

Factors for the adoption of agroforestry systems in the Eastern Amazon, Brazil

dos Santos, Leonilde Rosa¹; Carlindo Silva Raiol²; Thiago Almeida Vieira^{3,4}; João Guimarães Pinheiro¹

¹Universidade Federal Rural da Amazônia. Av. Tancredo Neves, 2501. Montese, Belém, Pará, Brasil;

²Instituto de Estudos Superiores da Amazônia. Av. Gov. José Malcher, 1148. Nazaré, Belém, Pará, Brasil;

³Universidade Federal do Oeste do Pará. Rua Vera Paz, s/n. Salé, Santarém, Pará, Brasil;

⁴thiago.vieira@ufopa.edu.br

dos Santos, Leonilde Rosa; Carlindo Silva Raiol; Thiago Almeida Vieira; João Guimarães Pinheiro (2014) Factors for the adoption of agroforestry systems in the Eastern Amazon, Brazil. Rev. Fac. Agron. Vol 113 (2): 140-146.

The purpose of this study was to identify and evaluate the relevant factors for the adoption of AFSs in subsistence farming in Santa Maria do Pará, in the Brazilian Amazon. The study was conducted with 32 smallholders who established 51 multistrata agroforestry systems. Tools such as structured interviews, direct observations and an agricultural calendar were used to collect the data. The data were analyzed by factor analysis. The technical/educational level, followed by the social/organizational level, environmental (AFS) awareness, and land tenure/financial conditions were the most relevant factors for the adoption of agroforestry systems in the context of family agriculture, in this study.

Keywords: Smallholder agriculture, Amazon, Socioeconomy, Factor analysis.

dos Santos, Leonilde Rosa; Carlindo Silva Raiol; Thiago Almeida Vieira; João Guimarães Pinheiro (2014) Factors for the adoption of agroforestry systems in the Eastern Amazon, Brazil. Rev. Fac. Agron. Vol 113 (2): 140-146.

Este trabalho teve por objetivo identificar os fatores relevantes para adoção de sistemas agroflorestais comerciais em áreas de agricultores familiares de Santa Maria do Pará. O trabalho foi realizado com 32 agricultores familiares, que estabeleceram 51 experiências de sistemas agroflorestais multiestratificados. Para a coleta de dados foram utilizadas entrevistas estruturadas, observação direta e calendário agrícola. Os dados coletados foram analisados pela análise fatorial. Os fatores mais relevantes para adoção de sistemas agroflorestais foram: técnico-educacional; sócio-organizacional; percepção agroflorestal; e fundiário-econômico.

Palavras-chave: Agricultura familiar, Amazônia, Socioeconomia, Análise fatorial.

Recibido: 10/10/2013

Aceptado: 26/01/2015

Disponível on line: 01/03/2015

ISSN 0041-8676 - ISSN (on line) 1669-9513, Facultad de Ciencias Agrarias y Forestales, UNLP, Argentina

INTRODUCTION

The dynamics of land use in the Amazon region has been characterized by the slash-and-burn agriculture and pasture establishment, among others. However, these systems have degraded the primary and secondary forest vegetation, as well as the soil and other natural resources.

Although a great part of the smallholders of the Brazilian Amazon have used slash-and-burn agriculture, the sustainability of this land use system is highly questionable; on the contrary, agroforestry systems (AFS) are seen as a sustainable alternative to shifting cultivation and for the rehabilitation of degraded areas (Rosa et al., 2009).

There are numerous advantages to the AFSs over the traditional land use systems from the ecological, economic and social points of view (Dubois, 2009; Rosa et al., 2009). However, despite all benefits, there is a great lack of information about the adoption of these systems in smallholder communities in the Brazilian Amazon region, raising a series of questions and uncertainties regarding the adoption of these systems.

