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Potential for adoption of improved agroforestry technologies by rural communities in North-Sudanian Zone of Burkina Faso

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Abstract

The adoption of agroforestry at large scale appears to be an efficient solution for the conservation of biodiversity and the well-being of local communities, especially in developing countries. The present study analyzes the factors that influence farmers 'decisions to adopt agroforestry technology promoted by the Ecosystem Based Adaptation (EBA) approach in the 20th Ramsar site of Burkina Faso. We identified the major constraints for adopting agroforestry and discussed the criteria for choosing smallholders to conserve and preserve certain tree species in their farmlands. Data were collected from 120 households in three villages concerned by the agroforestry experience using the EBA approach. The collected data were analysed using logistic regression to predict the agroforestry technique adherence variable and then the chi-square independent test was used to analyze the association between gender and agroforestry plant use variables. Results showed that, gender, education level and farmland size, availability of seeds and plants, training in agroforestry had a strong influence on farmers' decision to keep or incorporate desired trees in their farmlands. In addition, the kind and type of use of agroforestry species influence the farmer's choice to integrate or conserve them in their farmlands. Women appreciate trees in farmland for their nutritional, aesthetic and environmental conservation roles; whereas men are favourable for their economic role. Taking these findings into account could considerably improve the participatory programs of local communities in the adoption of agroforestry.

Keywords: Agroforestry, Conservation, Climate smart agriculture, Ecosystem Based Adaptation, Farmers' perceptions, Smallholders, West Africa.

Introduction

Forests play an important role in the conservation of animal and plant biodiversity useful to humans. Thus, thousands of rural households have drawn most of their daily needs (food, fodder, fibers, medicines, energy, shade, timber, construction materials, etc.) through forest formations for centuries (Bognounou et al. 2013; Zizka et al., 2015; Sanou et al., 2017, Ouedraogo et al., 2019).

Over the past decades, the world's forests have been shrinking by 13 million hectares per year. This situation is worsened in sub-Saharan Africa where the total losses in forests, cultivated land and pastures are estimated at 30%, 20% and 10% respectively (FAO, 2010). It threatens 1.5 billion people who depend on forests around the world. In Burkina Faso, forest degradation affects more formations with a high rate of plant cover. From 2007 to 2012, these dense plant formations experienced a negative evolution from -11.48% to -17.42%. The main drivers of land degradation are linked to climate variability and anthropogenic pressure (Soulama et al. 2015, Bazame et al. 2018; Sanou, 2020). The impoverishment of agricultural land has the direct consequences of low production yields, food insecurity and increasing rural poverty (Kima et al. 2016). Faced with this alarming situation, farmers in the Sudanian zone are opting for the extension of cultivated areas through the conversion of forest areas, the practice of agriculture on formerly marginalized lands, the reduction of fallow time or simply its abandonment in order to fill the performance gap observed (Sanou et al. 2017). However, these options have a negative impact not only on the biophysical environment but also favor the reduction in the means of subsistence of rural populations who are becoming increasingly vulnerable in a context of climate change (Connolly-Boutin and Smit 2016, Bruckerhoff et al. 2020).

Agroforestry, which can be defined as a system of agriculture integrating annual crops and trees, appears as a solution to address ongoing environmental problems. The integration of local candidate tree species in crop farmlands and degraded lands helps to slow down the regressive trend of agrosystem forests. Thus, trees that are spared and conserved in farmlands provide socio-economic, agroecological and environmental opportunities and benefits (Ndayambaje, 2013; Bayala et al., 2014; Sanou et al., 2017; Cissé et al., 2018). Agroforestry has become a sustainable measure to combat soil degradation, soil loss and promote soil fertility. Trees in the farmland improve the hydrological cycle, biodiversity conservation and increase carbon sequestration in the soil (Acharya 2006; Garrity and Stapleton 2011; Weston et al. 2015). In addition agroforestry has other advantages such as the availability of wood for services and energy, fodder for livestock, non-wood forest products (Bayala et al., 2014; Sanou et al., 2017; Cissé; et al., 2018). It provides also the opportunities for payments for environmental services, including through the Reducing Emissions from Deforestation and Forest Degradation (REDD+) program advocated by the United Nations (Sanou et al. 2017).

The growing recognition of the contribution of agroforestry to sustainable agriculture has paved the way for a redeployment of this practice (Bengali 2018). However, the low adoption of natural resource management strategies accentuates land degradation (Ajayi et al. 2003; Weston et al., 2015). Several studies have shown that the adoption of agroforestry must necessarily take into account the socio-economic factors of households as well as the characteristics of the biophysical environment in order to meet local preferences and requirements (Oino and Mugure, 2013; Sanou et al., 2017; Azongnide et al., 2019). Research in the area of farmer perceptions related to agroforestry adoption indexes five categories of factors: household preferences, farmers' resource endowments, market incentives, biophysical factors as well as risk and uncertainties (Omuregbee 1998, Ndayambaje 2013). Other studies have shown that the age of the head of the household, the education level, the sex, the sanitation of the households, the size of the household, the wealth of the household, the surface of the farmlands and the access to agricultural inputs. , influence the adoption by farmers of agroforestry technologies (Jamala et al. 2013, Ndayambaje 2013).

