ADOPTION OF AGROFORESTRY SYSTEMS BY SMALLHOLDERS IN BRAZILIAN AMAZON

[ADOPCIÓN DE SISTEMAS AGROFORESTALES POR LOS PEQUEÑOS AGRICULTORES EN LA AMAZONIA BRASILEÑA]

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SUMMARY

The objective of this study was to identify the factors that have affected the adoption of commercial agroforestry systems (AFS) by smallholders of the municipality of Bragança, state of Pará, Brazil. Tools of Rapid Rural Diagnosis (structured interview and direct observation) and of Participatory Rural Diagnosis (agricultural calendar and ranking) were used.. The majority of smallholders that adopted these systems in Bragança received funding from government banks to purchase seedlings and other inputs; in order of importance, access to financing, utilization and management of agroforestry systems, education of farmers and decision-making are determinant factors for adoption of agroforestry systems implanted in smallholders' areas of the municipality of Bragança, state of Pará.

Key words: Smallholder agriculture; Eastern Amazon; Agroforestry Systems.

RESUMEN

El estudio tuvo como objetivo identificar los factores que afectan la adopción de sistemas agroforestales (SAF) de los pequeños agricultores de Bragança, Pará. Fueron utilizadas las herramientas de Diagnóstico Rural Participativo (entrevistas semi-estructurada y observación directa) y Diagnóstico Rural Rápido (calendario agrícola y *ranking*). La mayoría de los agricultores que han adoptado estos sistemas en Bragança recibieron financiamiento de la banca oficial, para comprar semillas y otros insumos, en orden de importancia, el acceso a financiamiento, la gestión de los sistemas agroforestales, la educación de los agricultores y la toma de decisiones son los factores más importantes en la adopción de sistemas agroforestales para los agricultores en Bragança, Pará, Estado.

Palabras clave: Agricultura familiar; Amazonia Oriental; Sistemas Agroforestales.

INTRODUCTION

Slash and burn agriculture is a widely used practice by smallholders in Amazon region. However, this model of agricultural production has created many doubts about its sustainability, which is hampered by factors such as the use of low level technology, and the negative environmental impacts of agricultural practices, among others.

An alternative to shifting cultivation in Brazilian Amazon are agroforestry systems (AFS). Among the various models of these systems practiced in this region, commercial multistrata systems are highlighted, which are important for income generation for smallholders (Sanguino *et al.*, 2007;

Francez, 2007; Bentes-Gama *et al.*, 2005), besides providing various environmental services.

Despite the advantages listed above, the adoption of multistrata AFS for commercial purposes by the farmers in the Brazilian Amazon is low compared to shifting cultivation. This happens due to political, technical, structural, economic and sociocultural barriers (Rosa *et al.*, 2009). These authors highlight the necessity of public policies that support the adoption of AFS based on scientific knowledge and local expertise as well.

Although AFS have been extensively studied in last decades, there is a growing demand for scientific research designed to systematize the experiences of AFS and that enable the identification of constraints

and opportunities related to the AFS adoption in the context of family farming in the Brazilian Amazon. In order to understand this problem, the objective of this research was to identify factors that have affected the adoption of commercial agroforestry systems established by smallholders in Bragança, Pará State, in Eastern Amazon, Brazil, aiming to supply subsidy to the programs for smallholder in Amazon region, specially the ones that contemplate the implantation of agroforestry systems.

MATERIAL AND METHODS

The research was carried out in the municipality of Bragança (01º 03' 15" S e 46º 46' 10" W), Pará State, situated in the Bragantina Microregion, Eastern Amazon, Brazil. The climate of Bragança is equatorial super humid, with maximum temperature of 33ºC and minim of 18º C, presenting average of 27º C. This municipality presents high rainfall (2,501 mm/year), with rainy period in first six months of the year. The original vegetation of the up land areas was composed for the subtype dense forest that was substituted by secondary forests with different stages, after the deforestations (Governo do Estado do Pará, 2005).

The total population in the urban and rural zone, until the year of 2000, was of 93,779 inhabitants, distributed in 2,333,70km^2, however the percentage of the economically active population was of 38.4% until the year of 2000 (Fundação IBGE, 2000). The economy of the municipality is based in the agricultural and raising cattle activity, and the most important crops economically are: cassava, beans, black pepper, orange and coconut. (Governo do Estado do Pará, 2005).