Importantly, most studies on AFSs show that a number of social, economic and technical factors, among others, represent barriers to AFS adoption, contributing to the frequent failure of experiences in the context of smallholder agriculture in the Brazilian Amazon region (Vieira et al., 2007a; Francez, 2007; Henkel & Amaral, 2008; Rosa et al., 2009, Pompeu et al., 2012).

To understand and clarify this problem, this study aimed to identify and evaluate relevant factors for the adoption of commercial agroforestry systems on family farms, in Santa Maria do Pará.

MATERIAL AND METHODS

The study was carried out in the municipality of Santa Maria do Pará (01°21'00"S, 47°34'30"W), in the region of Bragançana, in the Eastern Amazon, Brazil. The climate of Santa Maria do Pará is equatorial super humid, "Am" (climate with high temperatures around 20° C, humidity between 80% and 90%, and rainfall of nearly 2.250 mm) according to Köppen (1931). Precipitation is high, with an annual mean of 2.250 mm. The mean annual temperature is 27°C and humidity between 80% and 90%. The vegetation of Santa Maria do Pará consists of secondary forests in different stages, as a result of deforestation for urban occupation and agricultural activity (Governo do Estado do Pará, 2005).

The economy of the municipality is based on agriculture and livestock, and the economically most important crops are cassava, maize, beans, black pepper, passion fruit, orange, and coconut. (Governo do Estado do Pará, 2005).

The study was carried out with 32 smallholders who established 51 AFSs with multistrata agroforestry. Common permanent species were: *Cocos nucifera* L. (coconut), *Piper nigrum* L. (black pepper), *Theobroma grandiflorum* Chum. (cupuaçu pulp), *Anacardium occidentale* L. (cashew), *Euterpe oleracea* Mart. (açai palm), *Passiflora edulis* Sims. (passion fruit), *Citrus*

sinensis (L.) Osb. (orange) and *Citrus limon* L. (lemon). The common temporary species were *Vigna unguiculata* (L) Walp. (cowpea) and *Manihot esculenta* Crantz. (cassava). All these species have special characteristics such as: commercial fruit trees; food security; adapted to local climates and soils. The most common multistrata agroforestry systems were: a) cashew with black pepper; and b) coconut with black pepper.

Data were generated using tools of Rapid Rural Appraisal, such as direct observations and structured interviews. In addition, an agricultural calendar, an application of Participatory Rural Appraisal, was used. Participation of key representatives of social movements, for example of the Rural Workers' Union, presidents of local associations and cooperatives, as well as of government organs engaged in agricultural activities in Santa Maria do Pará, were important for the identification of communities with at least one experience of AFS. The use of different tools and the participation of key people of this municipality favored data triangulation, increasing the accuracy of the information collected.

Of the 32 variables extracted from the field research, only 8 were correlated with each other (technical assistance, formal education level, farmers' age, participation in community organizations, awareness of importance of the AFS, reasons for AFS adoption, land tenure and financial resources).

The Factor Analysis Method was used to describe the dependence structure of a set of variables by creating factors that supposedly measure common aspects. The extraction of factors was performed by the principal components method with Kaiser's varimax criterion, as used by Mingoti (2005).

The method was adjusted using the Kaiser-Meyer-Olkin (KMO) measure, accepting values of > 0.50, as well as Bartlett's sphericity test as measure of sampling adequacy (Hair Jr et al., 2005). Data were analyzed, using the "Statistical Package for the Social Sciences" (SPSS 13.0®).

RESULTS AND DISCUSSION

The Kaiser-Meyer-Olkin and Bartlett's sphericity tests (Table 1) demonstrated the viability of the sample as well as the adequacy of the use of Factorial Analysis, according to Hair Jr et al. (2005) and Noronha (2005).

The eigenvalues and main components were obtained from the spectral decomposition of the correlation matrix. The eigenvalues of the first four components were > 1, which is above the acceptable minimum of 70% (Hair Jr. et al. 2005), and together explained approximately 72% of the total variance.

