Farmers' perception of the conservation of *Afzelia africana* around the Benoue National Park and adaptation to the drought in controlled condition of *Afzelia africana* plants.

Abstract: *Afzelia africana* is one of the most popular woody forage resources used by pastoralists in northern Cameroon in the dry season. Its overexploitation makes it a threatened resource in its distribution areas. In order to contribute to the sustainable management of this species in the Benoue National Park (BNP) and its surroundings, a study was conducted on the perception and conservation of this species, the knowledge of fodder ligneous by the riparian population of the BNP and adaptation to the drought of its seedlings. A survey was carried out in four surrounding villages of the BNP with 100 people per villages (Banda, Gamba, Sackdje and Guidjiba) making a total of 400 respondents. A hundred seedlings were monitored during two dry seasons and the mortality rate was calculated at the end of each dry season. This study determined the impact of drought on the survival of this species. The percentages of male respondents according to age group were 30%, 23%, 15%, 6% and 5% respectively for respondents whose age range was between 20-30 years, 10 and 20 years, 30-40 years, 40 to 50 years and over 50 years. For the female sex these percentages are 10%, 5%, 5% and 1% for the respective age groups of 10- 20 years, 20-30 years, 30-40 years and 40 to 50 years. On knowledge of *A. africana*, men have better knowledge with 80%; 74%; 70% and 64% respectively for Banda, Guidjiba, Gamba and Sackdje. On its conservation, 44% of the sample responded favorably. Sixteen forage trees belonging to 10 families were reported by the respondents, the Caesalpiniaceae family and the Mimosaceae family, were the most represented (nearly 18.75%). The average drought mortality rate was 20% after two droughts. Such a study is a fundamental prerequisite for the development of restoration and sustainable management strategies for *Afzelia africana* in the Bénoué National Park (North Cameroon).

Key words: *Afzelia africana*, woody forage, Bénoué National Park, drought.

1. **Introduction :** African savannahs are experiencing rapid processes of rural landscape transformation and degradation of natural resources (Ariori and Ozer 2005, Larwamou *et al.*, 2005, Mama *et al*., 2013) in relation to human activities such as livestock farming, agriculture, logging and climate degradation etc. (Grouzi *et al.*, 1991, Goudie 2000, Robinson 2000, Hien *et al*., 2002, Tsague 2004, Gregoire and Simonetti 2010, Inoussa *et al.*, 2011, Alessandra 2011, Amougou *et al.*, 2017). In North-Cameroon, livestock is a major socio-economic activity and people depend on it for food and cash income (Moise *et al.*, 2003, Zoundi and Hitimana, 2008). This activity is confronted with drought that lasts about six months in the Sudano-Sahelian zone and fodder trees are a natural alternative for feeding cattle during this period. *Afzelia africana* is the most used aerial forage in the North Onana Region (2002). This species has not protected natural environments is at the origin of the multiple intrusions of transhumant shepherds in the Benue National Park. IUCN (2000) has listed this species on the red list as a vulnerable species because of the different pressures it faces in its natural habitats. But in some countries such as Mali, Benin, Burkina Faso and Cameroon, it is about to be threatened (Gérard *et al.*, 2011). The present study aims to provide answers on the peasant perception of the conservation of this species, the state of knowledge of fodder ligneous by the riparian population of the Benoue National Park and the adaptation to the drought in controlled condition of the plants of *A. africana*.

Comment [LI2]: Preferably the introduction should be added with the reasons for the research

2. **Materials and Methods**

- **Location of the study site**: The operational technical unit of Benoue (UTO) includes the Benoue National Park and its peripheral AHI (area of hunting interest) cover an area of 800 000 ha (180 000 for the park and 620 000 for the AHI). It straddles the regions of the North (80%) and Adamaoua (20%) in Cameroon. The vegetation is of the Sudano-Sahelian type and there is an important hydraulic network centered on Benue River. The richness of this area includes: 15 types of vegetation with 692 species of plants, more than 30 diurnal mammals, about 306 species of birds and 77 species of fish. The UTO is crossed by two very important roads namely the National N ° 1 linking it to Garoua and Ngaoundéré and the Guidjiba-Tcholliré road (Figure 1). These axes are factors favoring the increase of the human pressure in general and the poaching, and especially its annexation National Park of Benoue and its periphery by the national transhumant shepherds in search of the forage resource. With this ease of access provided by these highways, around 60,000 people live in the 100 or so villages in the outskirts and their lives depend entirely on international natural resources in search of the fodder resource. With the ease of access provided by these highways, around 60,000 people live in the 100 or so villages on the outskirts and their lives depend entirely on natural resources.