However, in a participatory process of strengthening the economic and ecosystem resilience of rural communities, the analysis of the factors determining their adherence to the agroforestry practices promoted is important to guide development strategies. The study aimed to analyze the factors that influence farmer's decision in the Sudanian zone to adopt the agroforestry technology promoted by the EBA approach. We hope that the findings of this study may be taken in account in the conception of agroforestry programs in North-Sudanian region of Burkina Faso.

Material and methods

Description of the study area

The study area is the 20th Ramsar site in Burkina Faso which is located in the Boucle du Mouhoun region and part of the Center-West region, between longitudes 2 ° 26 'and 4 ° 38' West, and between latitudes 11 ° 15 'and 13 ° 44' North (Figure 1). This zone is characterized by annual water heights that vary between and 700 to 1000 mm (Fontès and Guinko 1995). The annual average temperature is 29 ° C. According to Fontès and Guinko (1995) this zone is located in the Sudanese phytogeographic domain. The entire Boucle du Mouhoun forest corridor network housing the study site is organized into five sub-watersheds which are Banifing, Lower Mouhoun, Upper Mouhoun, Nakambé and Sourou.

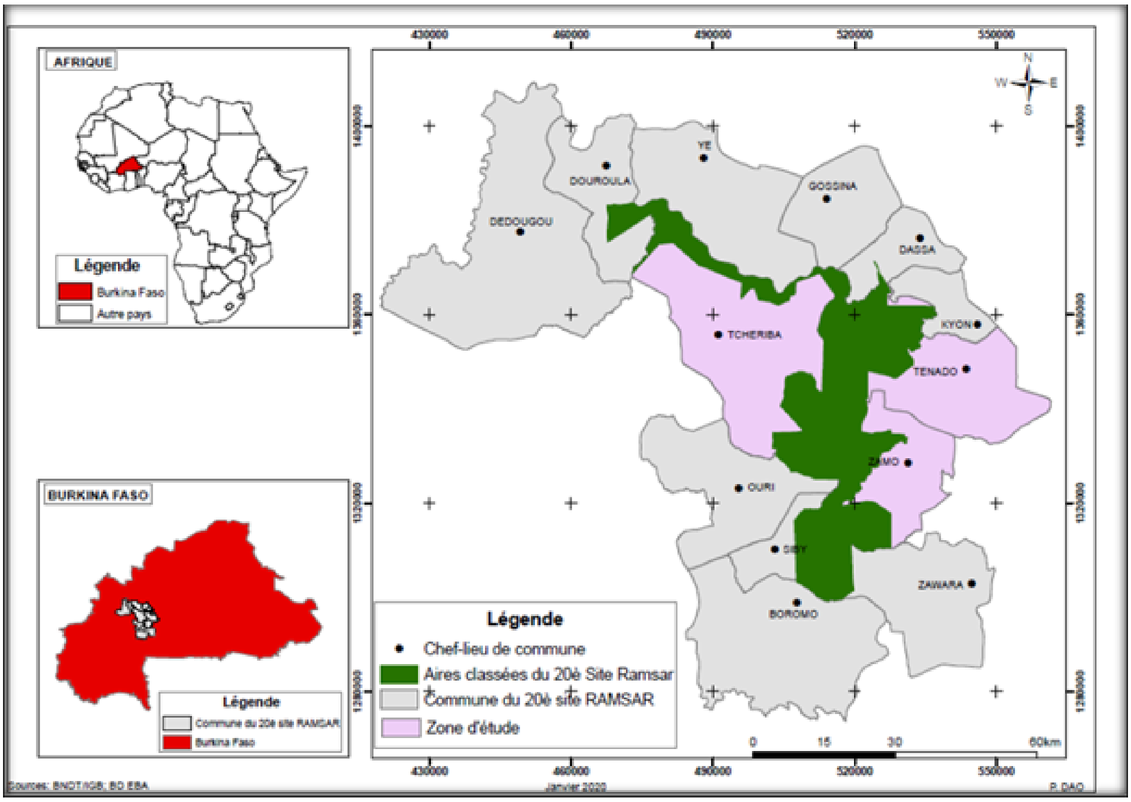

Figure 1: Location map of the study areas

Dominantly farmers, the population of the study area increased from 100,761 inhabitants in 2006 to 139,777 inhabitants in 2020 (INSD 2017). The majority ethnic groups in the area are the Gourounsi, the Nuni, the Marka, the Mossis and the Peuhls. The main crops are *Arachis hypogaea*, *Coton*, *Gossypium hirsutum*, *Panicum miliaceum*, *Sorghum bicolor*, *Vigna unguiculata* and *Zea mays* (Sanou et al. 2017).