These results are similar to those reported by Pompeu et al. (2012) when studying the adoption of commercial AFSs by smallholders in the municipality of Bragança. This author verified that the first four components represented 71.7% of the total data variability, while the others accounted for about 28%.

After octagonal rotation by the Varimax method, four relevant factors for adoption of AFS in Santa Maria do Pará were identified, which together expressed more

than 71% of the accumulated variance. Each factor consisted of only two interrelated original variables (Table 2).

Table 1. Results of KMO and Bartlett tests. Source: Field Research

Measurement of viability of the sample:		
KMO (<i>Kaiser-Meyer-Olkin</i>)		0.502
Bartlett's sphericity test	Chi-square	37.846
	Degree of freedom	28
	<i>p</i> -value	0.002

The commonality values from 0 to 1 express how much each variable is explained by each extracted main component. The values were high for the variables technical assistance, farmers' age, importance of the AFS, reasons for AFS establishment and land tenure. These variables were well-represented by the main component, to which they belong, when compared to the other variables in Table 2.

To facilitate interpretation, the four factors were characterized as follows: Factor 1 - Technical/educational level; Factor 2 - Social/organizational level; Factor 3 - Agroforestry awareness and Factor 4 - Land tenure/financial conditions (Table 3).

Factor 1 - Technical/educational level. The weight of this factor is significant in the decision on AFS adoption by the smallholders in Santa Maria do Pará, once this factor alone explains 19.79% of the total variance.

For the first variable – technical assistance – interrelationships were high and negative, while for formal education they were moderate and positive. These data can be explained by the farmers' limitations, especially of the older and illiterate farmers, who had difficulties in accessing information about AFS management. It is noteworthy that 16% of the farmers were illiterate. On the other hand, 25% of the farmers that received technical assistance during the establishment phase of the AFS belonged to an intermediary age group, and had a higher level of schooling. These results revealed that a low level of formal education can be a barrier to the access to information, but is not a limiting factor for the adoption of AFSs in Santa Maria do Pará, in contrast to technical assistance.

Formal education was not decisive for AFS adoption in a smallholder community in Igarapé-Açu, Pará (Vieira et al., 2007a) and Bragança, Pará, (Pompeu et al., 2011), Eastern Amazon, but was positively associated to the access to information and financial resources for AFS establishment.

Studies on AFSs developed on the African continent showed that formal education is positively associated to access to information of the farmer and to financial resources for AFS establishment (Franzel et al., 2002).

The problem with lacking technical assistance associated with adoption of AFS in smallholder communities was also observed in other municipalities in the region of Bragantina (Francez, 2007; Vieira et al., 2007a; Henkel & Amaral, 2008; Rosa et al., 2009; Pompeu et al., 2011). The authors consider the lack of technical assistance as a barrier to AFS adoption in the eastern Amazon, in contrast to schooling.

It is important to highlight that problems related to technical assistance, among others, contributed to the failure of many AFS projects in the region of Bragantina (Rosa et al., 2009; Pompeu et al., 2012).

Table 2. Matrix of factor loadings of the variables after orthogonal rotation by the Varimax method. Factor 1: Technical/educational level; Factor 2: Social /organizational; Factor 3: Agroforestry awareness; Factor 4: Land-financial condition. Note: Factor loadings in bold > 0.50.

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Commonality
Technical assistance	-0.850	0.242	0.075	-0.042	0.789
Formal education	0.637	0.324	0.066	0.089	0.523
Farmers' age	-0.264	-0.796	-0.053	0.035	0.707
Participation in community organizations	-0.190	0.761	-0.227	-0.061	0.670
Importance of the AFS	-0.138	0.087	0.901	0.041	0.841
Reason for AFS adoption	0.195	-0.325	0.740	-0.155	0.716
Land tenure	0.238	0.140	-0.008	0.844	0.788
Financial resources	0.485	0.248	0.127	-0.600	0.673
% of variance	19.790	19.615	18.017	13.909	-
Accumulated variance	19.790	39.405	57.422	71.331	-

Table 3. Relevant factors for adoption of agroforestry systems in Santa Maria do Para, Brasil.