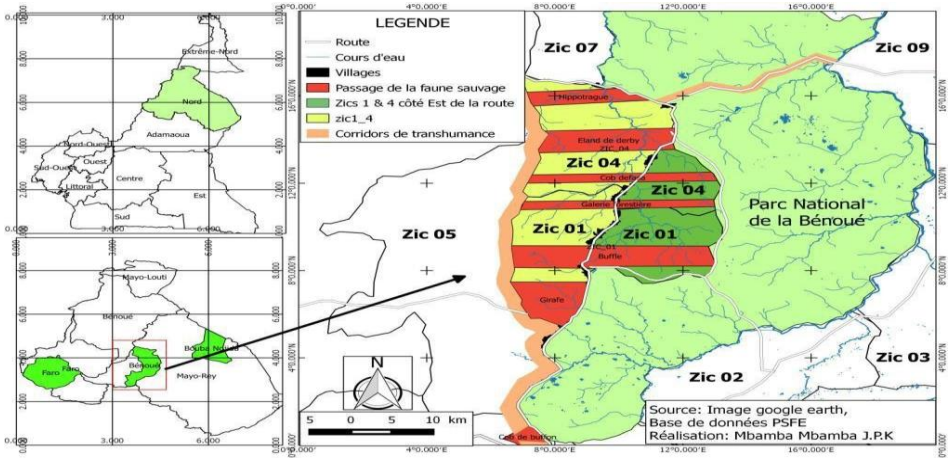

Figure 1: Location map of the study area

- Investigations

In each village, the scientific approach used was participatory. The work took place in two phases: a pre-inquiry phase and an investigation phase. The study was conducted based on a questionnaire completed by discussions and exchanges between informant group or individual and investigator (appendix). These investigations consisted of a series of interrogations with the resource persons and observations made on the ground during the patrols in the PNB.

The pre-survey phase consisted of interviews of farmers in groups or individually ranging from four to twenty. The preliminary test made it possible to make contacts with the natives and to identify the constraints relating to the administration of the questionnaire (length of the interview, difficulty of translation, attitude towards the farmer, order of the questions) and allowed to restructure the final questionnaire and to identify the different study sites or villages. At the end of the preliminary investigations, the method of individual semi-structured interviews was chosen. Indeed, the social structures among Africans do not allow young people in the group to make corrections or opinions contrary to those of the elderly. In addition, this method has the advantage of generating new questions. The questionnaires included identification variables of the respondents (name, first names, age, sex, level of education, village of origin). This has the effect of creating a climate of trust between the respondent and the interviewers.

Questions relating to the different uses of *A. africana* (culture, food, traditional pharmacopoeia) were asked. This section made it possible to evaluate the interest of the farmers in this case; knowledge of plant material (preferred environments, silviculture, propagation and management) to ensure its sustainability and enhancement. Do not allow young people in the group to make corrections or opinions contrary to those of the elderly. In addition, this method has the advantage of generating new questions. The questionnaires included identification variables of the respondents (name, first names, age, sex, level of education, village of origin). This has the effect of creating a climate of trust between the respondent and the interviewers.

This made it possible to identify the farmers' proposals for safeguarding the species. It follows that, all these headings help to justify the socio-economic importance of *A. africana* which could lead to the need to domesticate this species. The last part of the questionnaire concerned the activities practiced inside and on the periphery of the PNB and the perception

that the populations have towards the park, of their participation in the management of this protected area as well as the difficulties encountered by forest officers in the accomplishment of their mission.

In total, 4 villages were explored Banda (100), Gamba (100), Sackdje (100) and Guidjiba (100) which gives a total of 400 people surveyed.

The seeds were harvested in the GNP. Several methods have been useful for seed collection. One method was to harvest the seeds falling under the tree while the other was to harvest the fruit directly from the tree and then to extract the seeds by crushing the fruit. The second method allowed us to overcome the aforementioned problems; however we had to be reassured to take only some fruit in order to have a negative impact on the natural reproduction process. It was therefore advisable to pick a number that is proportional to the production of the tree this number varied from 50 to 100 fruits / tree. After germination in a sprouter, the plants were placed in four plots at the rate of 25 plants per plot. These plants were followed without any treatment during three dry seasons from 2015 to 2018. At the beginning of the rainy season and at the beginning of the dry season, observations were made on the number of plants that started again.

