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Farmers' perceptions of the impacts of *Adansonia digitata* L. leaves exploitation on its conservation and on livelihoods of local communities in Mali, West Africa

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Abstract

Baobab tree species plays a significant role in the livelihoods of rural dwellers in the Sahel regions. This study was carried out to analyze farmer's perceptions on the impacts of *Adansonia digitata* L. leaves exploitation on its conservation and on livelihoods of local communities. Data were collected by interviewing 120 farmers to elucidate the impacts of leaves exploitation as well as the contribution of the species on their livelihoods. Descriptive statistics and multiple regression analysis were used to analyze the data to identify the annual contribution and to determine the socio-demographic characteristics influencing farmer's perception of baobab leaves harvesting techniques. The results show that non-timber forest products (NTFPs) are the second pillar to support the respondents after agriculture. Their contribution

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rate ranged between 4 and 7% in the study sites. The findings revealed that the annual income obtained per person from the exploitation of baobab leaves ranged from 33,714 FCFA (56.00 USD) to 52,857 FCFA (87.80 USD). Its contribution to annual household income varies between 2.51 and 5.4%. Two (used of machete and stick) out of the three (manual collection, used of machete and stick) methods used by farmers to harvest the baobab leaves, have negative impacts on baobab species conservation. Age, educational level, and gender are key factors influencing farmer's perception of baobab leaves harvesting. In view of the importance of the baobab tree, it is imperative that the domestication and propagation of baobab trees should be supported through the adoption of improved agroforestry technologies. In addition, sustainable harvesting practices of baobab leaves is also recommended for the conservation of this species.

Keywords: Annual income, domestication, Improved agroforestry technologies, non-timber forest products, rural dwellers, Sahel regions

1. Introduction

In many developing countries, the livelihoods of poor population would not be possible without availability of non-timber forest products (NTFPs) (Lokonon *et al*., 2021). These are more appreciated during the lean period, where NTFP constitute security options to compensate the crop failure through gathering and processing of wild edible fruits or other products from woodlands and forests (Gebauer *et al*., 2016). These wild edible fruit trees include the African Baobab (*Adansonia digitata*).

In West Africa, baobab fruits and leaves contribute to human diets in a major way (Gebauer *et al*., 2016). These resources from forest ecosystems are subject to various forms of harvesting and to the vagaries of the weather (Dossa *et al*., 2015). Furthermore, forest degradation is significant in West Africa, where annual forest clearance is estimated to 4% (FAO, 2001). Moreover, this rate increased to more than 13% between 2000 and 2015 (FAO, 2016). This situation is not favorable for the expansion of certain species in forest and savannah environments, including *Adansonia digitata*, a very important indigenous tree species in view of its role in the rural communities. In the last decade, international interest in the species increased following the acceptance by the European Union of the dry fruit pulp of baobab in the European food market. In addition to this, Gebauer *et al*. (2014) reported more than 300 baobab products or products with baobab as an ingredient that are available in Europe.

The integration between forest and forest-dwelling communities is receiving increasing attention from social experts and policymakers. This reflects a growing recognition of the contribution of the NTFPs to rural

