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ADAPTATION STRATEGIES OF SHEA AND AFRICAN LOCUST BEAN TREE MANAGERS IN AGRICULTURAL FIELDS IN A CONTEXT OF CLIMATIC VARIABILITY: A CASE STUDY FROM THREE REGIONS OF BURKINA FASO (WEST AFRICA)

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ABSTRACT

Agricultural field trees constitute social nets for rural households in Burkina Faso. However, in recent decades they have been affected by climate variability, which has led to a significant reduction in the populations of dominant species such as shea and African locust within them. The objective of this study is therefore to determine the adaptation strategies developed by managers, as well as the factors influencing these strategies to cope with the changing environment. The methodology deployed for this purpose consists of primary and secondary data collection. Descriptive statistics and binary logistic regression were used to analyse the collected data. The study revealed that more than 70% of the tree managers are men and the majority of them are illiterate, with households of 5-15 children. In addition, more than 80% of the managers have agriculture as their main activity, and the size of their holdings is between 1ha and 10ha. Three strategies are used by tree managers in agricultural fields. The proactive strategy aims to anticipate the consequences of climate variability. The reactive strategy aims to react to the effects of climate variability. The strategy of silvicultural techniques consists of pruning, grafting and assisting the trees. However, the choice of strategies is influenced by the socio-economic characteristics of the respondents. For example, the proactive strategy is influenced by education level, household size and income from non-timber forest products. For the reactive strategy, the size of the holding and the level of education have an effect on the choice of strategy. For the silvicultural techniques strategy, age and education level have an impact on the choice of strategy. It is then up to the relevant authorities to work in the light of these results to initiate actions to strengthen the coping strategies of the people managing the trees in the agricultural fields.

Keywords: *Trees in agricultural fields, socioeconomic characteristics, adaptation strategies, shea and African locust, Burkina Faso*

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INTRODUCTION

In the semi-arid and sub-arid zones of West Africa, farming households have for decades implemented a traditional land-use system that emphasises the association of trees and agricultural crops under the name "agroforestry park system" (Boffa, 2000). In most Sahelian countries, the agroforestry park is the most widespread agricultural production system (Kessler, 1992; Bernard, 1999; Petit, 2003; Taïbi and Dolfo, 2016; Seghieri, 2019). Over the years, this practice has become obligatory for farmers (Sturm, 2000) due to the deterioration of living conditions, causing the appearance of parkland species in the West African landscape, the most representative of which are, among others, *Faidherbia albida, Parkia biglobosa, Vitellaria, paradoxa* (Boffa, 1999). The products of these species in agricultural fields contribute to the food and nutritional security of rural Africans (Omotayo and Aremu, 2020), generate income (Sagna et al., 2019) and protect the environment (Kessler and Breman, 1991; Bonkoungou, 2002; Bayala et al., 2008; Assogbadjo et al., 2012).

Nowadays, agroforestry parklands have gained importance in different countries of Sudano-Sahelian Africa, especially in Burkina Faso (Bengali, 2018). This importance is mainly due to the downward trend in agricultural production induced by climatic variability and the high market value of non-timber forest products of the species (*Vitellaria paradoxa* and *Parkia biglobosa*) in agricultural fields. However, since the droughts of the 1970s, tree species in agricultural fields have been degraded in both density and age (Gijsbers et al., 1994, Kessler and Boni, 1991), and the reasons are both anthropogenic and climatic. Rainfall projections show that the number of episodes of heavy precipitation (> 50 mm/day) is expected to increase by 15% on average and the lengthening of dry periods by about 20% between 2021 and 2050 (Ibrahim, 2014). The situation of tree species in agricultural fields will therefore worsen in the coming years in Burkina Faso. All the more so as the impacts of climate change are expected to profoundly alter global ecological and social systems (Evans, 2019 cited by Nash et al., 2019). African agroforestry systems will be affected by climate change/variability (Luedeling et al., 2014; Gnonlonfoun et al., 2019). This could threaten the provision of ecosystem services by trees in agricultural fields. This will have traumatic consequences for vulnerable rural populations who depend on the fruits and leaves of trees in agricultural fields for their livelihoods. Thus, the IPCC Fourth Assessment highlights that adaptation strategies are essential in this situation (Claessens et al., 2012). Therefore, there is an urgent need to understand the coping strategies of tree managers in agricultural fields in order to set up resilience improvement policies. In this study, the main hypothesis states that tree managers (*Vitellaria paradoxa*, *Parkia biglobosa*) in agricultural fields mobilise several adaptive strategies to cope with the reduction and ageing of tree stands and that socio-demographic and socio-economic factors influence their choice of strategies. The main objective of this study is to determine the adaptation strategies developed by managers, as well as the factors influencing these strategies. More specifically, the aim is to profile the socio-demographic and socio-economic characteristics of tree managers in agricultural fields, to analyse the strategies used by tree managers in agricultural fields and to determine the factors influencing the choice of their strategies.