- **Data processing and analysis**

Data was compiled using Microsoft excel 2019 and imported into the program SPSS version for analysis.

3. Results

Percentage of respondents by gender

The survey revealed that in Gamba village, the percentages of male respondents by age group are 30%, 23%, 15%, 6% and 5% respectively for respondents whose age is between 20-30 years, 10 and 20 years, 30-40 years, 40 to 50 years and over 50 years. For females, these percentages are 10%, 5%, 5% and 1% for the age groups 20-30, 10 and 20, 30-40 and 40-50 respectively (Figure 2).

In the Banda village these percentages are 31%, 25%, 22%, 6% and 3% respectively for the age groups 20-30, 30-40, 40-50 and 50+. For females, these percentages are 5%, 4%, 3% and 1% for the age groups of 20-30, 30-40, 10 and 20 and 40-50 respectively. In the Sackdje village, these percentages are 31%, 25%, 22%, 6% and 3% respectively for the 30-40 years age groups 10-20, 20-30 years, 40 to 50 and 50 years and more. For the female sex these percentages are 5%, 5%, 3%, 1 and 1% for the respective age groups of 20-30 years, 10 and 20 years, 30-40 years, 40 to 50 years and 50 and more.

In Guidjiba village, these percentages are 28%, 25%, 20%, 7% and 1% respectively for the 20-30, 30-40, 40-50 and 50 and over age groups. For the female sex these percentages are 5%, 5%, 3% and 1% for the respective age groups of 20-30 years, 10 and 20 years, 30-40 years, and 40 to 50 years.

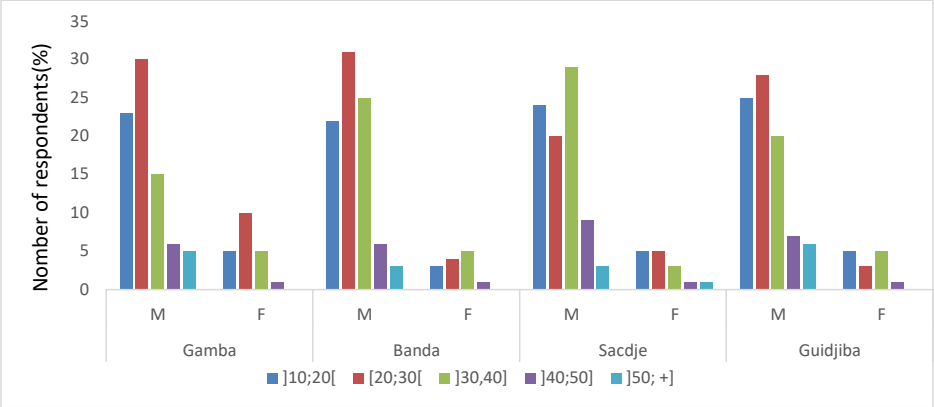

Figure 2: Percentage of respondents by age group

• Percentage of respondents by ethnicity

The respondents are grouped into eight ethnic groups distributed in the different villages (Table 2). The Mboum are mainly represented in all villages with Guidjiba (40), Gamba and Sackdje (35) and Banda (30), followed by Baya and Massah (11.75), the Toupouri are the third ethnic group represented in the villages Banda (13), Sackdje (12), Gamba (11). The least represented groups are Laka, Matakam and Bainawa, with proportions of 9; 6 and 3.75.

Table 1: Percentage of respondents by ethnicity

	Gamba	Banda	Sackdje	Guidjiba	Mean / standard deviation
Baya	9	13	10	15	11.75 ± 2.75^{c}
Mboum	35	30	35	40	35 ± 4.08^{d}
Massah	12	10	15	10	11.75 ± 2.36^{c}
Matakam	7	9	5	3	6 ± 2.58^{ab}
Peuls	13	11	9	15	12 ± 2.58^{c}
Toupouri	11	13	12	7	10.75 ± 2.63^{c}
Bainawa	2	2	5	6	3.75 ± 2.06^{a}
Laka	11	12	9	4	9 ± 3.56^{bc}

Figures carrying the same letters are not significantly different at the 5% significant level

- **Knowledge of *Afzelia africana* by gender**

The percentage of respondents on knowledge of *A. africana* by age and gender (Figure 3) shows that in all villages men (M) have a better knowledge of *A. africana*. Thus these percentages are 80%; 74%; 70% and 64% respectively for Banda, Guidjiba, Gamba and Sackdje. For the female (F) sex these percentages are: 36%; 30%; 20% and 20% respectively for Sackdje, Gamba, Guidjiba and Banda villages.