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livelihood, both in terms of supporting subsistence and financial income generation (Faye *et al*., 2010). Moreover, the conservation and sustainable use of non-timber forest species plays a crucial role in the well-being of the population and the economy. In Mali, NTFPs covered about 20 to 60% of the family budget need (CPS, 2016). Thus, NTFPs including the baobab species have multiple uses, which makes baobab one of the most useful species in Mali. Baobab tree is a source of foods and medicine; the leaves are mainly used as condiments and the fruits are consumed to complement diet. Its leaves contain important amounts of iron, calcium and vitamin A (Chadare *et al*., 2014; Assogbadjo *et al*., 2018). The provision of these services is increasingly threatened by human pressure and confronted with deteriorating climatic conditions (Traore *et al*., 2015). One of the ways such deteriorating conditions manifest themselves is through reduced tree coverage in landscapes including the agro-ecosystems because of the decreasing rainfall (Gonzalez *et al*., 2012). However, the species break in traditional agricultural systems and its preservation is a priority (Bationo *et al*., 2010) in the Sahel region and particularly in Mali. In that area, the livelihood of the population depends on agricultural production as well as ecosystems services. In this context, the World Agroforestry Centre (ICRAF) initiated a worldwide program to domesticate a certain number of species, including *Adansonia digitata* L., identified by local people as their priority for cultivation in agroforestry systems (Tchoundjeu *et al*., 2010). According to (Savard, 2003) fresh leaves of baobab are rich in vitamins, which improve the Malian diet, especially the rural community, while the bark is the most important part of the baobab in Est Africa (Savard, 2003). The commercialization of the fruit pulp provides income to rural dwellers (Venter *et al*., 2011). Thus, many studies were carried out on various aspects of baobab tree such as its germination (Savard *et al*., 2006), the morphological variability of the fruits and leaves (Kouyaté *et al*., 2011), its distribution (Duvall, 2007), assessment of its population (Lisao *et al*., 2018) and evaluation of its fruit production (Sanogo *et al*., 2015). However, none of these studies investigated the impact of baobab leaves exploitation on its conservation as well as its contribution to the livelihoods of the rural population. This research seeks to study the impact of leaves exploitation on the sustainable conservation of *Adansonia digitata* L. and its contribution to the livelihoods of the local communities.

2. Materials and Methods

2.1. Study Area

The study area is located in the commune of Cinzana, in the region of Segou, south central of Mali. This commune is located between 13°16'40" North and 5°58'20" West. It was selected after a preliminary investigation. This commune was chosen among other sites because of the significant

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presence of *Adansonia digitata* and pressure of the local population on non-timber forest products (NTFPs). Amongst the 49 villages of the commune, 4 villages were retained for the current study. These villages are: Bougoukourala, Nabougou, N'Gakoro, and Sorobougou (Figure 1). The climate of the commune of Cinzana is semi-arid and is characterized by the alternation of a long dry season from November to May and a rainy season from June to October. The average annual rainfall is 350 mm while the average temperature is 35°C. The natural vegetation is dominated by degraded savannah and soils are tropical ferruginous (Gustad *et al*., 2004). In the study area, men are more engaged in farmland activities while women are more into collecting and processing non-timber forest products such as shea, baobab, neré, saba, etc, which contribute to improve family livelihoods. The population in the study area are mainly farmers and herders and they earn their living through rainfed agriculture (dominated by the cultivation of Millet and Sorghum), herding and provisioning ecosystem services from trees.

2.2. Tree species studied

Adansonia digitata L. (Bombacaceae family) is commonly known as baobab tree native to Africa. Baobab is a deciduous tree from the African savannas. It is one of the most useful trees and it is found in the Sudanian and Sahelian zones of Mali. In West Africa, *Adansonia digitata* is found in Mali, Benin, Senegal, Ivory Coast, Cameroon and Burkina Faso (Munyebvu *et al*., 2018). Its height can reach up to 23 meters and the trunk can be up to 10 meters in diameter (Schumann *et al*., 2010). The leaves are palmate with five sessile leaflets. The bark is smooth, silver-grey, pinkish-purple, or dark grey in color, and contains a yellow or green inner layer, which is composed of thick, tough, longitudinal fibers. It is a very long-lived, fast-growing tree (in its juvenile stage) and has a life span of hundreds of years (SCUC, 2006).