DATA AND METHODS

Description of the study area

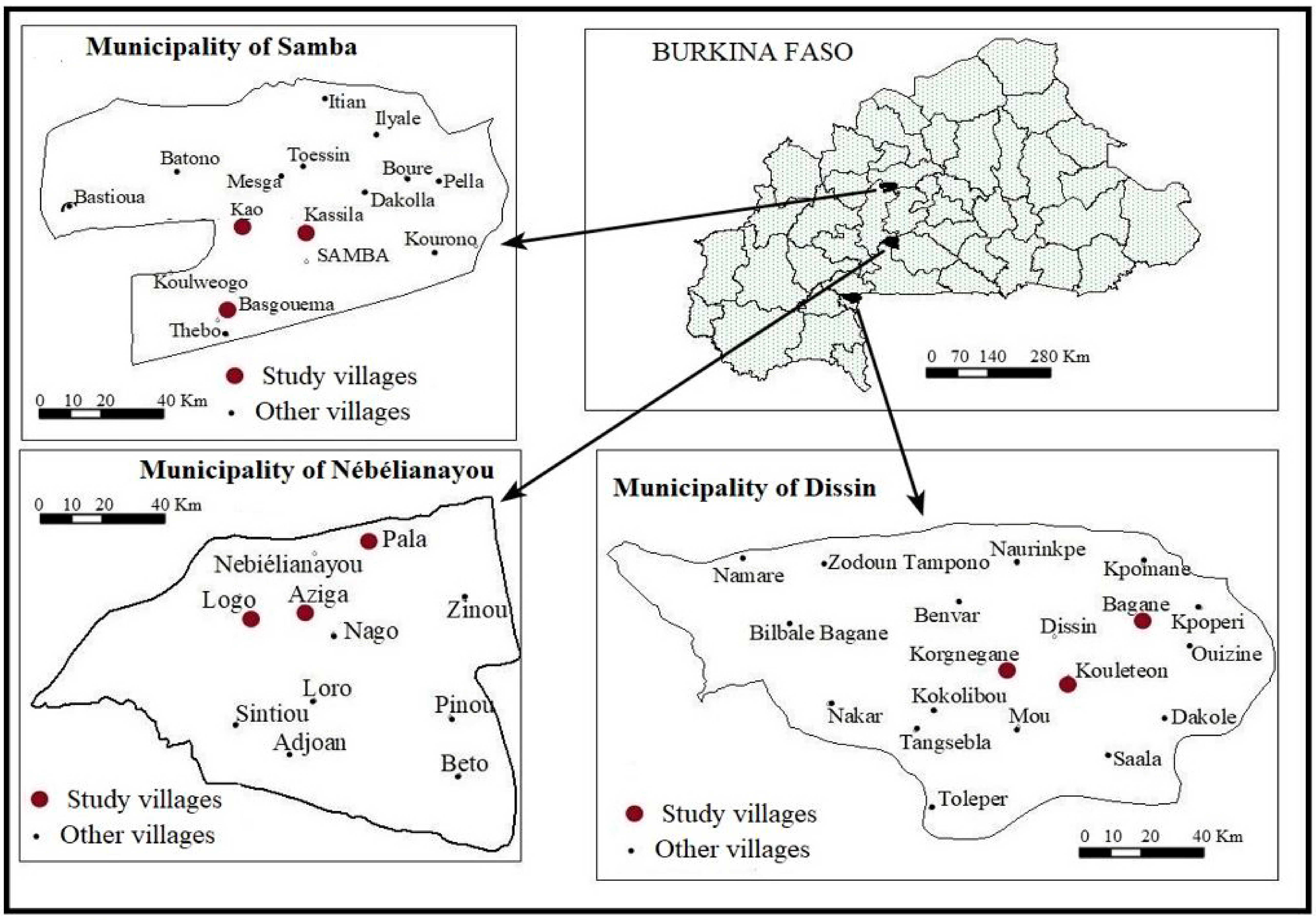
Three (03) communes are concerned by this study, namely the rural commune of Nébiélianayou, Samba and Dissin (Figure 1). The rural commune of Samba is located in the northern region of Burkina Faso, in the province of Passoré. The study villages that are concerned by the field surveys are : Kassila, Kao and Basgouema.

The Centre-West region of Burkina Faso is also concerned by this study. Indeed, the rural commune of Nébiélianayou, in the province of Sissili, constitutes the study area, which includes the study villages of Pala, Logo and Aziga

Species such as *Vitellaria paradoxa, Detarium microcarpum* and *Parkia biglibosa* are omnipresent in the area. However, in the study villages, species such as *Vitellaria paradoxa* and *Parkia biglobosa* are dominant.

The Commune of Dissin is located in the province of Ioba in the South West region. It has an estimated area of 389.52 km² (PIF, 2017). The study sites selected for this study are : Bagane, Kornyègahn and Kouleteon.

The species that dominate the communal territory are: *Burkea africana, Vitellaria paradoxa, Pterocarpus erinaceus, Crossopteryx febrifuge, Detarium microcarpum, Parkia biglobosa.* Agroforestry parklands are dominated by *Vitellaria paradoxa, Parkia biglobosa.*



Source : BNDT, 2014 Date : 20/09/2022 Author : YAMEOGO Joseph

Figure 1. Location of study areas

Sampling and selection of study villages

The present study was carried out in the three communes of Nébiélianayou, Samba and Dissin. However, they were four criteria that prevailed in the choice of the villages of the communes:

1. location in different phytogeographical domains (North-Sahelian (commune of Samba), South-Sahelian (commune of Nébiélianayou), South-Sudanese (commune of Dissin) of Burkina Faso;
2. tree species (*Vitellaria paradoxa, Parkia biglobosa*) are observed in the agricultural fields of the study villages;
3. the fruits of the trees are important both economically and in terms of food for the farmers,
4. has not been taken into account for numbering purposes

Furthermore, sample size plays a central role in obtaining reliable estimates and descriptions of meaningful outcomes (Haïr et al., 2014). Therefore, in order to obtain an adequate and appropriate sample size, the precision rate and confidence level approach of Kothari, 2004, p.175 was chosen. According to the author, the mathematical formula is as follows:

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + z^2 \cdot p \cdot q} \quad (1)$$

- n = sample size (target population); N = size of total population: 1703;
- z = Margin coefficient (determined from the confidence level);
- e = Margin of error, and
- p = Proportion of the population assumed to have the desired traits. This proportion varies between 0 and 1 and is a probability of occurrence of an event (Brissy et al, 2017). If no value for this proportion is available, it will be set at 50% (0.5); q = 1- p.
  For Kothari, 2004, p=0.5. Alors, q=1-0.5=0.5 ; z=1.96 et e=0.05

Thus, with the application of the formula, there were 314 target households, distributed in the rural communes of Nébiélianayou, Dissin and Samba. In addition, the distribution key of respondents by village was based on the socio-economic importance of trees in the households' agricultural fields, the density of trees in the fields and, above all, the security context of the study villages (Table 1).

Table 1. Summary of target populations sampled in the study sites

Rural commune of Nébiélianayou	Total number of households	Target population
Study villages	480	**110**
Logo	149	35
Aziga	76	20
Pala	255	55
Rural Commune of Dissin		
Study villages	841	**100**
Bagane	342	40
Kouleteon	238	30
Korgnegane	261	30
Rural commune of Samba		
Study villages	382	**104**
Basgouema	143	24
Kao	135	30
Kassila	104	50
Total	8 237	**314**

Source: General Census of Population and Housing, 2019

The choice of households surveyed was made on the basis of a reasoned choice based on three (03) criteria defined as follows:

1. The respondents have more than ten trees in the agricultural fields;
2. the respondent must be 40 years of age or older;
3. Availability of households during the field survey.

Data source and collection methods

The data for the study were collected from primary and secondary sources. The primary data was collected from 314 households that have trees in their agricultural fields. The primary data was obtained through the survey method. The surveys were carried out from December 2021 to June 2022 on the basis of specially designed survey forms. The exploratory surveys were first carried out in nine (09) villages spread over the three (03) communes of Samba, Nébiélianayou and Dissin. They concerned about forty people, who were surveyed over a period of one month, in this case the month of November 2021. The purpose of this exploratory survey was to adjust the data collection tools. Subsequently, the actual surveys were conducted in all the study villages. For this purpose, nine (09) survey teams (composed of five people) were set up for the surveys. In addition, three (03) teams were positioned in the commune of Samba, three (03) other teams in the commune of Nébiélianayou and three (03) others in the commune of Dissin. The surveys took six months, from December 2021 to June 2022 (Table 2).