The wooded riparian formations are mainly located on the banks of the Mouhoun River and its tributaries. The other plant formations in the area are the wooded and shrub savannas dotted with a continuous and intermittent herbaceous carpet in places (Savadogo et al. 2007; Sanou et al. 2018).

The Ecosystem Based Approach (EBA) project supports communities to promote agroforestry in the area. It provides material and agricultural equipment to the farmers (mainly women) for working the soil and planting the desired tree species chosen by the farmers. Thus, women are organized around gardens producing agroforestry plants. They are trained in agroforestry and plant production techniques and Assisted Natural Regeneration (ANR).

Sampling and data collection

This study is based on the quantitative approach to analyze the perceptions of local populations on the constraints that limit the adoption of agroforestry techniques. A project promotes the technique of the Agroforestry Approach Based on Ecosystems (EBA). It consists of organizing women around agroforestry production platforms in villages in the region. In addition to the women directly trained (experimental groups), the farming communities of the villages concerned are informed of this participatory experience. The statistical unit is any person aged at least 18, head of household and landowner, living in one of the three villages concerned by the EBA experience. Of those who are familiar with these technologies, we hope to have those who do not adopt the technology and those who do. The respondents were chosen on the basis of a stratified sampling in the villages experimenting with the EBA agroforestry approach. The stratification criteria are gender, age, education level, status of residence, adoption or not of agroforestry technology (Table 2). The data was collected on the basis of surveys of 120 people, including 75 women and 45 men. Three investigators easily understanding the local languages spoken (Lélé, Mooré and Dioula) from the different localities selected for the study were trained for three days on this information-gathering activity (Dolisca et al. 2006). The questionnaire was administered after the respondent had given their consent to participate. It included the socioeconomic characteristics of the interviewees, the sources of income based on the forest and the size of the household and herd, the agricultural practices in the village, the question of the use of forest resources and their degradation, the enumeration of constraints to adopt agroforestry based on the EBA approach, preferred agroforestry species and ecosystem services of these species, the criteria that guide their choice to keep certain types of trees in their farmlands.

Construction of the dependent variable

The dependent variable "the potential for adherence to agroforestry technology promoted by the EBA approach"

(ADHES) was constructed from the responses to the questions recorded in Table 1:

The questionnaire was developed using the survey methodology developed by Likert (1932). It consists in making statements about the problems and services generated by agroforestry activities in the living environment of the respondents. Each statement (Table 1) is accompanied by four answer choices ranging from 1 (strongly disagree) to 4 (fully agree). Respondents should select the answer option that best reflects their level of agreement or disagreement with the statement.

Table 1: Statements of the questions related to the dependent variable

N°	Statements
1	Plants in agroforestry give me a hobby, a satisfaction
2	I use agroforestry plants to delimit my field (cadastre)
3	Agroforestry helps maintain biodiversity for children
4	Agroforestry makes the environment better
5	Agroforestry limits cultivated plants by putting them in competition with trees
6	There are many drawbacks to planting and managing trees in the field
7	In the last three years I have planted x number of trees

1 = strongly disagree; 2 = slightly disagree; 3 = slightly agree; 4 = perfectly agree

These variables were subsequently transformed using the linear scoring technique of Liebig et al. (2001). To each variable, we apply scores ranging from 0 to 1 by applying the function "The more, the better" or the function "The less, the better", depending on a high value of the parameter reflects adoption of EBA agroforestry technology or vice versa. The "The more, the better" function is used to state indicators such as agroforestry provides a hobby; it makes it possible to delimit the farmlands; to maintain biodiversity and protect the environment. On the other hand, those who have planted a lot of trees join agroforestry. With this type of variable, each observation is divided by the highest value. Conversely, the "Less is better" function concerns statements such as agroforestry limits cultivated plants, and there are many disadvantages associated with managing trees in the field. In this case, the lowest observed value (= 1) is used as the numerator.

Then for the determination of the agroforestry adherence indicator (equation 1), a summation of the scores obtained from the above ratings was carried out (Andrews et al. 2002).

$$ADHES = \sum_{1}^{n} Si/n \qquad 1$$

Where Si = Score of the variable i; n = the total number of variables in the model

This variable was made dichotomous from the calculated mean. Individuals whose value of the adherence indicator is below the average report a non-adherence attitude, unlike those with a score ≥ the average.