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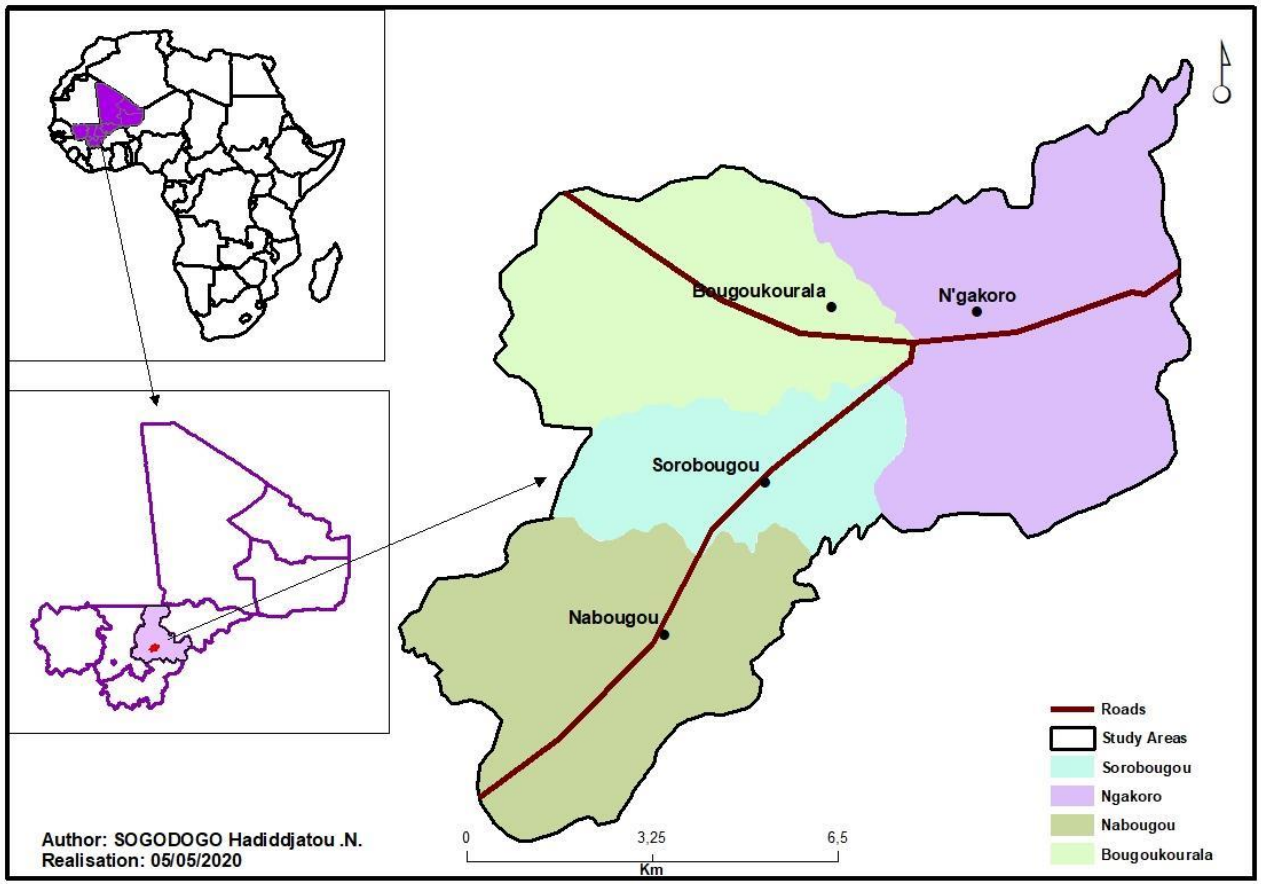

Figure 1: Study area location in the commune of Cinzan

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

3. Methods

3.1. Sample size

A preliminary investigation was done to determine the sampling size (N). A brief survey on 30 interviewees was done in the concerned village by applying the following formula of Dagnelie (1998) to determine the sample size (N). The farmers were asked whether they have at least one edible tree (baobab) in their field or whether, they consumed *Adansonia digitata L*. leaves in their diet. The proportion p of positive answers was considered to compute N. The proportion p of positive answers was 50%.

$$N = \frac{U^2_{1-\alpha/2} p(1-p)}{d^2}$$

$U_1-\alpha/2$ is the value of the Normal random variable at the probability value of $1-\alpha/2$.

For a probability value of 0.975 (or $\alpha = 0.05$), $U1-\alpha/2 \approx 1.96$; d is the margin error of the estimation to be computed from the survey that was fixed at 0.09.