Table 2. Survey periods by study village

Rural Municipality Nébiélianayou	Survey period
Study villages	December 2021 – January 2022
Logo	
Aziga	
Pala	
Rural Municipality Dissin	
Villages d'étude	February – April 2022
Bagane	
Kouleteon	
Korgnegane	
Rural Municipality Samba	
Study villages	May – June 2022
Basgouema	
Kao	
Kassila	

Source: Field survey, December 2021-June 2022

The primary data included socio-demographic, socio-economic characteristics, coping strategies of the respondents and factors influencing the choice of strategies. The study also used secondary data from journal articles and scientific books to supplement the data from primary sources.

Method of data analysis

Descriptive data analysis method

In this study, demographic and socio-economic data were first collected through survey forms, then entered into the SPSS spreadsheet, and finally analysed and presented using descriptive statistics such as frequency, percentage, graphs, figures and tables. The Excel 2021 spreadsheet was used to calculate the descriptive statistics.

Method of econometric data analysis

In the literature, the binary logistic regression model (BLRM) is more commonly used to identify the determinants of technology adoption (Yegbemey et al., 2020). However, in recent years, with the emergence of climate change and adaptation strategies, many authors ((Ndamani et Tsunemi, 2016, Khanal et al., 2018 ; Irawan et Syakir, 2019, Regasa et Akirso, 2019, Hirpha et al., 2020, Marie et al., 2020, Myeni & Moeletsi, 2020; Sujakhu et al., 2020, Atube et al., 2021, Gao et al., 2022) have addressed the logistic regression model in studies on the determinants of adaptation strategies. All the studies highlight the influence of socio-economic and socio-demographic variables on adaptation strategies, both in Asia (China, Indonesia, Nepal) and in Africa (Ethiopia, Ghana, Uganda, South Africa).

In the context of the determinants of the choice of adaptation strategies of fruit tree managers in agricultural fields, we adopted the binary logistic regression (LBR) model, which is useful for predicting the discrete outcome of the dichotomous dependent variable from independent variables that can be continuous, discrete and dichotomous or a combination of these (Tesfahunegn et al., 2016). In this context, the choice of each of the coping strategies mobilised by farmers is therefore a binary decision (0 or 1). The operationalisation of the model involves equations. According to, Hosmer & Lemeshow, (2000), Y is defined as follows:

$$Yi = \begin{cases} 1 \text{ if the -th farmer uses a given adaptive strategy} \\ 0 \text{ if the -th farmer does not uses a given adaptive strategy} \end{cases}$$

For Atube et al., 2021, in this case, Yi is a latent variable with probabilities p for Y*i =1 and 1 - p for Y*i = 0. Yi is a dichotomous dependent variable, i.e. 1 if a farm chooses a strategy, and 0 if the strategy was not chosen by the farmer.

The above binary dependnt variables were regressed against the variables X such that:

$$Y_i = \alpha + X_l^{'} + u_i$$

Where,

- α means constant;
- u_i is the standard error.
- X'_1 represent a vector of explanatory variables that influence the choice of coping strategies. The explanatory variables are presented in Table 3.

Table 3. Explanatory variables influencing the choice of coping strategies

Variables	Type of variables	Description	Expected sign
Gender	Qualitative	Takes the value 1 if the farmer is male, 2 female	+ or -
Age	Qualitative	Takes the value 1 if the farmer is adult (under 60 years old), 2 old (over 60 years old)	+ or -
Educational level	Qualitative	Takes value 1 if the farmer is uneducated, 2 educated	+ or -
Household size	Qualitative	Takes the value 1 if the farmer has 0 to 10 children, if 2 more than 10 children	+ or -
Residential status	Qualitative	Takes value 1 if farmer emigrated, 2 native	+ or -
Level of income from non-timber forest products	Qualitative	Takes value 1 if farmer income= 1-90000 FCFA[1], if 2, income =90000 FCFA-300000 FCFA	+ or -
Size of holding	Qualitative	Takes value 1 if farmer normal area (0-2ha), if 2 large area (more than 2.5ha)	+ or -
Main activity	Qualitative	Takes the value 1 if the farmer agropastoral activity, if 2 trade	+ or -

SPSS software was used for the analysis.

[1] 1 dollar US= 606,50 FCFA

RESULTS AND DISCUSSION

Demographic and socio-economic characteristics

Demographic characteristics are based on gender, age, education level, household size and ethnic group. In fact, gender and age are dominated respectively by men and those in the 40-60 age group in both the commune of Samba, the commune of Nébiélianayou and that of Dissin (Table 4)

Table 4. Distribution of respondents by village, gender and age

Municipality	Village	Gender		Age				
		Male	Female	40-50 years	50-60 years	60-70 years	70 years and over	Total
Municipality of Samba	Basgouema	17 (70.83%)	7 (29.17%)	11(45.83%)	7 (29.17%)	4 (16.67%)	2 (8.33%)	24 (100%)
	Kao	24 (80%)	6 (20%)	4 (13.33%)	15 (50%)	9 (30%)	2 (6.67%)	30 (100%)
	Kassila	41 (82%)	9 (18%)	24 (48%)	14 (28%)	7 (14%)	5 (10%)	50 (100%)
Municipality of Dissin	Bagane	39 (97.5%)	1 (2.5%)	18 (45%)	22 (55%)	0 (0%)	0 (0%)	40 (100%)
	Kouleteon	28 (93.33%)	2 (6,67%)	15 (50%)	10(33,33%)	5 (16.67%)	0 (0%)	30 (100%)
	Korgnegane	29 (96.67%)	1 (3,33%)	9 (30%)	3 (10%)	17 (56.67%)	1 (3.33%)	30 (100%)
Municipality of Nébiélianayou	Logo	29 (82.86%)	6 (17.14%)	17 (48.57%)	9 (25.71%)	9 (25.71%)	0 (0%)	35 (100%)
	Aziga	18 (90%)	2 (10%)	7 (35%)	9 (45%)	4 (20%)	0 (0%)	20 (100%)
	Pala	41 (74.55%)	14 (25.45%)	27 (49.09%)	19 (34.55%)	9 (16.36%)	0 (0%) (0%)	55 (100%)

Source: Field surveys December 2021; June 2022

The socio-ethnic group is dominated respectively by the Mossi in the commune of Samba, the Dagara in the commune of Dissin and the Gourounsi in the commune of Nébiélianayou (Table 5).