Statistical analyzes

Primary survey data were analyzed by SPSS Statistical Package for Social Sciences software (Copyright SPSS, Windows, version 2011, Chicago, IBM, SPSS; Inc.). Descriptive analyzes (frequencies, mean) were used to summarize the profile of respondents and establish the frequencies of citations between groups of respondents. The Chi-square test was used to analyze the association between genus and types of use of agroforestry plants. Finally, the binary regression model was used to find the socio-economic and demographic factors determining the potential for adoption of the EBA approach. The logistic regression model is an appropriate statistical tool to determine the influence of explanatory variables on response variables when the latter have dichotomous characteristics (Agresti 1996, Peng et al. 2002). In short, the logistic model predicts the logit of the response variable (Y) from the explanatory variables (X). The logistic regression is the logit, the natural logarithm (ln) of chances of occurrence Y, and the chances are ratios of the probabilities (π) that Y will occur to the probabilities (1 - π) that Y will not occur. The logistic model is defined as follows:

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki}$$

Where β0 is the intercept and β1, β2… βk are coefficients of the independent variables x_1, x_2… x_n.

Initially, the models contained ten explanatory variables (gender, age, ethnicity, religion, education level, household size, marital status, residence status, sources of income, year of residence in the village), that were introduced simultaneously, and stepwise linear regression (Stepwise Regression with forward elimination procedure) wad used to select the best combination of variables based on the most significant ones. Before performing the logistic regression, multivariate correlation analysis was applied to check the co-linearity between the explanatory variables. There were no co-linearity issues as the cut-off values were all above the recommended cut-off (50%). The significance of the logistic regression parameters was assessed by the likelihood ratio of the Chi-square test and the deviation test, as well as the analyses of Hosmer-Lemeshow and Wald (Tabachnick and Fidell 1996).

Results

Profile of respondents

The number of respondents with their socio-economic and demographic characteristics is shown in Table 2. Most of respondents (62%) are women, with 41% aged of over 20-40 years. They mainly belonged to the following ethnic group: Gourounsi (55%), Nounouma (24.17%), Mossi (10.83%) and other ethnicities (10%). Regarding their education level, more than 54% indicate that they have no notion of writing and are therefore considered illiterate, 25% specify having attended primary school and 20% have received literacy courses in the past. . A large majority of respondents have for their source of income agriculture + livestock + crafts and collection of NTFPs (55%) and agriculture + livestock + trade (45%). Most of the interviewees use wood as an energy source and this high use is one of the main reasons that stimulate the preservation and conservation of trees in the farmlands of the selected sites. The dominant mode of access to land is inheritance and this form of land tenure allows successive owners to make the decision to adopt new agroforestry techniques.

Table 2: Profile of respondents

Variables		Workforce	Percentage (%)
Genre	Male	45	37,50
	Female	75	62,50
Age	[20-30[	17	14,17
	[30-40[	24	20,00
	[40-50[	37	30,83
	[50-60[	32	26,67
	≥70	10	8,34
Ethnic group	Gourounsi	66	55,00
	Dafing	8	6,67
	Nounouma	29	24,17
	Mossi	13	10,83
	Peulh	4	3,33
Education level	Primary school	30	25,00
	Literacy courses	25	20,83
	Illiterate	65	54,17
Matrimonial situation	Married	111	92,50
	Single	9	7,50
Residence status	Native	53	44,17
	Migrant	67	55,83
Access to land	Heritage	80	66,67
	Don	40	33,33
Source of income	Agriculture + livestock + trade	54	45,00
	Agriculture + livestock + crafts + NTFPs	66	55,00
Technical assistance	Yes	46	38,33
	Non	74	61,67
Energy source	Firewood	111	92,50
	Butane gas	9	7,50
Type of assistance	Agriculture + livestock	46	38,33
	Organization as a farmer group	74	61,67

Constraints on the adoption of agroforestry practices

Table 3 shows all of the variables involved in the model. The results of the binomial logistic regressions are presented in Table 4. The best performing model to explain the attitude of adherence to the agroforestry technique promoted by the EBA approach has an overall prediction percentage of 77.11%. The model as a whole explained between 47% (Cox and Snell's R squared) and 63% (Nagelkerke R squared) of the variance associated with the decision to adopt the EBA approach. Likewise, the fit of the model is good χ^2 HL [7] = 10.52; P = 0.23). The best model contains four independent variables that are gender, education level, technical assistance or training received and farmland size. In this model, these variables have a significant contribution in the prediction of the attitude of adherence to the agroforestry technique (Table 4): EXPER (OR = 278.35; Wald [1] = 5.63; P = 0.0001); GENRE (OR = 65.078; Wald [1] = 4.17; P = 0.001); DISP_PLT (OR = 14.073; Wald [1] = 2.64; P = 0.034); EDUC (OR = 8.117; Wald [1] = 2.09; P = 0.003) and SUPERF (OR = 0.39; Wald [1] = -0.93; P = 0.014). Among these variables, excepted farmland size, the others are positively associated with the decision to conserve tree on the farm and adopt EBA approach.