By computing the formula above, the sample size (N) was estimated at 120 farmers for the four villages. For each village, the sample site was prorated to its total number of households, giving 21, 28, 32, and 39 in Bougoukourala, N'Gakoro, Nabougou, and Sorobougou, respectively. However, the majority of our interviewees were women (74%) due to the fact that this activity is one of the pillars of rural women in this commune.

3.2. Data collection

The data were collected between September and October 2019 through a semi-structured questionnaire. A total of 120 farmers were interviewed in the commune of Cinzana. The interview was individual and, in each household, only one the volunteer was interviewed with the consent of the head of household. The main emphasis was on the use of baobab leaves in their diet, the techniques of leaves exploitation, and the price of selling fresh baobab leaves and powdered. The data related to the annual contribution of non-timber forest products as well as the annual contribution of baobab leaves in household income were recorded.

3.3. Data analysis

Thereafter data were verified by checking the categories of all variables for correction. Data collected were analyzed through the descriptive statistics and cross tabulation. Tables, figures, frequency distributions and percentages were used to present the results. Factors influencing farmers' perceptions of baobab leaves harvesting were investigated through the multiple regression analysis between each socio-demographic characteristic (age, educational level, gender, and marital status) and harvesting techniques

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

of baobab leaves. Due to the fact that all the four villages are in the same commune, and not far from each other, the data was combined in one sample for this purpose. The Statistical Package for Social Sciences (SPSS) software version 24.0 was used for further analysis.

4. Results

4.1. Socio-demographic characteristics of the respondents in the commune of Cinzana

The results show that most of the respondents in the different sites were women (74%). Education is an important factor that can affect the answer of the respondents. In the study area, the majority are illiterate in the four villages (Table 1). The important level of education after the illiterate is the number of respondents alphabetized by development projects supporting rural farmers in the context of capacity building. Respondents with primary and secondary school levels are very few in the study area (Table 1). The age of the respondents was arranged in three groups (Table1). The results show that most of the respondents in N'Gakoro are young (ranged between 20 and 40 years old), compared to the other sites. For the second group of age (40-60-years), Sorobougou recorded a higher frequency. For the last group of age, Bougoukourala recorded 24% of respondents aged more than 60 years. All the respondents were married whereas the widow's rate of 5 and 3 % was recorded in Sorobougou and Nabougou, respectively (Table 1).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 1 : Sociodemographic characteristics of the respondents in the commune of Cinzana

Variables	Sites							
	Bougoukourala		N'Gakoro		Nabougou		Sorobougou	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Gender								
Female	16	76	18	64	28	88	26	67
Male	5	24	10	36	4	13	13	33
Educational level								
Alphabetized	7	33	12	43	8	25	9	23
Illiterate	12	57	15	54	21	66	26	67
Koranic school	0	0	0	0	2	6	3	7
Primary level	0	0	1	3	1	3	0	0
Secondary level	2	10	0	0	0	0	1	3
Age group								
20-40	10	48	14	50	13	41	14	36
40-60	6	29	14	50	17	53	21	54
>60	5	24	0	0	2	6	4	10
Marital status								
Married	21	100	28	100	31	97	37	95
Widowed	0	0	0	0	1	3	2	5

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

4.2. Income-generating activities of the respondents

According to the respondents, the main income-generating activity is agriculture in all the villages (Table 2). The results show that non-timber forest products (NTFPs) are the second pillar to support the livelihoods of the respondents in the commune of Cinzana. Its rate ranged between 4 and 7% in the different villages. These NTFPs include the baobab leaves, which are the focus of our study. The respondents have also listed small trading as a source of income in the sites except for the village of Bougoukourala. The result from the survey indicates that the last activity listed by the respondents is vegetable production. This activity is done in 3 out of 4 villages in the study area (Table 2). According to these respondents, the vegetable production is the most important activity after agriculture and NTFPs in the commune of Cinzana.