Table 5. Distribution of respondents by village and socio-ethnic group

Municipality	Commune of Samba			Commune of Dissin			Commune of Nébiélianayou		
Village / Socio-ethnic group	Basgouema	Kao	Kassila	Bagane	Kouleteon	Korgnegane	Logo	Aziga	Pala
Mossi	22 (91.66%)	30	48 (96%)	0 (0%)	0 (0%)	0 (0%)	7 (20%)	2 (10%)	12 (21.81%)
Gourounsi	1 (4.16%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	26 (74.28%)	17 (85%)	36 (65.45%)
Dagara	0 (0%)	0 (0%)	0 (0%)	40	30 (100%)	30 (100%)	0 (0%)	0 (0%)	0 (0%)
Dioula	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Peul	1 (4.16%)	0 (0%)	2 (4%)	0 (0%)	0 (0%)	0 (0%)	2 (5.71%)	1 (5%)	7 (12.72%)
Other	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	24 (100%)	30 (100%)	50	40	30 (100%)	30 (100%)	35 (100%)	20 (100%)	55 (100%)

Source: Field surveys December 2021; June 2022

As for the size of the households surveyed, it varies between 5-10 and 10-15 persons in all the study villages. However, households with 5-10 children are numerous in the research sample (Table 6).

Table 6. Distribution of respondents by village and household size

Communes	Villages	[0 – 4]	[5 -10]	[11 - 15]	Total
Municipality of Samba	Basgouema	0 (0%)	17 (70.83%)	7 (29.17%)	24 (100%)
	Kao	0 (0%)	18 (60%)	12 (40%)	30 (100%)
	Kassila	3 (6%)	36 (72%)	11 (22%)	50 (100%)
Municipality of Dissin	Bagane	14 (35%)	19 (47.5%)	7 (17.5%)	40 (100%)
	Kouleteon	10 (33,33%)	18 (60%)	2 (6.67%)	30 (100%)
	Korgnegane	8 (26,67%)	18 (60%)	4 (13.33%)	30 (100%)
Municipality of Nébiélianayou	Logo	7 (20%)	20 (57.14%)	8 (22.86%)	35 (100%)
	Aziga	1 (5%)	16 (80%)	3 (15%)	20 (100%)
	Pala	5 (9.09%)	33 (60%)	17 (30.91%)	55 (100%)

Source: Field surveys December 2021; June 2022

The level of education is dominated by illiterates and secondarily by those who have attended primary school. Table 7 shows this reality.

Table 7. Distribution of respondents according to village and level of education

Municipality	Villages	Illiterate	Primary	Secondary	University	No answer	Total
Municipality e of Samba	Basgouema	14 (58.33%)	8 (33.33%)	0 (0%)	0 (0%)	2 (8.33%)	24 (100%)
	Kao	21 (70%)	8 (26.26%)	0 (0%)	0 (0%)	1 (3.33%)	30 (100%)
	Kassila	26 (52%)	18 (36%)	0 (0%)	0 (0%)	6 (12%)	50 (100%)
Municipality of Dissin	Bagane	19 (47.5%)	15 (37.5%	6 (15%)	0 (0%)	0 (0%)	40 (100%)
	Kouleteon	22 (73.33%)	7 (23.33%)	1 (3.33%)	0 (0%)	1 (3.33%)	30 (100%)
	Korgnegane	14 (46.66%)	10 (33.33%)	5 (16.66%)	1 (3,33%)	0 (0%)	30 (100%)
Municipality of Nébiélianayou	Logo	30 (85.71%)	5 (14.28%)	0 (0%)	0 (0%)	0 (0%)	35 (100%)
	Aziga	16 (80%)	3 (15%)	0 (0%)	0 (0%)	1 (5%)	20 (100%)
	Pala	41 (74.54%)	14 (24.45%	0 (0%)	0 (0%)	0 (0%)	55 (100%)

Source: Field surveys December 2021; June 2022

The socio-economic activities of the respondents are dominated by agriculture (Table 8).

Table 8. Distribution of respondents according to activities carried out

Villages	Main activity					Secondary activity			
	Agricultural	Agroforestry	Livestock	Trade	Total	Livestock	Trade	Collection of NTFPs (shea, néré)	Total
Basgouema	22 (91.66%)	0 (0%)	1 (4.16%)	1 (4.16%)	24 (100%)	20 (83.33%)	0 (0%)	4 (16.66%)	24 (100%)
Kao	24 (80%)	0 (0%)	4 (13.13%)	2 (6.66%)	30 (100%)	25 (83.33%)	5 (16.67%)	0 (0%)	30 (100%)
Kassila	41 (82%)		8 (16%)	1 (2%)	50 (100%)	39 (78%)	11 (12%)	0 (0%)	50 (100%)
Bagane	32 (80%)	0 (0%)	8 (10%)	0 (0%)	40 (100%)	39 (97.5%)	1 (2,5%)	0 (0%)	40 (100%)
Kouleteon	26 (86.66%)	0	4 (13.33%)	0 (0%)	30 (100%)	30 (100%)	0 (0%)	0 (0%)	30 (100%)
Korgnegane	25 (83.33%)	0	5 (16.67%)	0 (0%)	30 (100%)	28 (93.33%)	0 (0%)	1 (6.67%)	30 (100%)
Logo	35 (100%)	0 (0%)	0 (0%)	0 (0%)	35 (100%)	8 (22.86%)	4 (14.83%)	23 (65.71%)	35 (100%)
Aziga	20 (100%)	0 (0%)	0 (0%)	0 (0%)	20 (100%)	7 (35%)	3 (15%)	10 (50%)	20 (100%)
Pala	55 (100%)	0 (0%)	0 (0%)	0 (0%)	55 (100%)	17 (30.91%)	2 (3.64%)	36 65.45%	55 (100%)
Total	297	4	9	4	314	214	31	69	314

Source : Field surveys December 2021- June 2022

This table shows that almost 100% of the respondents are farmers. They have tree species on their farms. The size of the farms in the different villages surveyed varies from 1ha-2.5ha to 2.6ha-10ha (Table 9). Livestock and trade are secondary activities.