Table 3: Variables involved in the model

Independent variable	**Code**
Village of origin: 1 = Ouézala; 2 = Tiogo; 3 = Ziné	Vill_orig
Gender : 0 = Female ; 1 = Male	Genre
Age : 1= [20-30[, 2= [30-40[, 3= [40-50[, 4= [50-60[, 5= > 60 ans	Age
Education level: 0 = not literate; 1 = literate	Educ
Member of the group of forestry experts trained by EBA: 0 = not trained by the project; 1 = formed by the project	Exper
Residence status: 0 = migrant 0; 1 = non-migrant	Résid
Area harvested (in ha)	Superf
Ethnicity: 0 = Gourounsis; 1 = Peulhs; 2 = Nounouma; 3 = Mossis	Ethnie
Access to credit: 0 = access to credit is not seen as a constraint on agroforestry; 1 = access to credit is a constraint.	Credit
Existence of a market: 0 = the existence of a market is not perceived as a constraint on agroforestry; 1 = the existence of a market is a constraint	March
Labor: 0 = labor is not seen as a constraint on agroforestry; 1 = labor is a constraint.	M_Oeuv
The quality of the site (field): 0 = the quality of the site is not perceived as a constraint on agroforestry; 1 = the quality of the site is a constraint.	Q_site
Plant availability: 0 = plant availability is not seen as a constraint on agroforestry; 1 = plant availability is a constraint.	Disp_plt
Sale of forest products (FP): 0 = does not sell FP; 1 = wind from PF	PF

Table 4: Predictor variables of the attitude of adherence to the EBA technique

	Variables	B	S.E	Odds ratio : Exp(B)	95% de Odds Ratio		P
					Inferior	Superior	
Constant		2,965	1,301	19,403			0,23
GENDER	Female	4,176	1,169	65,078	6,583	643,335	**0,001**
	Male						
EDUC	Instruit	2,094	0,707	8,117	2,030	32,461	**0,003**
	No educated						
EXPER	Form	5,629	1,038	278,357	36,412	2127,948	**0,00001**
	Non forrm						
DISP_PLT	Yes	2,644	1,247	14,073	1,222	162,039	**0,034**
	No						
SUPERF	ha	-0,934	0,378	0,393	0,187	0,825	**0,014**

Legend: **GENDER** = Genre; **EDUC** = education; **EXPER** = training received; **AREA** = cultivated area; **DISP_PLT** = Availability of trees for planting; CI: Confidence interval; OR: Odd Ratio or probability of occurrence of an event; B: Wald statistic.
The probability values in bold are significant (P<0.05)

This means that an increase in these variables improves the agroforestry adherence score. Thus, training farmers in agroforestry is an important factor for membership. There is a 52,127.948 times more chance of joining for a member trained in the EBA technique than for one who is not trained. As for gender, there is a 65,078 times more chance of getting a woman to join compared to a man. When it comes to plants, there is a 14.073 times greater chance of getting an individual who has been provided with agroforestry plants to join. Compared to education, there is an 8,117 times more chance of adhering to an educated subject compared to one who has not gone to school. On the other hand, the more the area of the field (in ha) increases, the less the owner adheres to this agroforestry technique. There is a 0.393 times more chance of enrolling a farmer who has few cultivated areas than one with many hectares (Table 4).

The variables excluded from the model are: the village of origin (VIL_ORIG); age (AGE) residence status (RESID); ethnicity (ETHNIA); credit (CREDIT); the market (MARCH); the workforce (M_OUEVRE); the quality of the site (Q_SITE) and the trade in forest products (FP). In our context, these variables are not predictors of the attitude towards adherence to the agroforestry technique promoted by the EBA approach

Perceptions of ecosystem services of agroforestry woody species

Nine ecosystem services provided by agroforestry species to rural populations have been identified. These are: financial profits from the sale of these wood or non-wood products (Economy); the diet of populations (Food); soil fertility due to these agroforestry plants (Fertility); protection of the environment by agroforestry trees (Environment); medicines made from these plants (Medicine); the contribution of these plants to the enrichment of plant biodiversity (Biodiversity); shade provided by agroforestry trees (Shading); fodder drawn from these agroforestry trees, especially in the dry season (Fodder) and from the construction of houses (Construction). The average services rendered by these agroforestry woody trees are 3.68. The minimum being 1 service and the maximum 6 services. However, there is no significant difference between the number of known uses in men (3.76 ± 1.31) compared to women (3.64 ± 1.22); F [1; 118] = 0.24; P = 0.63.