Table 2: Different sources of income of the respondents in the commune of Cinzana

Sites	Source of incomes in percentage				Total
	Agriculture	NTFPs	Small-Trading	Vegetable production	
Bougoukourala	88	7	0	5	100
N'Gakoro	89	4	2	5	100
Nabougou	88	5	4	3	100
Sorobougou	90	7	3	0	100

4.3. Farmers' perceptions of baobab leaves powder trade at local level

In the study area, farmers confirmed that NTFPs like baobab highly contributed to improve their livelihood due to the benefits they get from baobab. In addition, they rely on a variety of nutritional and medicinal products (baobab leaves, powder, etc.) provided by the baobab tree. According to the farmers, the leaves are an important component of their diet. The results show that the price of baobab leaves powder varied from one village to another in the same commune (Table 3). Among the four villages, the higher price of baobab leaves powder was recorded in Bougoukourala and Nabougou. The findings (displayed in the table 3) indicate that Sorobougou has the lowest price of baobab leaves powder compared to the other villages. In the commune the price of baobab leaves powder varied from 175FCFA (0.29USD) to 250 FCFA (0.42USD). The price of fresh baobab leaves is lower than that of the baobab leave powder (Table 3). A similar trend was observed with the average selling price of fresh baobab leaves in the study sites. The average selling price of one 1 kg of baobab fresh leaves ranged between 125 FCFA (0.21 USD) and 175 FCFA (0.29 USD) (Table 3) in the commune of Cinzana. The standard deviation of both prices at the different villages is so high. The price mentioned in the table 3 is the selling price by the harvesters/processors in the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

village and local market. Almost all the main actors of selling that products are women in the commune of Cinzana.

Table 3: Selling price of baobab leaves powder and fresh leaves by kilogram in the commune of Cinzana

Sites	Average selling price of 1 kg of baobab leaves powder (FCFA)	Average selling price of one 1 kg of baobab fresh leaves (FCFA)
Bougoukourala	250±100	165±45
N'Gakoro	200±35	150±60
Nabougou	250±105	175±22
Sorobougou	175±105	125±25

4.4. Quantity of baobab leaves powder sold by respondents per year

The leaves of baobab seem to be the NTFPs of high value for the farmers in our study sites. The total of baobab leaves powder sold ranged from 148 to 261 kg per year and per respondent (Table 4). This quantity of biomass collected and sold per year varied between villages. Thus, the highest quantity of baobab leave collected by individual was recorded in the villages of Sorobougou and Nabougou while the lowest quantity was recorded in Bougoukourala and N'Gakoro respectively (Table 4). The results of the current study indicate that besides the family consumption, the leave of baobab is generating income to support their expenses. In the respective villages, the results show that the respondents of Nabougou sold more powdered baobab leaves than the respondents of other villages (Table 4). In general, most of the sellers of these products at local market are women. According to women, the income generated from the selling of these products are used to support the school fees of the children while others argued that the money is used to support the wedding of their daughters. In addition to this, some respondents confirmed that this income generated is used for food purchases especially during the food shortage period of the year.

Table 4: Quantity of powdered baobab leaves powder sold by respondent per year in the commune of Cinzana

Sites	Mean quantity of powdered baobab leaves sold by a respondent per year (Kg)	Mean quantity of powdered baobab leaves sold by a respondent per year (FCFA)
Bougoukourala	148,57±56,12	37142±14 042
N'Gakoro	182,86±88,11	33 714±17 622
Nabougou	211,43±74,72	52 857±18 680
Sorobougou	261,5±154,17	46 812±26 979

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

4.5. Actors involved in baobab leaves selling in the study sites

The actors involved in baobab leaves selling are depicted in the Figure 2. The actors are harvesters, processors, and wholesalers at the commune level. The harvesters and processors are women while the wholesalers are men. The results showed that women are the majority at the four sites for harvesting, processing, and selling the baobab leaves. Their involvement in selling baobab leaves is very important in Bougoukourala and Sorobougou compared to N'Gakoro and Nabougou. In the village of Sorobougou, only 3% of men are selling baobab leaves (Figure 2). According to men, women collect the baobab leaves and they support them for selling due to the issue of transportation to the local market.

