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Potentialities and local conservation strategy of *Ceiba pentandra* (L.) Gaertn in the Banwa province in Burkina Faso

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Abstract
Faced with the risk of disappearance of certain plant species linked to the combined actions of man and the climate, it is recognized that the preservation of tropical biodiversity constitutes a major challenge. According to the International Union for Conservation of Nature, currently some species from tropical Africa such as the species Ceiba pentandra (L.) Gaertn could be threatened with extinction. In this context, the present research carried out in the West of Burkina Faso aims to analyze the modalities of a sustainable management of Ceiba pentandra (L.) Gaertn through an improvement of knowledge on the species. The work of collecting both qualitative and quantitative data highlights, on the one hand, the spatial analysis of the population and the dendrometric characteristics of the species. This research on the other hand, highlights the state of regeneration of ceiba pentandra (l.) gaertn and local management strategies which don't guarantee the sustainability of this resource.

Keywords: Ceiba pentandra, regeneration, management strategies, Burkina Faso

Introduction

"We live among plants; look around yourself or around the cities: the landscape is made of plants, they populate our dishes, make and retain our soils, adorn our lives and our walks... But in this cohabitation, we are often difficult neighbours" (French Agency for Biodiversity, 2019, p.3). In fact, according to the latest update of the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN), 17,291 out of 47,677 listed species are threatened with extinction (IUCN, 2009) [14].

The African continent is home to a wealth of natural species, ranging from individual species to endemic habitats (IUCN, 1994) [13]. However, the Research Institute for Development (IRD, 2019) emphasizes that in front of the anthropic and climatic threats on nature, the preservation of tropical biodiversity constitutes a major challenge; as 31.7% of vascular plant species in tropical Africa could be threatened with extinction.

In this context, there is growing interest in the protection of natural species in general and certain particular plant species such as *Ceiba pentandra (L.) Gaertn*, which is found almost everywhere in West Africa (IUCN, 1994, *op.cit*) [13].

Ceiba pentandra (L.) Gaertn also called Kapok is a majestic-looking tree (S. Guinko, 2009) [29]. It has a pantropical geographical distribution, in Burkina Faso, Senegal, Cameroon, Central America, Antilles, India, etc. (M. Eyog, and, *al*.,2006) [21]. It is a fast-growing pioneer species that can grow in all areas, including those with poor soil fertility (C. Abengmeneng, and *al*., 2016) [6].

The species is of great importance to humans. It is used for food, timber and service, pharmacopoeia, crafts, and is often planted in alignment in towns and villages (M. Eyog, and *al*.,2006, *op.cit*; M. Rivers & J. Mark, 2017) [21, 22].

However, according to M. Rivers & J. Mark (2017, *op.cit*) [22], *Ceiba pentandra (L.) Gaertn* was assessed for the IUCN red list of threatened species in 2017, though listed as minor concern. Measures must be considered to ensure the conservation of the species. But beforehand it is necessary to know the existing potential. Indeed, as argued by M. Kouyate (2005) [19], knowing the traits of the species can indicate whether the disturbance uniformly affects the species of the community or only a certain functional type. In the case of the conservation of threatened and low-numbered species, the priority is to describe the characteristics of these species as exhaustively as possible. This information can more effectively guide conservation efforts (A. Danet, 2017) [1]. This is why this research was carried out in western Burkina Faso in order to study the methods of sustainable management of *Ceiba pentandra (L.) Gaertn* through improved knowledge of the species.

Research Methodology

The area of this investigation is the province of the Banwa. It is one of the 6 provinces of the Boucle du Mouhoun region (Figure 1).