Table 5 gives the comparative statistics on the criteria for preferences of agroforestry woody species according to sex. There is no statistically significant dependency (P> 0.05) between the genus and the preference of agroforestry woody species, based on use values such as fuelwood (WOOD); shade provided by trees (SHADOW); the medicinal use of trees (PHARM) and the conservation of these species for future generations (GEN-FUTURE).

Table 5: Criteria for preferences of woody species according to sex

Associated variables	Chi Pearson Square	ddl	P-value
Genre × BOIS	1,681	1	0,195
Genre × OMBRE	0,014	1	0,606
Genre ×PHARM	0,605	1	0,437
Genre × GEN_FUTURE	0,092	1	0,761
Genre × FOURRAGE	8,761	1	**0,003**
Genre × ENV	14,982	1	**0,001**
Genre × MARCH	6,587	1	**0,010**
Genre × HOBBY	15,674	1	**0,001**
Genre × CADASTRE	6,877	1	**0,009**
Genre × FRUITS	-	-	-

The P-values in bold are significant on the Tukey test at the 5% level

On the other hand, for the fruits of trees (FRUIT), both sexes agree in recognizing the importance of agroforestry trees for this service. There is therefore no calculated statistic for these variables, since it is a constant (Table 5).

Finally, there is a statistically significant dependency relationship (P <0.05) between gender and ecosystem services of agroforestry trees such as fodder (FORAGE); environmental conservation (ENV); procurement services such as the sale of wood and non-wood products (MARCH); aesthetic values such as the hobby provided by the presence of trees (HOBBY) and the delimitation of farmlands by trees (CADASTRE). For these explanatory variables, the standardized residual frequencies are above the statistical significance level of 5%. Thus, unlike women, there are many more men who value agroforestry trees for the supply of fodder (P = 0.002) and the pecuniary benefits they would derive from the sale of their products (P = 0.009). As for women, they are more likely than men to appreciate agroforestry trees for their role in environmental conservation (P = 0.001); their aesthetic value (P = 0.001) or their role in delimiting farmlands (P = 0.008).

Woody agroforestry species preferred by farmers

Figure 2 shows the woody species preferred by farmers. A total of 20 species are cited. Based on frequency of citations, the top 10 preferred species are in order: *Moringa oleifera* Lam (19.74% citations); *Adansonia digitata* L (15.98%); *Anacardium occidentale* L (14.85%); *Vitellaria paradoxa* C.F. Gaerntn. (13.16%); *Parkia biglobosa* (Jacq.) R. Br. Ex. G. Don (12.22%); Mangifera indica L (8.83%); Saba senegalensis (A. DC.) Pichon (6.02%); *Eucalyptus camaldulensis* Dehnh (4.51%); *Tamarindus indica* L. (3.20%) and *Lannea microcarpa* Engl. & K. Krause (1.50%). The results of the Chi-square comparison test of the number of citations of each species between the two modalities (male and female) indicate that women have more preferences for *Moringa oleifera, Adansonia digitata, Vitellaria paradoxa*, Parkia biglobosa, *Saba senegalensis* and *Tamarindus indica;* while men have more preferences for *Mangifera indica* and *Eucalyptus camaldulensis*.