The research was achieved with 53 smallholders that developed 62 experiences with multistrata agroforestry system on their property. This municipality was selected because it has a significant number of experiences of these kinds of AFS, established by smallholders, compared to others places.

The first field visits occurred in 2004. The following institutions were identified and contacted as key ones: Pará State Technical Support and Rural Extension Company (EMATER-PARÁ), Pará State Secretariat of Agriculture (SAGRI-PA), besides representatives of social movements, such as Rural Workers' Union and also presidents of local associations and cooperatives engaged in agricultural activities in Bragança. The collective participation of these social actors allowed the identification of communities with at least one experience of AFS in this municipality.

The tools used in order to collect the data in rural area were: one structured interview, direct observation, ranking and agricultural calendar with smallholders (Chambers, 1987). The use of different tools and the participation of key people of this municipality favored the localization by triangulation, increasing the accuracy of the information collected.

The collected data were analyzed by frequency distribution analysis and by factor analysis method, using the "Statistical Package for the Social Sciences" (SPSS 13.0®). Factor analysis aims to describe the dependence structure of a set of variables by creating factors that supposedly measure common aspects (Diego, 2003).The application of this statistical method aimed to identify the factors that most affected smallholders AFS adoption. The extraction of factors was performed by the principal components method using the *varimax* criterion.

Adequacy of the method was performed using the Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity. The first one calculated the partial correlation coefficient between pairs of variables, eliminating the effect of others, and the second one calculated the overall correlation coefficient, as well as it estimated the overall significance of the correlation matrix.

Among the 33 variables extracted from the field research, only 15 were correlated with each other, such as: AFS composition, source of financial resource, smallholder education level, the reason to deploy the AFS, the purpose of the AFS, purchase of seedlings, land preparation, smallholders sex, geographical origin of the smallholders, cultural practices, age of the smallholder, harvest methods, smallholder's aspirations in relation to AFS, benefits generated and frequency of sale of products. However, only the first eight variables were selected for correlation analysis, the most correlated with each other. After this step, factor analysis was applied using the statistical model in matrix form, according to Dillon and Goldstein (1984).

RESULTS AND DISCUSSION

Financial resources

Approximately 83% of smallholders with commercial AFS in Bragança received funding obtained from financial agents for the purchase of seedlings and other inputs to establish AFS (Figure 1). This figure reveals that more than 11% of smallholders used own resources to obtain these inputs and almost 6% of them established AFS with resources originated of both modalities (financed and own resources).
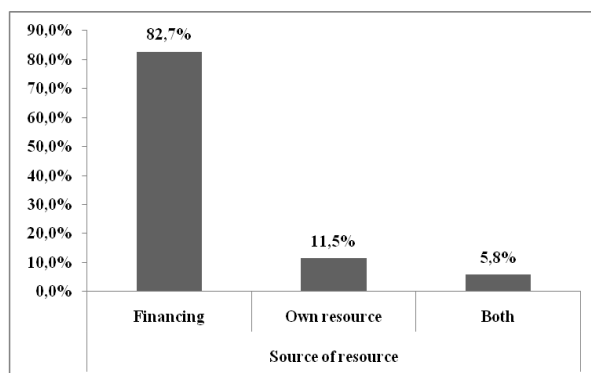
Figure 1. Source of resource used by smallholders to established AFS in Bragança, Pará, Brazil. (n=53).

These results show that smallholders used three modalities of financial resources. In spite of the great importance of the fundings obtained from financial agents for adoption of AFS, it must be recognized that the financial resources coming from smallholders played an important role for the establishment of AFS and diversification of monoculture areas, transforming them in AFS.

Factorial analysis

Analysis of correlation of variables

The results revealed that there was a dependence structure among the eight variables evaluated in this study. (Table 1). The AFS composition showed positive correlation with the source of funding and the purchase of seedlings. However, the most significant positive correlation occurred between the variable source of funding and purchase of seedlings. It was also detected correlation between variable source of funding and purchase of seedlings, once local smallholders have received funding of Constitutional Fund of Financing of the North (FNO-special) to buy

the coconut seedlings (*Cocos nucifera* L.) orange seedlings (*Citrus sinensis* (L) Osb.) and black pepper seedlings (*Piper nigrum* Vell.).