Factor	Fator specification	Determinant original variables
1	Technical/educational level	1 - Technical assistance 2 - Formal education
2	Social /organizational	3 - Farmers' age 4 - Participation in community organizations
3	Agroforestry awareness	5 - Importance of the AFS 6 - Reason for establishment of the AFS
4	Land-financial condition	7 - Land tenure condition 8 - Financial resource

According to Abramovay et al. (2010), agricultural projects of Brazil achieved the best economic results when aside from credit, farmers were supported with technical assistance.

Factor 2 - Social organization level, composed of the variables farmers' age and participation in community organizations. This factor alone explains 19.62% of the total variance. These two variables were highly interrelated, but the first was negative and the second positive. Interestingly, the participation of farmers in community organizations declines as the farmers' age increases.

However, it should be emphasized that the inclusion in social organizations is very important for AFS adoption in the Brazilian Amazon, especially to obtain credits, although it was not a limiting factor for the adoption of these systems. Studies on smallholder agriculture in the eastern Amazon also reinforced the importance of community organizations. These organizations support family farming, by enabling the farmers to obtain funding and to access rural credits (Francez, 2007; Rosa et al., 2009; Pompeu et al., 2011).

Francez (2007) observed that 83% of the smallholders with commercial AFS, in Nova Timboteua, eastern Amazon, participated in community organizations such as associations, cooperatives and Rural Labor Unions. The author pointed out that the participation of the farmers in community organizations was fundamental to obtain rural credits, technical assistance, property rights of their farms and general improvements in the infrastructure.

Rosa et al. (2009) found in the region of Bragantina, Eastern Amazon, Brazil, that 87% of the smallholders with experience in commercial AFSs participated in community organizations.

In Bragança, Pará, Pompeu et al. (2011) demonstrated the importance of the community organizations for the adoption of AFSs, since 92% of the smallholders with experience in commercial AFSs were members of these organizations.

Factor 3 - Perception of agroforestry is based on the variables importance and reasons to adopt AFSs. This factor alone explains 18.02% of the total variance. These variables with high positive interrelations indicated that the adoption of AFSs is promoted when the farmers are more motivated. A list of the importance of AFSs is presented in Figure 1.

According to half of the interviewed smallholders, income generation was the most relevant socioeconomic aspect for the adoption of AFS in Santa Maria do Pará. Soil protection was the second most important aspect in the perception of the group.

Furthermore, 31.5% of the smallholders reported other important socioeconomic aspects, such as land use optimization, improvement of living conditions, employment generation, production diversification, procurement of goods, self-consumption, and production increase.

In Igarapé-Açu, Pará, in an analysis of the perception of local smallholders, the species diversity in AFSs was considered as the decisive aspect for adoption (33%), followed by land use optimization (26.7%). Only 13.3% of the farmers prioritized the importance of income generation (Vieira et al., 2007a).

The awareness of the smallholders of the importance of production diversification for income generation, as well as of environmental benefits, was observed in Igarapé-Açu (Vieira, 2007b) and Bragança, Pará (Pompeu et al., 2009).

In Brazil, smallholders understand agroforestry systems as land-use systems that provide socioeconomic and environmental benefits (Castro et al., 2009, Rosa et al., 2009).

The reasons for the adoption of AFSs are listed in Figure 2. Approximately 47% of the AFSs were established because of the local farmers' own interest. However, 18.7% of the farmers reported other reasons related to financial issues such as funding by government programs, e.g., FNO - Especial (constitutional fund for financing in northern Brazil). Other reasons were cultural traditions, species diversification, followed by examples of surrounding farmers, motivation by the association, and experimental curiosity.

The reasons for adoption of AFS in Santa Maria do Pará were partly the same as reported in other studies in the Brazilian Amazon region. According to Pompeu et al. (2012) and Rosa et al. (2009), the most relevant reason for the adoption of AFS was the availability of financial resources through government programs, especially the FNO - Especial.