Table 9. Distribution of the population by village and farm size

Village	Size of farm			
	Smaller (0-1ha)	Medium (1ha-2.5ha)	Large (2.6 ha-10 ha)	Total
Basgouema	4 (16.67%)	10 (41.67%)	10 (41.67%)	24 (100%)
Kao	4(13.33%)	16(53.33%)	10 (33.33%)	30 (100%)
Kassila	8(16%)	22(44%)	20(40%)	50 (100%)
Bagane	7(17.5%)	14(35%)	19(47.5%)	40 (100%)
Kouleteon	5(16.67%)	15(50%)	10(33.33%)	30 (100%)
Korgnegane	3(10%)	12(40%)	15(50%)	30 (100%)
Logo	9(25.71%)	12(34.29%)	14(40%)	35 (100%)
Aziga	3(15%)	11(55%)	6(30%)	20 (100%)
Pala	10(18.18%)	19(34.55%)	26(47.27%)	55 (100%)

Source: Field surveys December 2021- June 2022

Analysis of this table shows that more than 80% of tree managers in agricultural fields have agricultural plots ranging in size from 1ha-2.5ha to 2.6ha-10ha.

Strategies used by tree managers in agricultural fields

In the study areas, farmers deliberately leave species (*Vitellaria paradoxa, Parkia biglobosa*) in agricultural fields for their needs. Farmers thus become the managers of the species in the agricultural fields. However, these tree species are subject to climatic variability, which further complicates the situation of farmers living in the countryside. Therefore, several strategies are mobilized by farmers who manage trees in agricultural fields. The literature review, surveys and field observations allow us to identify three (03) groups of adaptation strategies in the different study villages. These are the proactive, reactive and silvicultural adaptation strategies.

The proactive adaptation strategy aims to minimise the impact of climate variability by reducing vulnerability through potential anticipation of its effects (Smith, 1997). This requires foresight and planning (Fankhauser et al., 1999). In the villages studied, the proactive adaptation strategy corresponds to a set of strategies such as reforestation with fruit trees, banning bush fires, wood cutting and awareness raising. In the villages studied, reforestation with fruit trees is widely used by the respondents in the commune of Samba and the commune of Dissin, but is less widespread in the commune of Nébiélianayou (Figure 2).

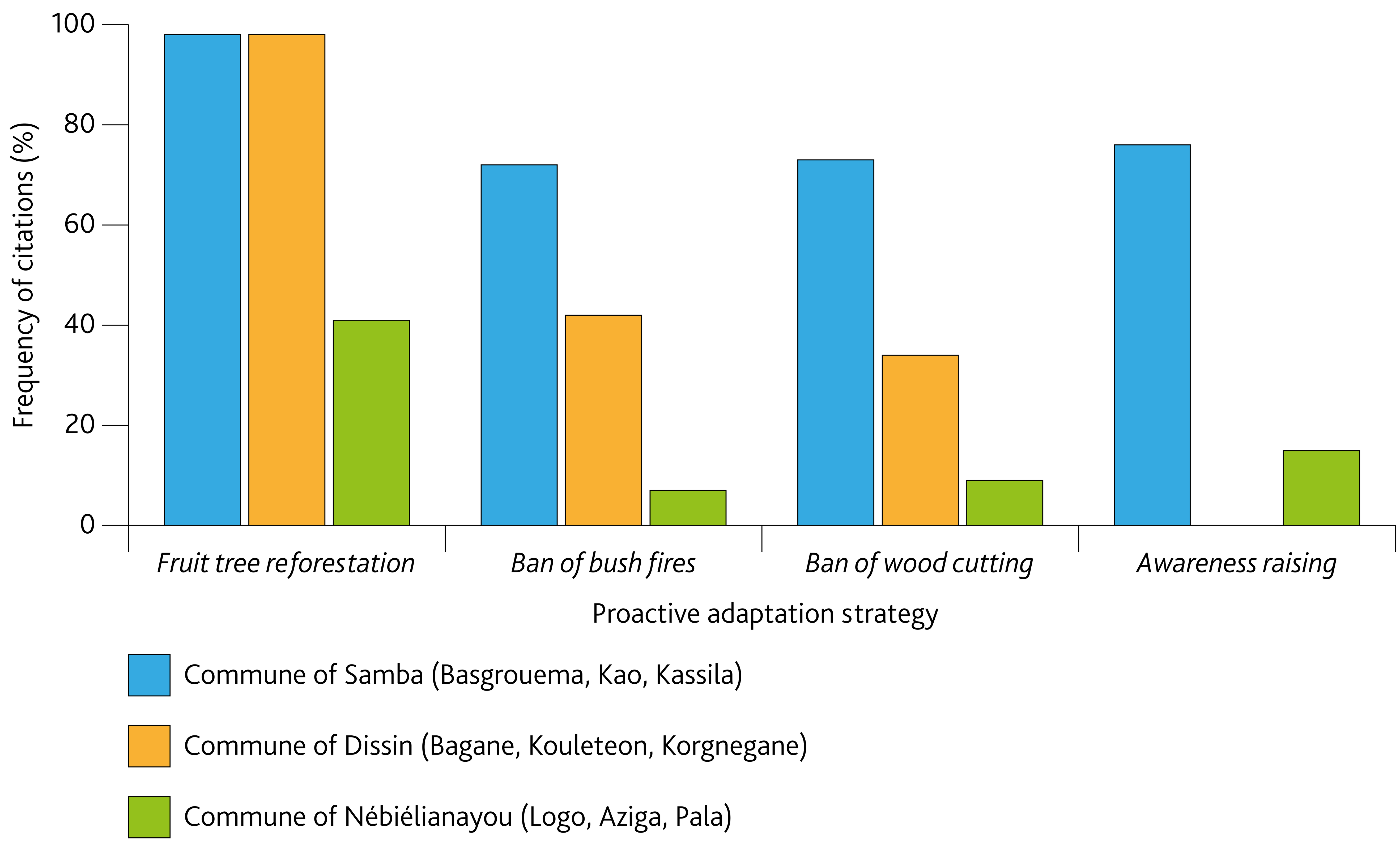


Figure 2. The proactive adaptation strategy group mobilised in the study villages
Source: Field surveys December 2021-June 2022

The proactive adaptation strategy group is furthermore conducted by farmers in different agroforestry parklands in West Africa. Ouoba et al, 2018 observed in the communes of Titao, Yako, Saaba, Fada N'Gourma, Sapouy, Péni and Niangoloko, in Burkina Faso the practice of tree monitoring (63%) and planting (60%) to manage their agroforestry parklands In the Vipalogo terroir, enrichment (reforestation of trees) was used as a practice to preserve agroforestry parklands (Yaméogo et al., 2005).

The reactive strategies group focuses on responding to the effects of climate variability which includes soil erosion control, construction of irrigation dams, improving soil fertility, developing new varieties, shifting planting and harvesting times (Shongwe et al., 2014), In the study villages, the reactive strategy includes soil fertility improvement (fallowing and use of organic fertilisers), erosion control (use of dike method and stone barriers). The practice of fallowing and the use of organic fertiliser are carried out respectively in the commune of Dissin and the commune of Nébiélianayou. (Figure 3).