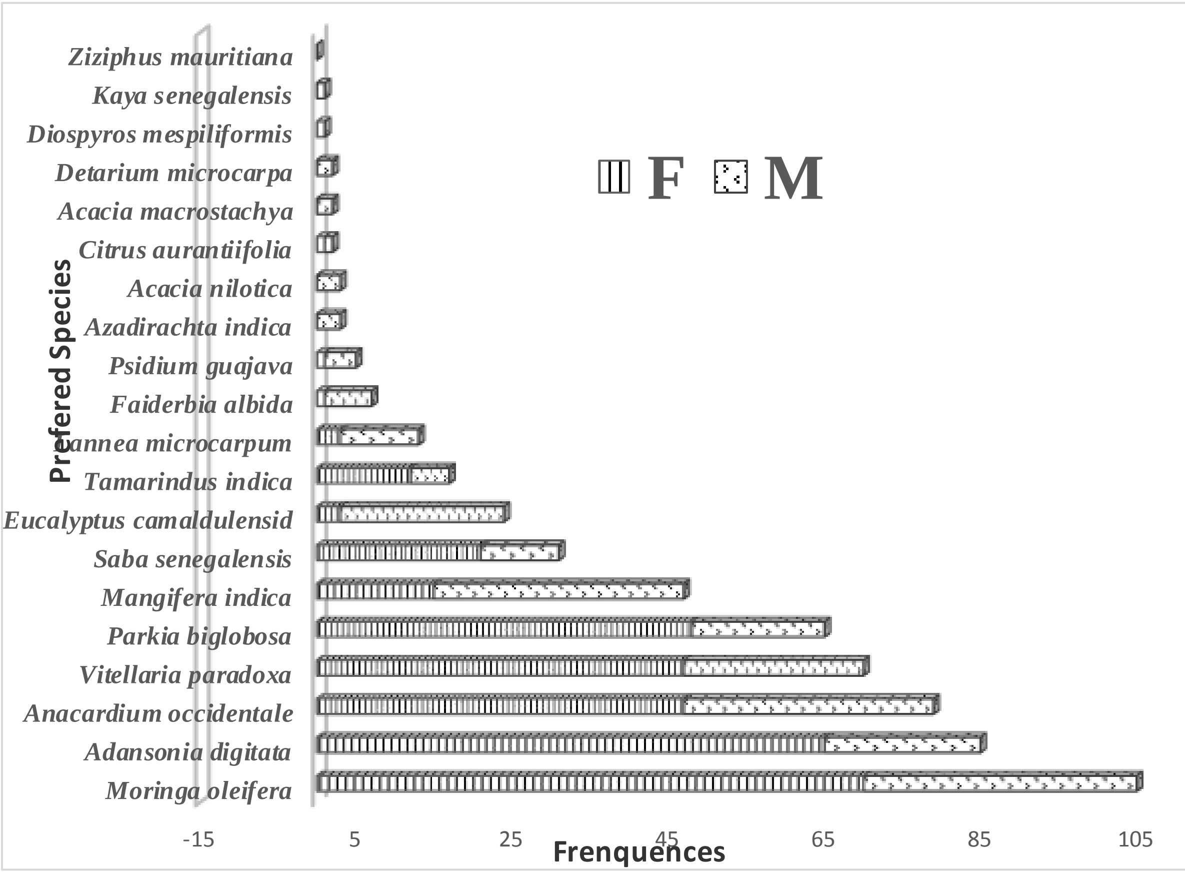

Figure 2: Agroforestry species preferred by farmers by sex

Discussion

Determinants of adoption of agroforestry technology

The exploration of farmers' perceptions related to the adoption of agroforestry technology promoted by the EBA approach revealed socio-economic constraints, lack of knowledge and proven skills in the field of forestry. The main factors that influenced the farmers' decision to adopt agroforestry included: the training received in the field of agroforestry, gender, access to agricultural inputs including plants, education level and finally the farmland size.

Among these variables, farmland size was negatively associated to adoption of agroforestry technology. According to Zerihun et al (2014), the negative B coefficients indicated that this variable reduced the likelihood of adoption agroforestry technologies.

Building the capacity of farmers in agroforestry techniques is critical for successful adoption. Thus, a trained member is more available and able to adopt agroforestry techniques and even other innovations than an untrained member. Our results corroborate some previous studies which reported that heads of households with a good knowledge of agroforestry technology adopt agroforestry technologies without major difficulties (Jamala et al., 2013; Mulatu et al., 2014; Sanou et al. ., 2017). From this perspective, demonstration farmlands (field schools) are also effective in facilitating individual or collective learning. Indeed, farmers who participate in experimenting with agroforestry technologies are more likely to adopt than those who do not (Phiri et al. 2004, Keil et al. 2005). However, inadequate training could lead to a low rate of adoption of agroforestry by farmers, especially if the training does not incorporate local knowledge and farmer innovations (Meijer et al. 2015).

It is admitted that gender-related decision-making, which is often linked to intra-household resources allocation, is an important determinant of the adoption of agroforestry technologies by both men and women (Kipot and Franzel 2012). In our case, women are more susceptible to adoption than men. There is a 65% chance of getting a woman to join compared to a man. Also, a gender approach based on equality, equity, access to land for women and sharing of economic benefits is necessary in these rural areas. This would increase social cohesion and improve adherence of men and women to the adoption of agroforestry technologies. This result is not corrobated by those of Buyinza and Ntakimanyire (2008) who found in Uganda that men are more likely to establish plantations on their farmland than women. This difference is probably due by to the fact the EBA project integrated more women than men during their interventions because in rural zone , women are more vulnerable to the negative effect of climate change compared to men.

Access to seedlings or forest seeds for possible production of desirable seedlings is a determining factor for the success of agroforestry. Farmers' access to seedlings increases their adherence to agroforestry. Farmers who have a certain education level are much in favor of adopting agroforestry technology than those who are not educated. Thus, they are more likely to perceive the effect of new technologies on the quality of agrosystems (Iiyama et al. 2017). The education and training received by farmers provides them with more capacities to use a variety of information and positively influences the adoption of technological innovations (Ketsia 2017). It is therefore necessary to improve formal and informal education in agroforestry and all other good agricultural practices among farmers for their better adoption.

The size of the farm has an impact on the attitude towards agroforestry.. These results are consistent with those of Ajayi et al. (2003) and Mulatu et al. (2014) who reported that households with large areas of land adopt agroforestry less while those with large families quickly embrace this technology.