On the other hand, in Nova Timboteua, Pará, 35% of the smallholders reported that as social entities representing the interests of rural workers contributed strongly to the establishment of AFS, followed by family

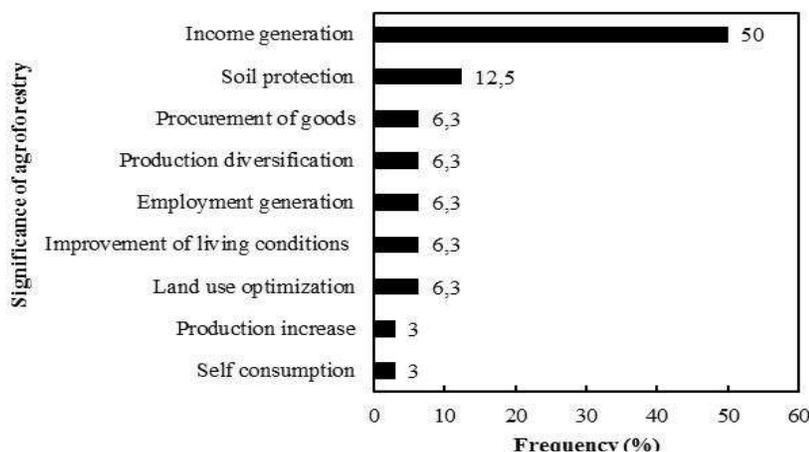


Figure 1. Significance of agroforestry in the perception of the interviewed smallholders.

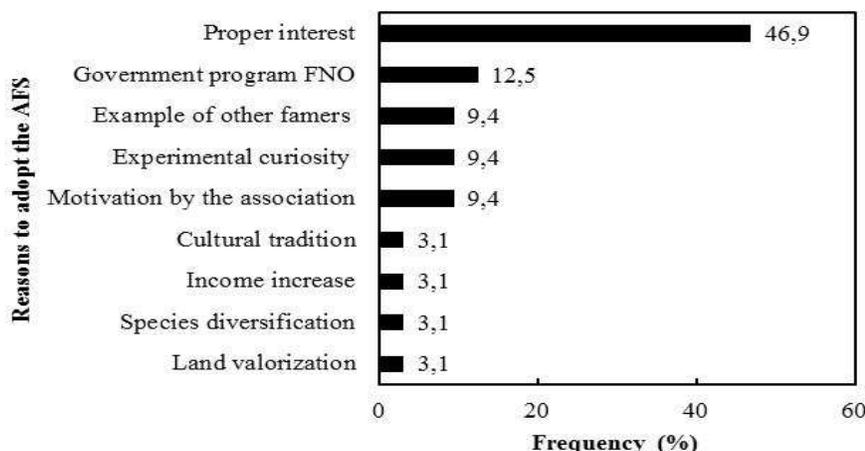


Figure 2. Reasons that led the farmers of Santa Maria do Pará to adopt the AFS.

tradition (24%). These results are somewhat similar to the observations in Santa Maria do Pará, where the participation of representative institutions as well as the cultural tradition were reasons for the adoption of AFS, though not the most relevant.

Factor 4 - explains 13.91% of the total variance. Land tenure/financial resources, consisted of the variables Land tenure and financial resources. For the first variable, interrelationships were high and positive, and for the second moderate and negative. The result demonstrated that when a farmer is his own landlord, his financial conditions tend to be more consolidated, depending less on external financial resources from governmental institutions to establish a commercial AFS.

This result can be explained by the fact that 78% of the producers with commercial AFSs are owners of their farms and the others are partners (13%), land occupants (6%) or tenant farmers (3%).

The land tenure also had an effect on the adoption of agroforestry systems in eastern Amazon. In Nova Timboteua, almost 88% of the families working with AFSs are owners of their lands (Francez, 2007). In Bragança, approximately 93% of the farmers are owners of their lands (Pompeu et al., 2009).