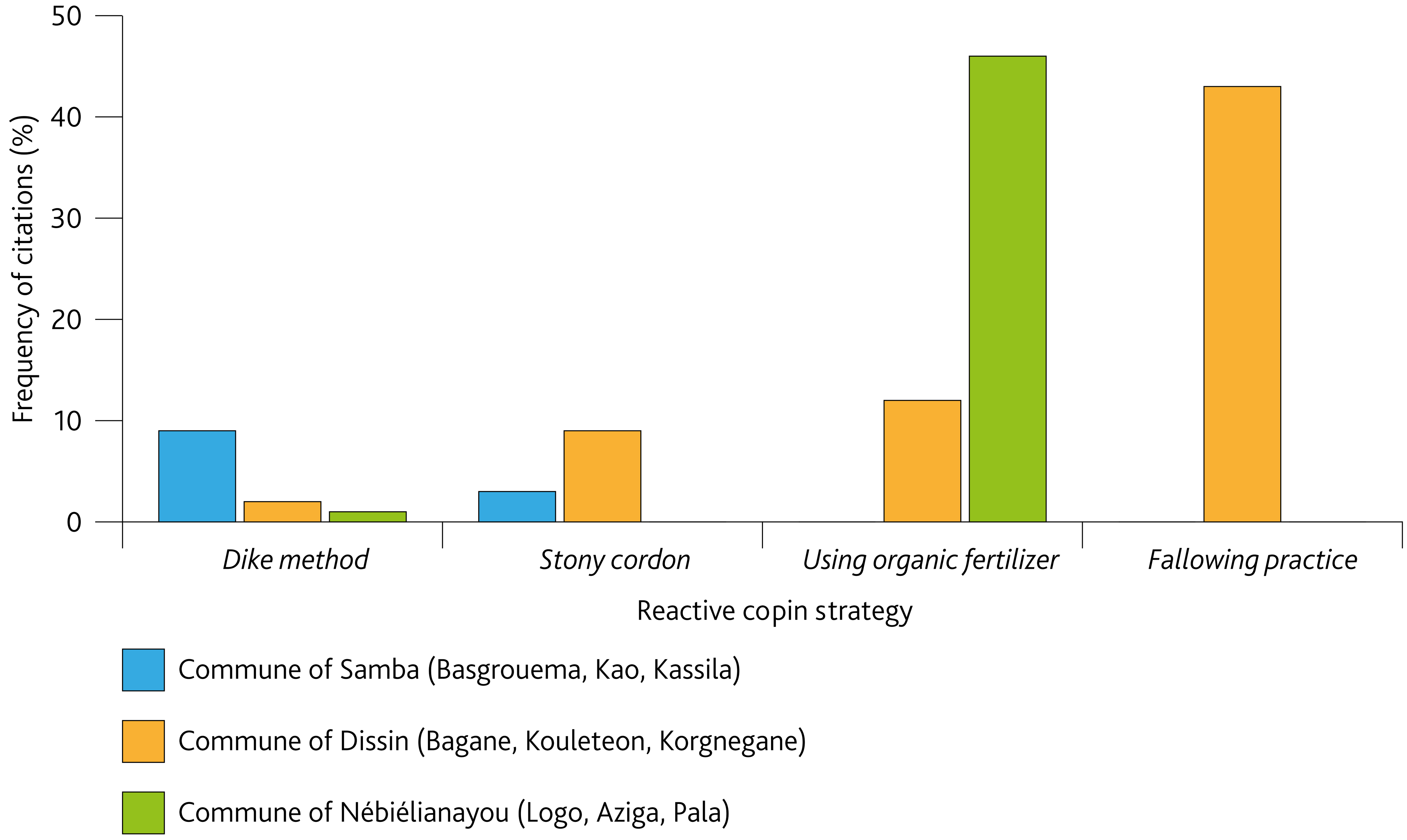


Figure 3. Reactive coping strategy group deployed in the study villages
Source: Field surveys December 2021-June 2022

Several authors note the choice of the reactive adaptation strategy group for the management of West African agroforestry parklands. In fact, Djibo et al., 2016 note that in Acacia senegal parklands in the western part of Niger, households mobilise reactive strategies such as the use of organic fertiliser (manure), changing the type of crops, changing sowing dates, developing and exploiting ponds, and using improved seeds. In the south-western part of Niger, fallow land (87.91%) among others is used massively in park management (Larwanou et al., 2006).

The silvicultural strategy includes grafting, pruning and assisted natural regeneration of young shea plants. This strategy emerged as a result of the fact that tree species such as shea have been more affected by parasitic species in recent years in the study districts. They are practised to a limited extent by the respondents. Indeed, in Figure 4, only 11.54% of managers practise grafting/ pruning and NRA (Natural Regenescence Assisted) in the commune of Samba. 22% of the research sample in the commune of Dissin graft or prune shea tree branches, and 8% practise NRA. In the commune of Nébiélianayou, 25% of managers use NRA to allow shea offspring to develop properly.

This strategy is also used by tree managers in the fields in Burkina Faso. In the Central Plateau of Burkina Faso (Manga, Ouagadougou and Kaya), farmers use strategies such as pruning to manage Parkia Biglobosa (Timmer et al., 1996). In North Cameroon, silvicultural strategies such as reasoned pruning (cut branches are selected according to use); pruning following a rotation of about 7 or 8 years etc. have been applied to better manage Faidherbia albida in agricultural fields (Smektala et al., 2005). In Senegal, in the groundnut basin, it is rather the strategies of pruning of basal branches, pruning of main branches and selective pruning of bushy branches that have been adopted by the respondents for the management of sterculia setigera and cordyla pinnat species in agricultural fields (Sene, 1994). Similarly, in the sites of Ngogom (site 1) and Ndangalma (site 2), in the Senegalese groundnut basin, farmers also practice pruning, 80% in site 1 and 60% in site 2 for the management of species in rural fields (Ba et al, 2018). In Senegal, in the rural community of Mangagoulack, assisted natural regeneration (ANR), among others, has been implemented as a silvicultural technique strategy for park management (Goudiaby, 2013). In the Maradi region of Niger, improved clearing, pruning and staking are promoted more by farmers to preserve trees in agricultural fields (Larwanou et al., 2010). However, the choice of coping strategies is modulated by several factors that need to be elucidated to better understand their influence on coping strategies.