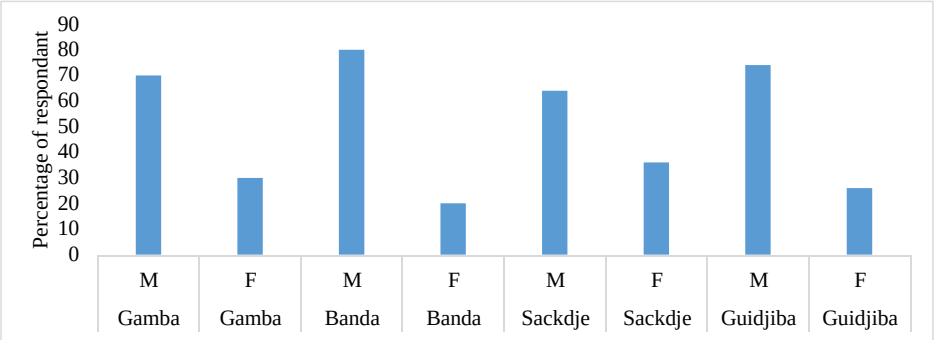

Figure 3: Knowledge of *Afzelia africana* by village by gender

• **Attitude of the residents of the National Park of Benoue on the conservation of *Afzelia africana***

In the NPB and its periphery, *A. africana* is exploited in the wild and as far as its conservation is concerned opinions are mixed in the different villages surveyed. About 44% of the total sample believes that this plant deserves to be preserved in their fields on the sole condition that it finds an interest other than fodder (Table 2). However, the latter raised several problems; in particular those related to the availability of seeds, vegetative regeneration and mastery of the species' propagation techniques. It should be noted that this species has almost disappeared in the periphery of PBN and in areas not belonging to conservation. However 56% of the respondents think the opposite. For them, conserving this species in their areas is a potential source of conflict between them and the breeders who sometimes introduce their animals in the fields where some individuals of *A. africana* are preserved and destroying the crops in passing. For these, given the abundant resources in some parts of the park, they do not see the value of protecting a resource they consider inexhaustible. Throughout the study area only one individual and two ZICs initiated by conservation services through the PNB conservator have undertaken to conserve *A. africana* especially in the villages of Banda and Guidjiba. A nursery has been set up in each of its villages and at the " Buffle Noir" camp, which has produced nearly 2,000 plants.

Table 2: Percentage of people who want to keep *A. africana*

Village	Total population	Percentage of people who want to keep *A. Africana (%)*
Gamba	100	9
Banda	100	12
Sackdje	100	10
Guidjiba	100	13
Total	**400**	**44**

- **Causes of mismanagement of *Afzelia africana***

The causes of the mismanagement of *A. africana* cited by the population bordering the BNP proved to be important. Indeed, during the works, the participation in several sensitization missions of the population, allowed to identify several causes (Table 3).

In Gamba villages 22% of people said they did not master the breeding technique, 20% for Banda village, 16% for Sackdje village.

For seed scarcity: Sackdje has the highest percentage of respondents 45%, followed by Guidjiba village 36%, Banda village and finally Gamba village. For the very long vegetative cycle Gamba with 26% presents the highest percentage, it is followed by: Guidjiba (14%), Sackdje (12%) and Banda (10%).

Concern over the seed harvest period, Guidjiba village had the highest percentage (36%), followed by Banda villages (25%), Sackdje (20%) and Gamba.

For non-control of dormancy Sackdje (45%) had the highest percentage of concern, followed by Guidjiba (32%), Banda (30%) and Gamba (12%).

Analysis of the variance shows that there is no significant difference between the villages (r^2 = 110, F = 1.39, P = 0.2815) and between the activities (r^2 = 100.617, F = 1. 81, P = 0.2815) at the 5% threshold.