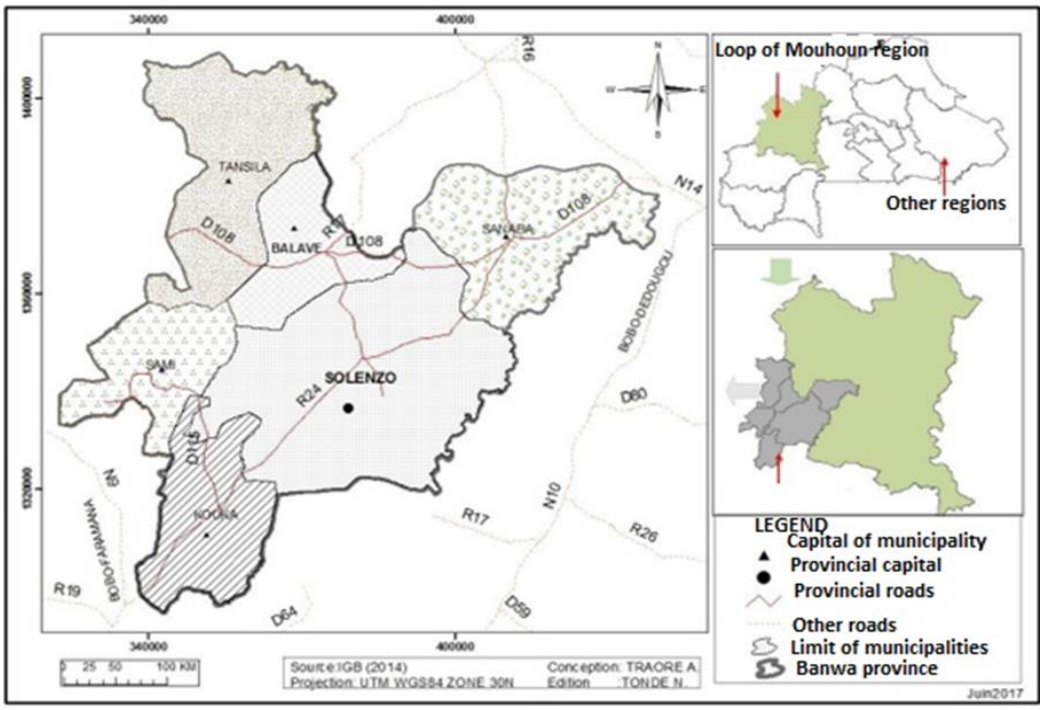
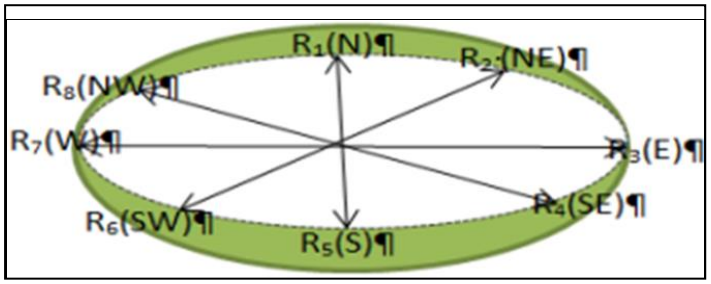


Fig 1: The Banwa province location map

Covering an area of 5,888 km2, the Banwa province is located in the northwest of Burkina Faso between the geographical coordinates 3°25' and 4°35' west longitude and 11°45' and 13°45' north latitude (National Soil Office, 2003) [24]. The Banwa province is made up of the communes of Solenzo, Sami, Sanaba, Balavé, Tansila and Kouka, and is entirely located in the southern Sudanese climatic sub-zone of Burkina Faso. There are 2 seasons there. The rainy season from May to October, with average monthly temperatures varying between 25°C and 28°C. The dry season from November to April marked by the harmattan. It is characterized on the one hand by a dry and cold wind with low temperatures (around 25°) from November to the end of January and on the other hand by a dry and hot wind with high average monthly temperatures often exceeding 40°C. from March to April. Precipitations, which vary from 700 to 1000 mm per year, is irregular and poorly distributed in space. Hydrographically, the province of the Banwa has a very dense hydrographic network, especially in its western side. The hydrographic network falls within the watersheds of the Mouhoun River and the Kossi River. It is a fairly uneven area. The relief is quite monotonous and altitudes rarely exceed 360m (R. Kissou and *al.*,2003) [27].
Regarding the sampling and data collection, a prospecting study was carried out in order to identify the localities which shelter the populations of the species studied. For the other stages, it consisted in listing the settling or isolated stands of the species in each concerned locality, delimiting the areas of influence of the settlement of the species, identifying resourceful people likely to help establish contacts with the inhabitants having knowledge on the species in the various concerned localities.
The inventory method used is the exhaustive enumeration or count of the trees of the species in the different localities of the province where it is represented. The main data collected relate to the identity of the respondent, the respondent's knowledge of the species and the local strategies developed for the sustainability of the species. For the forest management officials and the town halls of the municipalities concerned, the specific information collected focused on bad practices related to the exploitation of the species, the actions carried out for the management of this resource and the proposals to ensure its sustainable management. Thus, in the field, 3 types of data were collected:
The dendrometric variables: on each foot reaching the minimum pre-count circumference pre-fixed at 15 cm measured at 1.30 m above the ground (C1.30 m), the following variables were noted: The trunk circumference at 1.30 m above the ground, the total height of the individual, the height of the bole, the radii of the crown (figure 2);