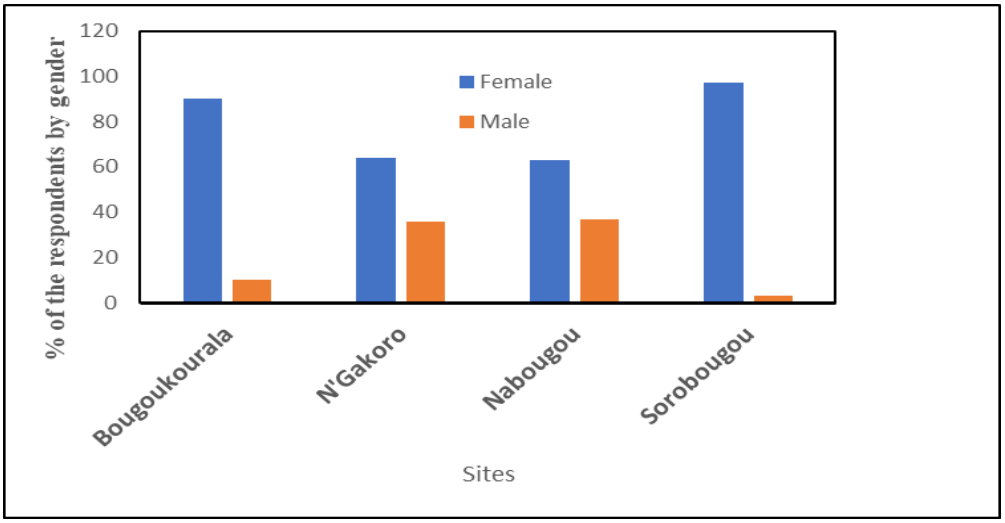

Figure 2: Percentage of male and female involved in baobab leaves selling in each village in the commune of Cinzana

4.6. Farmers' perceptions of the contribution of baobab leaves in household income

According to the respondents, besides the study species, there are some other agroforestry key tree species (*Vitellaria paradoxa*, *Parkia biglobosa*, *Ziziphus mauritiana*, etc.), which contribute to their household income. The results of the current study recorded a range of 2.51 to 5.4% as the rate of contribution to the household income. Indeed, it supports the farmers especially during the shortage period because this period coincides with the flowering of the baobab trees in Mali (Figure 3).

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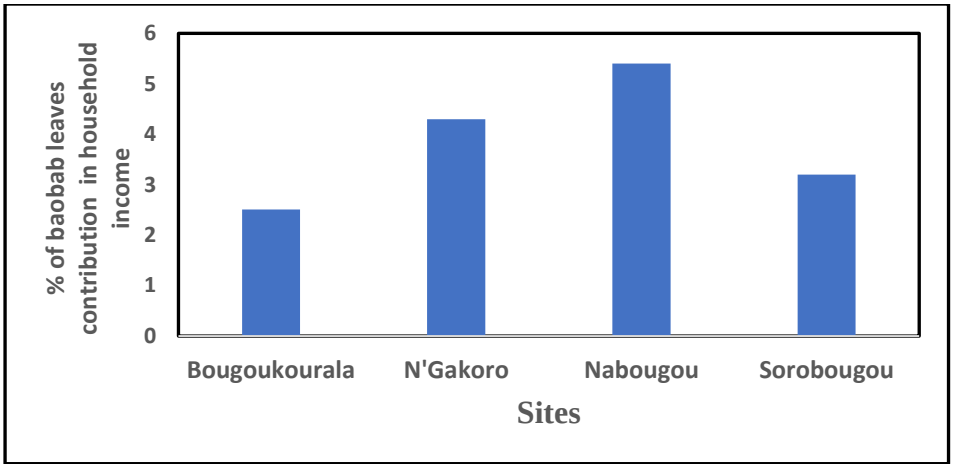

Figure 3: Percentage of baobab leaves contribution in household income in the study sites

