aurantium* and *C. limonum*, the latter two used as colds for adults and children and also to cure diseases common in chickens. Among the most versatile species, *Senna martiana* can be highlighted, used as forage, ornamental and shade.

The highest percentage of use (Figure 1) was recorded for food plants (67.2%), followed by ornamental (4.3%), medicinal (14%), shade (generally closed wide cover plants that provide natural shading) (2.5%), wood (13%) and other uses (2%). This last category includes mystical and technological uses. The proportion between native and exotic species, by use categories, is significantly higher for native species in the wood and medicinal categories (G-Test = 14.96; $p < 0.05$).

The native species in the area, cultivated in the systems, are used for timber, especially *Anadenanthera colubrina (*angico), eucalyptus and *Prosopis juliflora* (mesquite) for the production of firewood. This result, found, is an indication that the studied SAFs can contribute to the conservation of biodiversity, since the habit of cultivating native plants can reduce the pressure of use on the local vegetation. It was expected, however, to find a greater diversity of native species, due to the Atlantic Forest biome where they are inserted (Albuquerque et al. 2005).

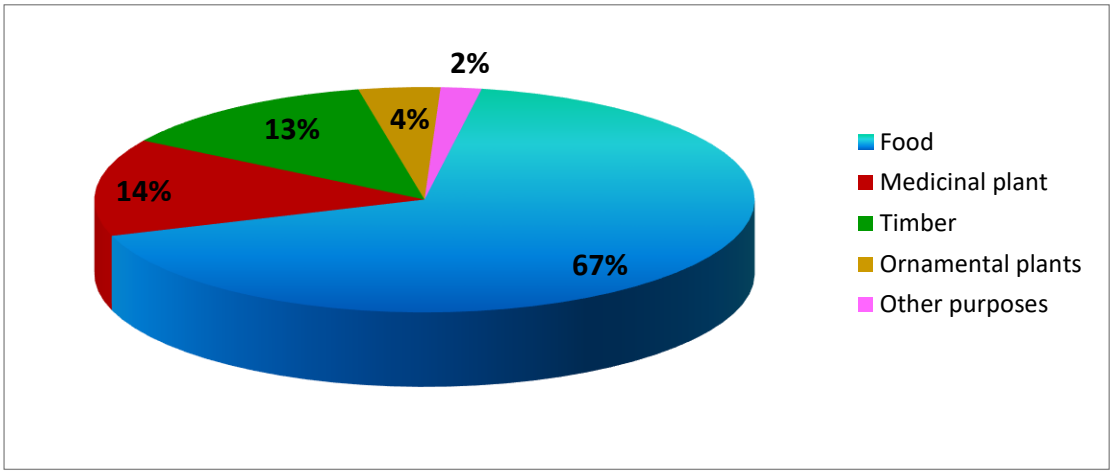

Figure 1: Distribution of use of species found in 82 agroforestry systems in six municipalities in the Recôncavo da Bahia.

Conclusions/ wider implications of findings

Organic agriculture, together with agroforestry systems, is of peculiar importance and finds promising conditions for its improvement in the Recôncavo and Recôncavo Sul regions of Bahia. When interacting with the Atlantic Forest ecosystem and coexisting as agroecological agriculture, the SAF's ensure favorable conditions for the implementation of sustainable production systems, helping to implement agroforestry organic agriculture, generating employment and income, conserving biodiversity and strengthening family farming including elements of agribusiness from the processing of agroforestry products such as the export of guaraná, cloves and the sale of products with a view to serving solidary (fair trade) and conservationist (biodiversity friendly) markets such as piassava, honey, fruit pulp, among others and mainly products forests such as rubber.

Agroforestry systems, when properly planned, allow the exploitation of natural resources with less impact on the environment. This fact is of importance, since commercial agriculture, almost always focused on production and income, relegates the sustainability of natural resources to a secondary level. It can be said that the SAFs were effective in the conservation and recovery of soils and in the diversification of production, which generated greater stability and financial autonomy for families.

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