In Asia, especially in Indonesia (Suyanto et al., 2005) and Philippines (Gascon and Takahashi, 2006), as well as in Ghana on the African continent (Zhang and Owiredo, 2007), studies demonstrated that land tenure is a determinant factor for the adoption of sustainable land use systems, e.g., of AFSs and planted forests.

Thus, land tenure is a common issue in tropical regions, especially where subsistence agriculture is predominant and public policies for family agriculture are fragile.

Results showed that more than half (56%) of the farmers in Santa Maria do Pará used their own financial resources, 31% received funding from government agencies and almost 12.5% used both sources. These data showed that the farmers that invested capital of their own to establish AFSs were confident and optimistic about the success of their investments, in spite of the uncertainties of agroforestry systems in several aspects.

The effectiveness and efficiency of the governmental programs supporting projects of subsistence agriculture in Amazon has been target of several studies. According to Vieira et al. (2007a), Pompeu et al. (2009) and Rosa et al. (2009), the delayed release of funds caused a knock-on delay in planting, resulting in a high death rate of seedlings.

Pompeu et al. (2011) verified that the funding by government programs in Bragança was mainly destined for agricultural crops (annual and perennial species) of commercial value in monoculture. However, in many cases, local subsistence farmers, on their own initiative, diversified the crops, transforming them into AFSs (Vieira et al., 2007a; Rosa et al., 2009; Pompeu et al., 2011).

According to Rosa et al. (2009), the establishment of AFSs projects with the support of the FNO program in the eastern Amazon is affected by technical, financial and logistic problems. The authors pointed out that strategic policies are required that provide decision-support tools to promote AFSs, such as market-assessment tools, value-added strategies for AFSs products, local market enhancement, agroforestry extension services linking scientific with local knowledge, provision of credit and incentives for investments and operations, as well as for agribusiness and smallholder training in the management of AFSs and rural properties. These authors concluded that funding by government programs is decisive for the adoption of AFS in this region.

CONCLUSIONS

In this study, the technical/educational level, followed by the social/organizational level, environmental (AFS) awareness, and land tenure/financial conditions were the most relevant factors for the adoption of agroforestry systems in the context of subsistence agriculture.

Acknowledgements

We wish to thank the World Agroforestry Center (ICRAF) for the financial support. We also wish to express, to the smallholder farmers from the region of Bragança, for their readiness to kindly receive and cooperate with us, our sincere gratitude.