According to farmers, seedlings of the black pepper and orange seedlings were purchased on Bragantina microregion. Coconut seedlings were bought in northeastern of Brazil, because the plant nurseries in the microregion Bragantina did not have enough coconut seedlings, required for the project.

It is important to point out that according to the smallholders, they did not took part on the selection of species in the projects supported by the Special FNO, once it was previously determined by financial agents, but they had interest in these species.

The correlation between the purpose of the AFS and the purchase of seedlings was negative and weak. According to almost 86% of local smallholders, the primary purpose of the projects was to sale the products (Figure 2). However, except of black pepper, the remaining fruitful species above mentioned did not produce fruits of the good quality, due to poor quality of the seedlings provided by the financing programs, and, consequently they did not present the expected development, resulting in low or no productivity of the fruits.

The bad quality of seedlings contributed to their high mortality, leading them to introduce commercial species of their own interests which are better adapted to local conditions, leading to diversification of the AFS floristic composition. In this case, the seedlings were produced by the smallholder.

Table 1. Correlation matrix of the variables studied in the municipality of Bragança.

	A	B	C	D	E	F	G	H
A	1.000							
B	0.357	1.000						
C	0.226	-0.095	1.000					
D	0.090	-0.208	0.151	1.000				
E	0.063	-0.180	0.026	0.232	1.000			
F	0.417	0.438	0.282	-0.088	-0.322	1.000		
G	-0.107	-0.173	-0.136	-0.233	0.273	-0.204	1.000	
H	0.081	0.044	0.009	0.065	0.038	0.043	-0.074	1.000

Where: A – AFS Composition; B - Source of financial resources; C - smallholder education level; D - Reason to deploy the AFS, E - Purpose of the AFS; F - Purchase of seedlings; G – Land preparation; H – Sex smallholders.
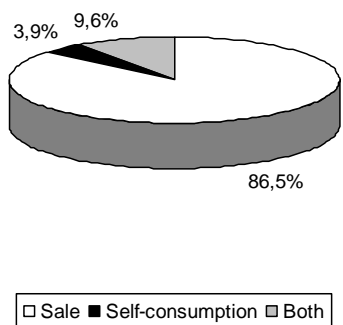
Figure 2. Agroforestry systems purpose in family agriculture areas in Bragança, Pará, Brazil. (n=53).

Almost 4% of farmers have implemented systems only for family consumption, aimed at food security (Figure 2). This happened mainly when the AFS were implemented with own funds. The remaining percentage (almost 10%) aimed to sale and self-consumption.

Extraction of factors

According to Diego (2003), the results obtained by the tests of Kaiser-Meyer-Olkin (KMO) and by Bartlett's sphericity test (Table 2), demonstrated the viability of the sample as well as the adequacy of the use of the Factorial Analysis.

The eigenvalues and the principal components obtained from the spectral decomposition of the correlation matrix are presented in Table 3. The first four components (all with eigenvalues greater than one), together explain approximately 72% of the total variance of the data. The other components explain only around 28% of the total variance.

The matrix of factor loadings, after orthogonal rotation is presented in Table 4. It is observed the creation of four significant factors (Factor 1: Access to finance; Factor 2: AFS use and Management; Factor 3: Education level of smallholders and Factor 4: Decision-making), representing almost 72% of the variance of original data set. A synthesis of the analyisis of factors is presented in Table 4.

Table 2. Results of KMO and Bartlett tests

Measurement of viability of the sample: KMO (*Kaiser-Meyer-Olkin*)		**0.53**
Bartlett's sphericity Test	Chi-square	57.882
	Degree of freedom	28
	p-value	0.001

A summary of the analysis of the factors is presented in Table 5. The AFS composition, the source of financial resources and purchase of seedlings and others materials are closely related and have a direct relation to access to finance (factor 1).Thus, this factor has a significant weight to the adoption decision of the AFS by the smallholders in Bragança, once this factor, itself, explains around 23% of the total variance.