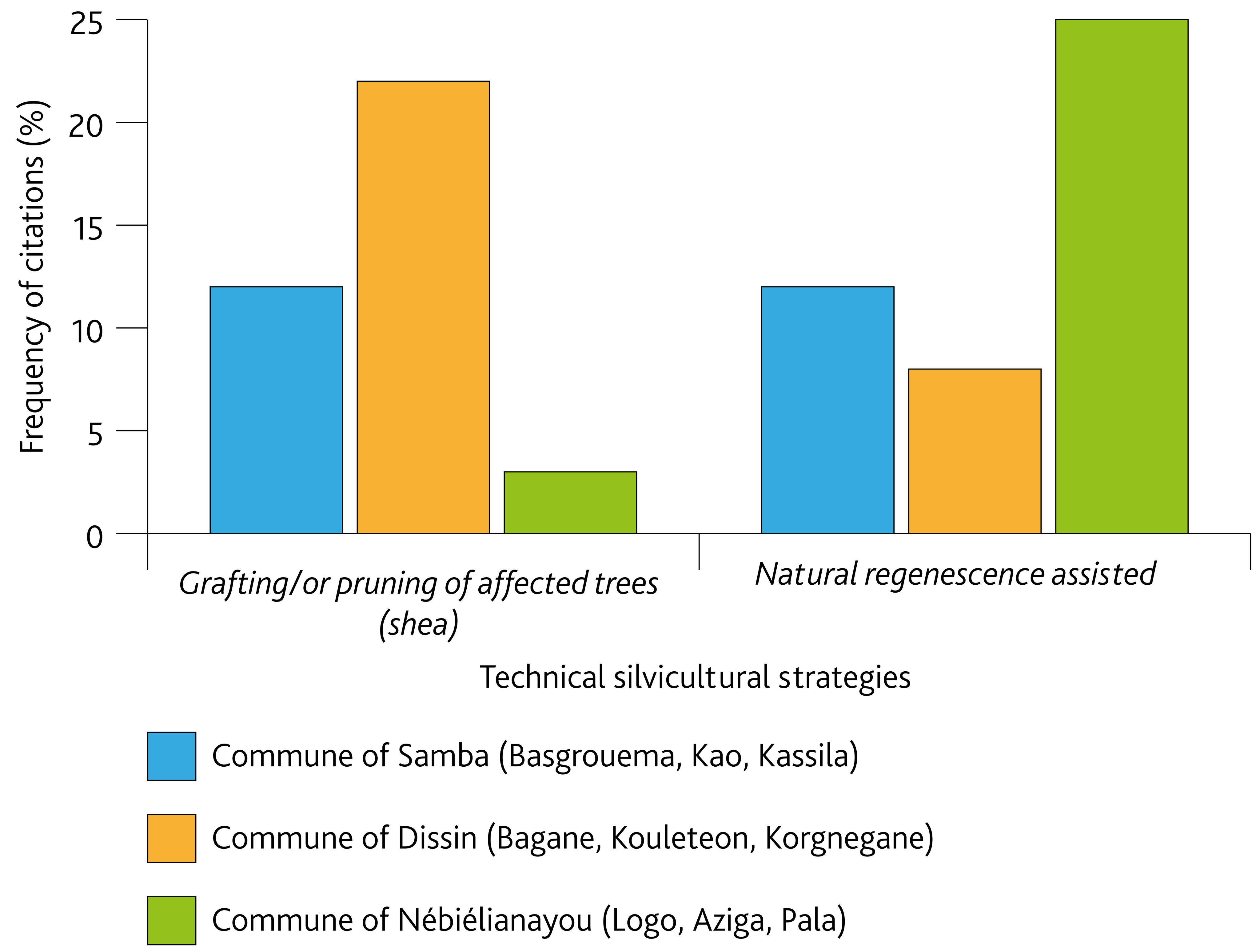


Figure 4. Technical silvicultural strategies in the study areas
Source: Field surveys December 2021-June 2022

Factors influencing the choice of adaptation strategies

Binary Logistic Regression (BLR) generated four (04) models for the proactive adaptation strategy group, four (04) models for the reactive adaptation strategy group and two (02) models for the silvicultural technique strategy. These models indicate that the predictions using the logistic regression model are acceptable or not for strategy selection. The proactive adaptation strategy group which admits four (04) models shows differentiated influences between the explanatory and dependent variables (Table 10).

According to this table, the results of the binary logistic regression show that household size, level of education, residential situation and level of income from non-timber forest products positively and significantly influence the choice of proactive strategies (awareness raising, banning of bush fires and reforestation of fruit trees) by managers. However, the significance is moderate (1%) between the choices of banning bushfires, wood cutting and household size. In addition, the influence of the choice to ban bushfires on the level of income from non-timber forest products is moderate.

Furthermore, the odds ratio (Exp (B)) shows that the chance of choosing the awareness strategy is 689.7% ((1-7.897) *100) for household size. This shows that the effect of household size on the choice of the awareness strategy is very strong.

In addition, the chances of choosing reforestation of fruit trees and banning bushfires increase by 99.8% ((1-1.998) *100) and 197.9% ((1-2.979) *100) respectively for education level. Thus, respondents are more likely to opt for banning bushfires than reforestation of fruit trees. The same is true for the level of income from non-timber forest products with regard to the choice of the awareness strategy, and for the residential situation with regard to the reforestation of fruit trees strategy. In fact, the chances of adopting the awareness strategy increases to 157% ((1-2.57) *100), and for the choice of reforestation of fruit trees, it increases by 190.2% ((1-2.902) *100). On the other hand, gender, age, farm size and main activity do not affect the choice of proactive strategies.

For the reactive coping strategy group, binary logistic regression produced four (04) models that present the influence of explanatory variables on the strategies promoted by the respondents (Table 11).

Table 10. Binary logistic regression of explanatory variables and proactive coping strategies

	Model 1			Model 2			Model 3			Model 4		
	Proactive coping strategy			Proactive coping strategy			Proactive coping strategy			Proactive coping strategy		
	Fruit tree reforestation			Ban on bush fires			Ban on wood cutting			Awareness raising		
Explanatory variables	**Exp (B)**	**E. S**	**p-value**	**Exp (B)**	**E. S**	**p-value**	**Exp (B)**	**E. S**	**p-value**	**Exp (B)**	**E. S**	**p-value**
Gender	1.015	0.414	0.97	0.668	0.596	0.498	0.823	0.574	0.734	1.443	0.415	0.734
Age	1.045	0.391	0.91	0.641	0.464	0.338	2.463	0.453	0.46	1.304	0.351	0.449
Household size	0.764	0.443	0.545	0.432	0.515	**0.10****	2.324	0.540	**0.10***	7.897	0.671	**0.002*****
Educational level	1.998	0.591	**0.044****	2.979	0.422	**0.010*****	0.877	0.419	0.754	0.877	0.419	0.754
Residential status	2.902	0.487	**0.029****	6117592.73	2661.98	0.995	9567105.64	2661.98	0.995	54413924	2679.58	0.995
Level of income from non-timber forest products	0.859	0.359	0.672	0.423	0.562	**0.10***	0.548	0.550	0.275	2.570	0.393	**0.01*****
Size of holding	0.975	0.322	0.937	0.910	0.419	0.822	1.033	0.413	0.937	0.944	0.316	0.854
Main activity	2.399	22349.803	1	4.851	4177.595	1	2685831.52	3128.16	0.996	6713182	2533.802	0.995