Table 3: Causes of mismanagement of *Afzelia africana*

	Gamba	Banda	Sackdje	Guidjiba	Mens
No control of regeneration techniques	13	20	16	22	17.75±4,03[a]
Rarity of the reproductive material	15	25	45	36	30.25±13[a]
Very long vegetative cycle	26	10	12	14	15.5±7.19[a]
Period of harvest of the seeds	15	25	20	36	24±8.98[a]
Dormancy survey problem	12	30	45	32	29.75±13.6[a]
Means	16.2±5,63[a]	22±7.58[a]	27.6±16.13[a]	28±9.69[a]	

Figures carrying the same letters are not significantly different at the 5% significant level

• **State of knowledge of fodder ligneous by the riparian population**

The respondents declared that they knew 16 fodder trees (Table 4) belonging to 10 families. The Caesalpiniaceae and Mimosaceae families, all legumes, are the most represented (almost 18.75% of the woody species each). *Afzelia africana* (100%), *Piliogstigma thonnengii* (93.75%) *Ficus thonnengii* and *Manguifera indica* (90.25%), are the best-known species. 50% belong (except *Ficus thonnengii* and *Manguifera indica*) to the large family of Fabaceae (or legumes). *Ficus sycomorus* (83.75%), *Faidherbia albida* (82.5%) and *Cassia sp*. (54%) are the next group and belong respectively to the family Moraceae and Mimosaceae. *Stereopersmum kunthianum* (9.75), *Terminalia macroptera* (13.5), *Lonchocarpus laxiflora* (16), *Vitex doniana* (16.5), *Cassia siberiana* (18.5) are the least represented species.

Variance analysis shows that there is a significant difference between species at the 5% threshold (0.00-0.05).

Table 4: State of knowledge of fodder ligneous by the riparian population

Species	Family	Gamba	Banda	Sackdje	Guidjiba	Means
Acacia sp	Mimosaceae	45	65	54	52	54±8,29[a]
Afzelia fricana	Caesalpiniaceae	100	100	100	100	100±0[i]
Anacardium occidentalis	Anacardiaceae	31	30	23	38	30.5±6.13[d]
Anogeissus leocarpus	Annonaceae	23	22	18	20	20.75±2.22[c]
Cassia siberiana	Caesalpiniaceae	20	16	15	23	18.5±3.69[bc]
Faidherbia albida	Mimosaceae	87	80	84	79	82.5±3.67[g]
Ficus thonnengii	Moraceae	97	96	90	92	93.75±3.3[h]
Ficus sycomorus	Moraceae	85	78	85	87	83.75±3.95[g]
Khaya senegalensis	Meliaceae	45	38	43	37	40.75±3.86[e]
Lochocarpus laxiflora	Loganiaceae	12	20	15	17	16±3.37[bc]
Manguifera indica	Anacardiaceae	95	86	88	92	90.25±4.03[h]

Piliogstigma thonnengii	Caesalpiniaceae	92	94	86	89	90.25±3.5[h]
Prosopis africana	Mimosaceae	32	35	28	32	31.75±2.87[d]
Pterocarpus sp.	Fabaceae	32	33	40	35	35±3.56[de]
Stereopersmum kunthianum	Sterculiceae	13	9	7	10	9.75±2.5[a]
Terminalia macroptera	Combretaceae	13	12	9	20	13.5±4.65[ab]
Vitex doniana	Verbenaceae	12	20	16	18	16.5±3.42[bc]
Total	16	49,06	49,06	47,12	49,47	

The numbers assigned the same letters are not significantly different.

• Adaptation of *Afzelia africana* to drought under controlled conditions

Table 5 shows the mortality rate of *A. africana* seedlings subjected to three dry seasons. It appears from this that the averages these rates vary from 28% to 12%.

Table 5: Adaptation of *Afzelia africana* to drought

	NPVI	NPV1	NPV2	NPM1	NPM2	TM1 (%)
lot1	25	21	19	4	2	16
lot2	25	18	15	7	3	28
lot3	25	19	16	6	3	24
lot4	25	22	20	3	2	12
Mean±SD	25±1.6	20±2	17.5±1.6	5±0.5	2.5±6.3	20±3.5

- **Discussion**

These results show that individuals over the age of 50 and women are less represented in all villages. This is explained by the fact that during our surveys it was not easy to find young people under the age of twenty available, the survey having taken place during the class period, the cultural habits of these societies did not do not give too much importance to young people who cannot express themselves in the presence of the elders. The majority representation of the Dii is explained by the fact that they are the indigenous ethnicity of these villages.

These results agree with those of MINEF (2004) and Aoudou (2006) which show that the Dii are the first occupants of this locality. The other ethnicities settled later for several reasons.