4.7. Farmers' perceptions of the techniques of leaves exploitation and their impacts on baobab tree conservation

The results of our study show that the respondents have three techniques of baobab leaves harvesting. The first main technique used in the study area is the stick (knife attached to the end of a long bamboo). The adoption of this technique in Bougoukourala is so high (table 5), compared to the other three villages (N'Gakoro, Nabougou and Sorobougou). The second technique used by the actors for collecting baobab leaves in the sites is the cutting of leaves with machete. In general, this technique is applied in two ways. The first way is done by climbing on the tree to cut the branches with leaves. The second way is applied from the ground. It is more adopted by the respondents in Nabougou compared to the other villages. The last technique adopted by the respondents is the manual collection of baobab leaves. This technique is only applied in only two villages. (Table 5). The adoption rate of this technique is low compared to the other two techniques used for baobab leaves collection. The manual collection of baobab leaves is applied on baobab tree with small diameter (less than 1 m). This technique is also applied in general in the food bank of baobab.

The two techniques (used of machete and stick) were listed by the farmers to have a negative impact on the sustainability of baobab tree in the study area. In Bougoukourala, 67% of the respondents asserted that the techniques of cutting with machete have negative impact on baobab tree. In the same vein, village 33% of the respondents also confirmed a negative impact of the used of stick. For both techniques, the respondents argued that the cutter as well as the stick can cause injuries on the tree, of which parasites take advantage to infest the tree of baobab. In N'Gakoro, 82% have noticed that the techniques of cutting with machete and stick have a negative impact on the baobab tree, contrary to 18% use cutting with machete and stick to

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

harvest baobab leaves. In Nabougou, 69% of the respondents confirmed a negative impact of the technique of cutting with machete, compared to 31% of the respondents for the use of stick. In Sorobougou, most of the respondents (56%) found that the use of stick has negative impact on baobab tree than the technique of cutting with machete (asserted by 44% of the respondents). The respondents in all the study area found the manual technique of baobab leave harvesting to have no negative impact on the tree of baobab. According to the respondents, both techniques can lead to the death of the baobab tree or expose the baobab tree to the parasites and consequently affect the sustainability of the baobab species conservation.

Table 5: Different Techniques of harvesting baobab leaves exploitation in the commune of Cinzana

Sites	Manual collection (%)	Cutting leaves with machete (%)	Stick (knife attached to the end of a long bamboo) (%)
Bougoukourala	-	5	95
N'Gakoro	-	21	79
Nabougou	3	37	60
Sorobougou	8	21	43

4.8. Socio-demographic factor influencing the baobab leaves exploitation techniques

The results of the current study revealed that the socio-demographic factor like age, educational level, and gender are key factors influencing the baobab leaves harvesting techniques in the study area. The results show that the marital status does not have any influence on the baobab leaves harvesting in the study area (Table 6).

Table 6: Socio-demographic characteristics influencing baobab leaves exploitation in the commune of Cinzana

	Leaves harvesting techniques		Sig
Commune of Cinzana	Age	0,26**	0,004
	Educational level	1,19*	0,040
	Marital status	0,01	0,910
	Gender	1,96*	0,033

Discussion

NTFPs play an important role in households especially during the shortage period. In the study area, their contribution to household incomes generation ranged between 4 and 7%. The current findings are closed to those reported by INSTAT (2013), which recorded 8.5% of contribution of NTFPs to households' incomes in Mali. Baobab leaves contribute to daily diets of the local population in the study area. Indeed, the leaves contribute to food and nutritional security, medicine, and fodder. They play an important role and