These results correspond to the data presented earlier in Figure 2, which shows that the majority of smallholders in this study received funding from financial agents for the purchase of seedlings and others inputs for the AFS adoption. In spite of that, many smallholders related difficulties in the reception of the financial resource, what, most of the times was received out of the period of planting, what delayed the development of the species in the AFS.

Table 3. Results of the eigenvalues for the extraction of factors, components and total variance explained by the values of the variables under study.

	Eigenvalue e initial variances			**Variance after rotation**		
Components	**Eigenvalue**	**% Variance**	**Cumulative variance**	**Eigenvalue**	**% Variance**	**Cumulative variance**
1	2.106	26.319	26.319	1.876	23.453	23.453
2	1.419	17.739	44.058	1.411	17.641	41.094
3	1.185	14.812	58.870	1.403	17.542	58.637
4	1.029	12.862	71.732	1.048	13.095	**71.732**
5	0.854	10.674	82.406	-	-	-
6	0.576	7.201	89.607	-	-	-
7	0.476	5.952	95.559	-	-	-
8	0.335	4.441	100.000	-	-	-

Table 4. Matrix of factor loadings of the variables after orthogonal rotation by the *Varimax* method

	Variables	Factor 1	Factor 2	Factor 3	Factor 4
1	AFS composition	0.826	-	-	-
2	Source of financial resources	0.610	-	-	-
3	Smallholders' education	-	-	0.656	-
4	Reason to deploy the AFS	-	-	0.767	-
5	Purpose of AFS	-	0.820	-	-
6	Purchase of seedlings	0.753	-	-	-
7	Land preparation	-	0.712	-	-
8	Sex of smallholders	-	-	-	0.858
	% variance	23.453	17.641	17.542	13.095
	Cumulative variance	23.453	41.094	58.637	71.732

Note: The line in the empty spaces represents values less than 0.5.

Table 5. Factors determining the adoption of the AFS deployed in areas of smallholders in Bragança, Pará, Brazil.

Order of factor	Name of factor	Variables
1	Access to financing	1 AFS composition
		2 Source of financial resources
		6 Purchase of seedlings
2	AFS use and management	5 Purpose of AFS
		7 Land preparation
3	Education level of smallholders	3 Smallholders'education
		4 Reason to deploy the AFS
4	Decision-making	8 Sex of smallholders

Studies developed by Rosa *et al*. (2006) and Rosa *et al*., (2009), in areas of smallholders in the microregion of Bragança, showed the same problems, however, these authors point out that government funding programs, such as the FNO-special, were fundamental for the AFS adoption in this microregion.

Studies in Latin America found that financing projects were also decisive in the AFS adoption (Current, 1997). The author emphasizes that credit projects that provide technical assistance combined with minimum incentives are the ones that have obtained the best results in economic terms.

Funding is a major factor in the adoption of commercial agroforestry systems in the tropics. However, the success of these systems need other factors such as social organization, marketing of products and the presence of technical assistance which together constitute a viable option for family agriculture. Bentes-Gama *et al*. (2005) and Rosa *et al*. (2009) point out that technical assistance plays a fundamental role to the AFS adoption.

Almeida (1999) concluded that the main reasons for the AFS adoption in El Salvador were land ownership, presence of technical assistance and the benefits generated by trees. The author reports that farmers who held land ownership were the most interested ones in the AFS adoption.

The factor 2 (AFS use and management) also exerts a strong influence on the AFS adoption in Bragança, for it represents almost 18% of the total variance. This can be explained by the fact that, in many cases, the AFS that were focused to the market, received more attention from the farmer and from the government in terms of mechanization and fertilization, because both aimed to increase the generation of family income.

It is important to emphasize that problems related to marketing like the lack of technical assistance, among others, contributed to the failure of many experiences of AFS in Bragança. Similar results were reported by Rosa *et al*. (2006) and Rosa *et al*. (2009) evaluating the multistrata AFS in the microregion of Bragança, by Vieira (2006) investigating the AFS in Igarapé-Açu-PA, as well as Francez (2007) studying multistrata AFS in Nova Timboteua- PA. In the case of Bragança, smallholders reported that the official enterprise of technical assistance and rural extension of Pará State (EMATER-PA) only provided assistance in the early years of AFS establishment. According to these local smallholders, this short period of the assistance was one of the causes of failure of the AFS.