Despite the fact that the majority remain insensitive to the preservation of this species, many recognize that this species is disappearing and that this would lead to an imbalance in farming which is almost dependent on it in the dry season. The worst to fear is that, the latter would substitute this species by another and thus we will witness a continuous elimination of the species. This allegation is confirmed by the pruning of *Acacia siberiana* in the eastern part of the GNP as observed during our patrols.

Despite the important contribution that this species makes to people's livelihoods and to the national economy (livestock), governments are not yet paying sufficient attention to it. Similar results were obtained by Hamawa (2015) in the case of *Vepris heterophylla*. Indeed the period of fall of the seeds is in full dry season, period when the forage resource is rare thus it causes the pressure on the seeds in particular on the part of the animals. According to our own observations, baboons, Buffon's cats and in general, antelopes consume the seeds of *Afzelia africana*, to which must be added the birds (Arbonier, 2002).

The lack of reliable data or statistics on *A. africana* makes it difficult to develop viable strategies for their expansion in the logic of international trade (Awono *et al.*, 2002). The lack of information also remains a serious handicap for local populations who ignore the commercial interests of the exploitation of this resource.

In fact, the participatory approach that was used proved to be important because it involved the various actors involved in the degradation of plant species of socio-economic interest in the Bénoué biosphere reserve (Guédjé, 2002; Hamawa, 2015). This method made it possible to understand the interest which the population carries for this plant what allowed us to be able to determine strategies so that this plant is: ecologically viable, economically profitable, socially appropriate.

These remarks were obtained following three consultations with breeders, two of which were organized by the PNB curator and one under the initiative of the three ministries (MINFOF, MINEV, MINEPIA) and the American embassy. The breeders although aware of the rarity of the species have expressed the desire to participate in the conservation of *A. africana* the only problem remains the mobility of the latter because the breeders move according to the climatic grimaces and the rarity of the grazable land. The northern region has made pastoralists the most neglected in the return of land for the benefit of the environment 40% and agriculture (Labonne *et al.*, 2003). These same problems have been raised by farmers who know that *A. africana* is a soil fertilizer but however, the presence of the latter in agricultural plots is a potential source of conflicts with breeders who, to feed their animals are take all the risks. They also raised the problem of the unavailability of the reproductive resource.

The opposite results were obtained by Tostain, 1980 (100 species) and Ngom, 2001 (70 species) and or in the Sudanian zone or 48 species found by Sewadé *et al.* (2015). However, Ndiaye in 2008 found (23 species) results similar to this study. The result obtained by this study can be explained by the forgetting of certain species by respondents. The high proportion of legumes can be explained by the fact that the vegetation in this area is dominated by this family (Arbonnier, 2002). However, twelve (12) of these woody species are found among those inventoried by Yanra (2004) in three villages in the province of Kénédougou. These results support the idea that natural vegetation is used a great deal to feed livestock during the dry season (Onana *et al.*, 2002; Sarr et al., 2013 and Séwade *et al.*, 2016). This suggests that the water stress caused by the dry season would have little impact on the survival of seedlings under natural conditions. The plant would therefore have its own mechanisms to adapt to the drought which could certainly be found in its root system. This allows us to conclude that, among the multiple causes of disappearance of this species drought is a minor cause. Similar results were obtained by Ahouangonou and Bris (1995) studying its germination showed that this species had a significant root development. Onana *et al.* (2002) showed that from the start of the growth of this species, strong root growth was observed compared to stem growth.

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4. Conclusions and Recommendations

This study focused on the peasant perception of the conservation of *A. africana*, state of knowledge of woody fodder by the population living near the Benoué National Park and Adaptation to the drought in controlled condition of *A. africana* plants. It emerges from this study that: the percentages of male respondents by age group were 30%, 23%, 15%, 6% and 5% respectively for respondents whose age range was between 20 -30 years, 10 and 20 years, 30-40 years, 40 to 50 years and over 50 years. For the female sex these percentages are 10%, 5%, 5% and 1% for the respective age groups of 20-30 years, 10 and 20 years, 30-40 years

and 40 to 50 years. On the knowledge of *A. africana*, men have the best percentages with 80%; 74%; 70% and 64% respectively for Banda, Guidjiba, Gamba and Sackdje. On its conservation, 44% of respondents were favorable. Sixteen fodder trees belonging to 10 families were reported by the respondents, the Caesalpiniaceae and Mimosaceae families were the most represented. The average drought mortality rate was found to be quite low.. Such a study constitutes a fundamental prerequisite for the development of restoration and sustainable management strategies for *A. africana* in the Bénoué National Park in North Cameroon.

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