*Source: Processing of field survey data, December 2021-June 2022; * significance at 10%; ** significance at 5%; *** significance at 1%.*

Table 11. Binary logistic regression of explanatory variables and reactive coping strategies

	Model 1			Model 2			Model 3			Model 4		
	Reactive coping strategy group			Reactive coping strategy group			Reactive coping strategy group			Reactive coping strategy group		
	Dike method			Stony cordon			Using organic fertilizer (dung)			Fallowing pratice		
Explanatory variables	Exp (B)	E. S	p-value	Exp (B)	E. S	p-value	Exp (B)	E. S	p-value	Exp (B)	E. S	p-value
Gender	0.000	10944.95	0.999	0.000	11055.95	0.999	0.815	0.413	0.621	0.290	0.779	**0.10***
Age	0.522	0.867	0.453	0.000	11601.51	0.999	1.309	0.345	0.435	1.017	0.440	0.970
Household size	0.598	1.228	0.676	2.233	1.089	0.463	1.021	0.412	0.960	0.677	0.534	**0.04***
Educational level	8.609	0.898	**0.01*****	21.458	1.085	**0.005*****	0.985	0.345	0.964	0.695	0.408	0.373
Residential status	0.178	10819.14	1	159472186.9	10890.69	0.999	0.841	0.495	**0.049***	47100128.11	5125.57	0.997
Level of income from non-timber forest products	0.799	0.897	0.803	1.348	0.675	0.658	0.749	0.375	0.442	0.000	5947.006	0.997
Size of holding	0.570	0.746	0.452	4.438	0.728	**0.041***	1.358	0.305	0.316	0.272	0.463	**0.005*****
Main activity	0.000	33445.122	1	9.882	35096.444	1	0.000	22378.708	1	0.432	5727.212	1

*Source: Processing of field survey data, December 2021-June 2022; * significance at 10%; ** significance at 5%; *** significance at 1%.*

The table shows that the choice of fallowing depends significantly on gender and very significantly on household size and farm size. It should be noted, however, that the odds ratio (Exp (B)) shows that the odds of dependence on fallowing decrease to 71% for gender. Conversely, it is 32.2% for household size and 68.4% for farm size. This implies that the choice of fallowing practice is more influenced by household size, as the latter has decreased less than gender and farm size. In addition, the choice of dike methods is highly significant for education level. Similarly, the adoption of stone barriers is highly significant for education level and significant for farm size respectively.

As for the silvicultural technique strategy, the logistic regression allows for two models, which show that the explanatory variables have little influence on the strategies developed by the managers (Table 12).

Table 12. Logistic regression between explanatory variables and silvicultural technique strategy

	Model 1			Model 2		
	silvicultural technique strategy			silvicultural technique strategy		
	Grafting/or pruning of affected trees (shea)			Natural Regenescence Assited (NRA)		
Explanatory variables	Exp (B)	E. S	p-value	Exp (B)	E. S	p-value
Gender	0,603	0,652	0,437	0,72	0,60	0,51
Age	1,341	0,400	0,463	4,44	0,730	**0,040***
Household size	0,450	4,440	**0,041****	0,720	0,401	0,42
Educational level	0,724	0,398	0,416	2,90	0,420	**0,010****
Residential status	162471657,9	6037,98	0,998	163471657,03	61031,98	0,995
Level of income from non-timber forest products	0,632	0,603	0,446	0,64	0,612	0,451
Size of holding	0,611	0,401	0,220	0,711	0,501	0,382
Main activity	0,000	4817,83	0,997	0,000	48187,95	0,999

*Source: Processing of field survey data, December 2021-June 2022; * significance at 10%; ** significance at 5%; *** significance at 1%.*

This table shows that the choice of grafting/tree pruning depends statistically on the size of the household. Thus, the larger the household size, the more it adopts grafting/tree pruning. In contrast, for NRA (Natural Regenescence Assited), the level of education and age are statistically significant. This implies that the adoption of NRA depends on the level of education, but also on age. Furthermore, results on the determinants of adaptation strategy choice show that explanatory variables have a differential impact on the choice of adaptation strategies by tree managers in the agricultural fields of the study areas. Similar results on the differential impact of explanatory variables on adaptation strategy choices were found in northern Uganda (Atube et al., 2021), central Ethiopia (Addis and Abirdew, 2021). Mabe et al. 2014, in northern Ghana, makes a similar finding. Empirical results from binary logistic regression models revealed that there are differential effects of explanatory variables on the choice of coping strategies. Similarly, Atinkut & Mebrat, 2016 in Ethiopia find that the explanatory variables (agro-ecology, age of household head, family size, farm size, access to extension services and perception of climate variability) are significantly and positively correlated with adaptation strategies (crop diversification, soil and water conservation and seasonal migration). However, in contrast to the study area, in the Gondar zone of Ethiopia, the level of education of the household head, among others, did not have a statistically significant effect on the adaptation measures chosen by the respondents. In the central highlands of Ethiopia, Alemayehu and Bewket, 2017 found similar results to those in the Gondar zone. In contrast, non-farm income, community participation, livestock ownership and temperature did not clearly influence the choice of climate change adaptation strategies. In Zimbabwe, in the Chiredzi area, Muzamhindo et al, 2015 through the binary regression model show that the explanatory variables significantly influence farmers' choice of adaptation strategies. However, these influences are either positive (access to extension, number of employable members, livestock ownership, access to credit) or negative (age of household head and farm income).

CONCLUSION

Tree managers in the agricultural fields are mostly male, illiterate farmers between the ages of 40 and 50. The disturbances that climatic variability brings to the trees (*Vitellaria paradoxa* and *Parkia biglobosa*) in the agricultural fields push the managers of the study areas to mobilise several strategies, which are grouped in three (03) levels such as the proactive strategy, the reactive strategy and the strategy of silvicultural techniques The proactive strategy, namely reforestation with fruit trees, is widely used in the study villages. Reactive strategies are practiced secondarily. Socio-demographic and socio-economic factors influence the choice of adaptation strategies. Thus, authorities need to improve socio-economic factors such as income level, education level and household size in order to increase the level of resilience of tree managers in agricultural fields to climate variability/change in the study areas.

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