The education level of smallholders (Factor 3) was responsible for approximately 18% of the total variance. This factor exerts a strong influence on the adoption of the AFS in the study area. These results indicate that the education enabled the credit acquisition for the implantation of AFS, as well as the access to the information.

The results found in Bragança correspond to the ones found by Pereira (2004) in Santo Antônio do Tauá, Pará State. This author observed that the education level of the smallholders had a positive relationship with the implantation of AFS. Similar results were reported by Rosa *et al.* (2009) evaluating the adoption of AFS in the microregion of Bragança, in the state of Pará, observed that the adoption of these systems is directly influenced by education, social organization and cultural aspects. To Franzel *et al.* (2004) the educational level may influence the ability to access information and to obtain funding for the establishment and management of agroforestry systems, thus, it can be decisive in the AFS adoption. Vieira (2006), however, in studying agroforestry systems in Igarapé-Açu, Pará State concluded that the education factor was not decisive for the AFS adoption.

Decision-making (Factor 4), which included only the variable sex of farmers, also had a strong influence on the AFS adoption in this municipality, as it represented almost 13% of the total variance of data, evidencing the force of the patriarchal model in the adoption of technologies, including land use systems as AFS, as well as the importance of organization of men. The total of the number of smallholders who have adopted AFS, 89% were men and only 11% were women.

Vieira *et al.* (2008) and Vieira *et al.* (2009) investigating the role of men and women in agroforestry activities, in the Bragantina microregion, Pará State, found that men take responsibility over commercial AFS decision making, while women are responsible for agroforestry and home garden decisions.

Franzel *et al* (2004) argue that gender and social class are factors directly related to the AFS adoption. Studies conducted in Zambia showed that approximately 23% of women farmers have adopted AFS. The authors attributed to the strength of local women's organization.

Lok (1997), evaluating sustainability in agroforestry systems in Latin America observed that the adoption of these systems is subjected to variables related to family income, the vulnerability of the farmer, as well as to several social and cultural variables that influence directly in the AFS adoption.

The participation of smallholders, including women in AFS adoption needs to be strengthened, as well as local community organizations in order to have access, control, and decision-making on the projects implemented by the governmental official institutions, empowering themselves. Brose (1999) points out that only groups or institutions that work in a participatory way and that want to accept changes in the *status quo*, are capable of introducing projects that involve the smallholders. According to the author, projects that develop this proposal employ participatory tools and establish systems for planning, monitoring and evaluation.

Therefore, the effective participation of smallholders in decision-making of the financing projects can be a way to minimize the failure of many projects in agroforestry systems. Projects outside the local reality of these farmers also contribute to the existence of the problems described above. The proposals tend to be "top down" ones, carrying away the farmers' decision power.

Thus, credit policies besides the ones that foment the implementation of agroforestry systems for family agriculture in the Brazilian Amazon, must take into account smallholders prior knowledge of certain species and/or land use systems, as well as problems related to market so that agricultural and agroforestry become socio-economically and environmentally sustainable.

Similarly, Rosa *et al.* (2009) suggest that political instruments should contemplate the following aspects in relation to AFs: adoption of the appropriate mechanisms for the improvement and the commercialization of the products originated of the AFS; strengthen of the local market; guarantee the agroforestry extension orientated in the scientific and of the common *census* knowledge (traditional knowledge); to provide facilities in the obtaining of official resources of credits and financings for the acquisition of materials and agricultural machines, as well as to stimulate agribusiness opening, and to provide training for the farmers in several knowledge areas related to the smallholders agriculture, mainly in the management of rural properties and agroforestry systems, aiming the empowerment of the same ones.

CONCLUSIONS

The adoption of the commercial multistrata agroforestry systems by smallholders of Bragança was strongly influenced by the financial resources of official agents of government funding, used to purchase seedlings and other inputs.

By order of importance, access to financing, use and management of AFS, education of smallholders and

decision-making are the decisive factors in agroforestry systems adoption in areas of family agriculture in Bragança, Pará, Brazil. Men take responsibility over the adoption of commercial multistrata AFS in the Bragança, Pará State. Women have little participation on decision-making and in the control of the resources generated in the family unit, even contributing with the labor force and for family budget.

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