Unlike our results, other authors have found that some of our excluded variables are, on the contrary, predictors of adherence attitude. Ethnicity and residence status are not mentioned because these communities have lived together for several decades. This may have brought their perceptions of agroforestry and its constraints closer together. However, both ethnicity and age have been mentioned as factors of differentiated perceptions of natural resources and agroforestry innovations (Tietiambou et al. 2016, Sanou et al. 2017). The quality of the site is not seen as a constraint on agroforestry by these communities. According to Mulatu et al. (2014), the more vulnerable the farm site, the more farmers are in favor of adoption. Also, Gladwin et al. (2002) and Keil et al. (2005) found that the probability of adoption increases when farmers perceive low soil fertility as their current problem.

In addition, farmers do not fully perceive the impact of certain economic factors (the perception of marketing opportunities for agroforestry products, household financial capital and the availability of labor) on agroforestry. Many farmers lack knowledge of the new marketing opportunities for many of the agroforestry products available to them (Ketsia 2017). Finally, the size of the farm has a positive link with the decisions of farmers to establish and even continue agroforestry practices (Ajayi et al. 2003).

These factors, positively or negatively associated with the model, must be considered in the design of adoption and agroforestry promotion programs in the localities selected for this study.

Preference criteria for agroforestry species

According to the results presented in Figure 2, female preference is greater for *Moringa oleifera; Adansonia digitata; Vitellaria paradoxa; Parkia biglobosa; Saba senegalensis* and *Tamarindus indica*. As for men, they prefer *Mangifera indica* more than *Eucalyptus camaldulensis*; *Anacardium occidental* and *Lannea microcarpa*.

Except exotic species such as *M. oleifera, E. camaldulensis, M. indica* and *A. occidentale*; all the other endogenous species used by the respondents are also integrated in agroforestry by several ethnic groups in the Sudanian zone (Cissé et al. 2018). The species chosen by women strongly contribute to the food and health care of the populations of the area (Thiombiano et al. 2012, Lamien et al. 2018). On the other hand, the criteria of preference of agroforestry species in men are mainly based on their economic value. In fact, the fruits of the mango tree are marketed just like cashew kernels and eucalyptus wood. Furthermore, Weston et al. (2015) showed that farmers in most cases tend to quickly accept growing species that yield earlier benefits than those with a long maturity period.

The importance of agroforestry species is well known because of the multiple services and products they provide. Preferred species differ significantly by sex because women do not have the same uses as men (Figure 3).

Farmers in the Sudanian zone perceive certain ecosystem services provided by agroforestry trees. Thus, for the fruits of trees (FRUIT) everyone (men and women) agrees to recognize the importance of agroforestry trees for this supply service. In addition, both women and men are unanimous on the services provided by agroforestry trees, such as fuelwood; shading; the pharmacopoeia and the contribution to local biodiversity for future generations (Table 5). The perception of these same types of woody forest use by local communities has been noted by several authors (Sanou (Sanou et al. 2017b, Cissé et al. 2018, Lamien et al. 2018).

These results show that the farmers mainly rely on the utility values of the woody plants to maintain them in their farmlands. They do not seem to perceive certain aspects of the ecosystem services of these agroforestry plants such as regulatory services, support services and cultural services. Cissé et al., (2018) have shown that in tropical areas, the ecosystem services associated with agroforestry species are little known. While agroforestry generates important public environmental services such as biodiversity, watershed protection and carbon sequestration for which there are market failures (Weston et al. 2015).

Conclusion

The principal objective of this study was to analyze the factors that influence the farmer's decision to adopt the agroforestry technology promoted by the EBA approach in the North-Sudanian zone of Burkina Faso. The results showed that certain socio-economic determinants such as gender, education level, farmland size, agroforestry training, availability of seeds and plants have an influence on the farmers' decision of to integrate trees into their farmland. In addition, supply services that included food, pharmacopoeia, fodder, fuelwood etc. dominate farmer's preference for agroforestry tree species. However, the preference criteria for these species vary between the genders. Thus, women appreciate agroforestry species for their nutritional, aesthetic and environmental conservation role and men for the economic role of these species. In context of ecosystem degradation and food insecurity; improving the resilience of rural populations through the dissemination and transfer of agroforestry knowledge and methods to restore land is a solution to address common challenge in developing countries. Also, the government of Burkina Faso and their NGO partners could encourage the promotion of EBA approach by helping smallholders to improved multipurpose tree species on their farmlands. These helpings may include the provision of locally-suitable tree germplasm and tools to plant trees for example. Because, fight against rural poverty, food insecurity, wood and forage crisis and desertification may be resolve by the adoption of agroforestry at large scale. Finally, the success of agroforestry programs requires taking into account the socio-economic determinants of rural communities and farmers.

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