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improve the well-being of poor communities. The current study revealed that the total annual income derived from the powdered baobab leaves by respondent ranged between 33714±17 622 FCFA (56.00±29.27 USD) to 52 857±18 680 FCFA (87.80±31.03 USD) in the study sites. According to Buchmann *et al*. (2010), one ton of powdered baobab leaves was commercialized and generated up to 15 million FCFA for 139 rural population in Benin. Similarly, Nellie (2018), reported the annual net profits of baobab leaves to be about USD 595 per person in Malawi. Both amounts recorded by these two different authors are bigger than that reported in the current study and may be explained by the availability of the baobab population. This is the evidence that the baobab tree contributes to improve the livelihoods of the populations in the geographical location including the current study area. On the contrary, Buchmann *et al*. (2010) argued that the commercialization of NTFP could not achieve both livelihood improvement as well as ecosystem and species conservation (Nemarundwe *et al*., 2008). The present study revealed that the baobab leaves contribute up to 5.4 % in family income. This is a substantial contribution of baobab leaves in the commune of Cinzana. However, Birhane *et al*. (2020), reported a lower contribution rate (2.5%) of the powdered baobab leaves in Ethiopia, compared to the current findings. This difference with the present results may be explained by the reduced size of baobab tree population in the study area due to agriculture. In addition, it may be explained by the motivation of the value chain actors involved in that activity in each site because of the over commercialization of baobab leaves by local communities. Similarly, Decaluwé (2011) reported that the cash income obtained from baobab and tamarind products is about 4 % for the poorest and 5 % for the richest households in Mali, whereas, in Benin, a contribution of up to 11 % was reported for the poorest group of smallholders. The previous results reported by Decaluwé (2011) in Mali are closed to the current findings while the one mentioned for Benin is higher than the present results.

The results recorded three harvesting techniques, manual collection, cutting leaves with machete, knife attached to the end of long bamboo. The population use knife attached to the end of long bamboo and cutting with machete because they are not able to climb up the tree. However, few people use manual collection because only some people domesticate baobab tree the last two techniques have an important negative impact on baobab tree conservation. In addition, these techniques negatively impact the survival of the tree as they expose the tree to diseases. Only the first technique mentioned is better because it has no negative impact on the species conservation. Dhillion *et al*. (2004), show that the population of Cinzana harvest baobab leaves with a sickle mounted on a long stick, and this enables the women to harvest leaves without having to climb the trees. Buchmann *et al*. (2010)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

reported similar techniques (hand tools such as knives or bamboo canes) for baobab leaves harvesting in Benin. The same authors argued that such harvest technique reduces the number of flower buds, and consequently threatens the conservation of baobab tree species. The current study aligned with the findings reported by Munyebvu *et al*. (2018) in Namibia who stated that human activities play a significant role in affecting the population structure of baobab stands. It also corroborated results reported by Korbo *et al*. (2013) in Mali, who mentioned that the traditional methods for collection and use of leaves have some drawbacks on the species conservation.

The present study reveals that the socio-demographic factors like age, educational level, and gender are key factors influencing the baobab leaves harvesting techniques in the study area. In contrast, the results show that the marital status does not have any influence on the baobab leaves harvesting in the study area. The best technique for collecting baobab leaves is the manual collection. In addition, there is the domestication of baobab trees for food bank and trading to generate income for local population. Thus, these techniques and strategies allow local population to collect baobab leaves manually and contribute to better conservation of the baobab tree.

Conclusion

The main objective of this study was to analyze farmers' perceptions of the impacts of *Adansonia digitata* L. leaves exploitation on its conservation and on livelihoods of local communities in the commune of Cinzana in Mali. The results showed that the non-timber forest products (NTFPs) are the second pillar after agriculture to support the livelihood of the rural population in the study sites. Its contribution reaches up to 7% of the livelihoods of the rural population. In the study aera, farmers confirmed that NTFPs, like baobab leaves, highly contribute to improve their livelihood due to the benefits they derived from the species. The price of one 1 kg of powdered baobab leaves ranged between 175 FCFA (0, 29 USD) to 250 FCFA (0,41USD) and it contributes up to 5.4 % in family income. The results of our study show that the respondents have three techniques of harvesting baobab leaves. Two harvesting techniques (used of machete and stick) have negative impact on the survival of the baobab tree. Therefore, in general, sustainable harvesting practices need to be developed and proposed to promote the species' conservation in the commune of Cinzana. Three socio-demographic characteristics (age, educational level, and gender) of the respondent's influence farmers' perceptions of baobab leaves harvesting techniques in the commune of Cinzana. The major limitation of the current study was the missing of the neighboring communes in the investigation. However, this study should be extended to regional level in the future to harmonize regional

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

impact of baobab leaves exploitation that will guide conservation of the mentioned species.

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