REFERENCES

- Abramovay, R., R. Magalhães & M. Schroder. 2010.** Representatividade e Inovação na governança dos Processos participativos: o Caso das Organizações Brasileiras de Agricultores Familiares. *Sociologias*. 12: 268-306.
- Castro, A.P., T.J.P Fraxe, J.L Santiago, R.B Matos & I.C. Pinto, 2009.** Os sistemas agroflorestais como alternativa de sustentabilidade em ecossistemas de várzea no Amazonas. *Acta Amazonica*. 39: 279-288.
- Dubois, J.C.L. 2009.** Sistemas agroflorestais na Amazônia: avaliação dos principais avanços e dificuldades em uma trajetória de duas décadas, *Informação Tecnológica*. pp. 171-217. In: Porro, R. (Org.). *Alternativa agroflorestal na Amazônia em transformação*. Brasília: EMBRAPA.
- Francez, D.C. 2007.** Sistemas agroflorestais no contexto socioeconômico dos agricultores familiares de Nova Timboteua, Pará. M.Sc. Tesis. Universidade Federal Rural da Amazônia. Belém, Pará, Brasil. 104 pp.
- Franzel, S., S.J. Scherr, R.P. Coe, J.M. Cooper & F. Place. 2002.** Methods for assessing agroforestry adoption potential. In: *Trees on the farm: assessing the potential of agroforestry practices in Africa*. Franzel, S.; Scherr, S.J. (eds.). Nairobi: CAB/ICRAF. pp.197.
- Gascon, N.A.F. & K. Takahashi. 2006.** Agroforestry systems in the Philippines: Experiences and Lessons Learned in Mt. Banahaw, Hanunuo Mangyan and Some Community-based Forestry Projects. Ohwashi: Japan International Research Centre for Agricultural Sciences. pp. 119.
- Governo do Estado do Pará, 2005.** Estatística Municipal. Disponível em <<http://www.pa.gov.br>> Accessed Oct. 30, 2005.
- Hair Jr, J.F., R.L. Tatham, R.E. Anderson & W.C. Black. 2005.** Análise multivariada de dados. Porto Alegre: Bookman. 593 pp.
- Henkel, K. & I.G. Amaral. 2008.** Análise agrossocial da percepção de agricultores familiares sobre sistemas agroflorestais no nordeste do estado do Pará, Brasil. *Boletim Museu Paraense Emílio Goeldi, Ciências Humanas* 3: 11-327.
- Köppen, W. 1931.** *Grundriss der Klimakunde*. Berlin: Walter de Gruyter. 390 pp.
- Mingoti, S.A. 2005.** Análise de dados através de métodos de estatística multivariada: uma abordagem aplicada. Belo Horizonte – M.G. Ed. UFMG, 295 pp.
- Noronha, V.A.B. 2005.** Estatística aplicada à Administração: Análise do uso em pesquisa na área construção de ambiente virtual de ensino-aprendizagem. Ribeirão Preto - SP. USP.
- Pompeu, G.S.S., L.S. Rosa, M.M. Santos, R.S. Modesto & T.A. Vieira. 2012.** Adoption of agroforestry systems by smallholders in Brazilian Amazon. *Tropical and Subtropical Agroecosystems* 15(1): 165-172.
- Pompeu, G.S.S., L.S. Rosa, S.L.F. Araújo, A.B.B. Araújo & E. de L. Silveira. 2011.** Influência das características socioeconômicas de agricultores familiares na adoção de sistemas agroflorestais. *Revista de Ciências Agrárias* 54(1): pp.35-43.
- Pompeu, G.S.S., L.S. Rosa, R.S. Modesto, M.M. Santos & A.F. Rodrigues. 2009.** Sistemas agroflorestais comerciais em área de agricultores

familiares no município de Bragança, Pará: um estudo de caso. *Revista de Ciências Agrárias*. 51: 191-210.

Rosa, L.S., T.A. Vieira, A.P.A. Santos, A.A.S. Meneses, A.F. Rodrigues, J.R.S. Perote & C.V.C. Lopez. 2009. Limites e oportunidades para a adoção de sistemas agroflorestais pelos agricultores familiares da microrregião Bragantina, Pa, pp. 645-670, 2009. In: *Alternativa agroflorestal na Amazônia em transformação*. Porro, R. (Ed.). Brasília: Embrapa-ICRAF.

Suyanto, S., R.P. Permana, N. Khususiyah & J. Laxman. 2005. Land tenure, agroforestry adoption, and reduction of fire hazard in a forest zone: A case study

from Lampung, Sumatra, Indonesia. *Agroforestry Systems*. 65: 1-11.

Vieira T.A., L.S. Rosa, P.C.S Vasconcelos, M.M. Santos & R.S. Modesto. 2007a. Adoção de sistemas agroflorestais na agricultura familiar em Igarapé-Açu, Pará, Brasil. *Revista de Ciências Agrárias*. 47: 9-22.

Vieira, T.A., L.S Rosa, P.C.S. Vasconcelos, M.M. Santos & R.S. Modesto. 2007b. Sistemas agroflorestais em áreas de agricultores familiares em Igarapé-Açu, Pará: caracterização florística, implantação e manejo. *Acta Amazonica*. 37: 549-558.

Zhang, D. & A. Owiredu. 2007. Land tenure, market, and the establishment of forest plantations in Ghana. *Forest Policy and Economics*. 9: 602-610.