Source: realized by the author

Fig 2: the locations of the 8 combs measured at the crown of each inventoried tree

Legend: N=North, NE=North East, E=*east*, SE=*South East*, *S=south*, SW=*South West* and =*West*

- Cartographic data: the geographical coordinates of each foot identified were recorded by GPS. This made it possible to generate the locations of the feet of the species on the base maps of the province of the Banwa and its municipalities;
- Data on regeneration: natural regeneration is considered to be the set of processes that ensure the restoration of plant populations as old individuals disappear (A. Thiombiano,2005) [4]. Plants whose diameter at 1.30 m is less than 5 cm are considered young plants and therefore taken into account in regeneration (B. Belem, 2009) [5]. As part of the study, it was a question of exhaustively counting the subjects of the regeneration.

Descriptive data of the physical environment were also collected, particularly the texture of the soil, which made it possible to determine the types of soil preferred by *Ceiba pentandra (L.) Gaertn* in the study area. The health status of each plant and the type of the existing land occupation were also recorded.
Regarding data analysis, data from the forest inventory were entered and processed with Excel. It allowed the synthesis of the data in tables, the calculations and finally the realization of the illustration graphs. The parameters that have been calculated from the collected and encoded data are:
The average height of individuals of the species by municipality. The formula used is:

$$\bar{h} = 1/n \sum_{i=1}^{n} hi \quad (1)$$

$\bar{h}$*=average height*
n=number of trees measured in the municipality;
hi=height per foot i of the measured species in the municipality.

The average diameter of the subjects of the species per municipality: The formula applied is:

$$\bar{d} = 1/n \sum_{i=1}^{n} di \quad (2)$$

$\bar{d}$*=average diameter of feet of the species per municipality*
n=number of feet measured of the species in the municipality;
di=diameter of the individual i of the species.

The basal area: it corresponds to the surface of the horizontal section of the stems measured at 1.30 m above the ground. The average basal area of the feet of the species per municipality was calculated using the following formula:

$$\bar{g} = 1/n \sum_{i=1}^{n} gi \quad (3)$$

$\bar{g}$*= average basal area of plants per municipality*
n=number of foot of the species in the municipality: $gi = \pi di^2/4$
with di=diameter of the individual i of the species identified in the considered municipality.

In the case of n rays (8 rays in the context of this study), the surface of the horizontal projection of the crown on the ground was determined from the formula for calculating the quadratic mean (J. Pardé & J. Bouchon, 1988; F. Cailliez, 1980) [16, 8]:

$$Sp = \pi \sum_{i=1}^{n} ri/n \quad (4)$$

Sp=Surface the horizontal projection of the crown on the ground;
n = the number of rays of the measured crown;

From the previous formula, the (average) diameter of the crown (doc) is deduced as follows (J. Rondeux, 1993) [17]:

$$doc = \sqrt{\frac{4}{\pi}Sp} = \sqrt[2]{\sum_{i=1}^{n} r_i^2 / n} \quad (5)$$

The average density of the feet of the species per municipality was calculated by the following formula:

$$Average\ density = \frac{Number\ of\ individuals\ of\ the\ species}{Total\ surface\ of\ the\ settlement} \quad (6)$$

The regeneration rate (RR): the state of regeneration is an index of the capacity of the forest ecosystem to reconstitute itself. The rate of regeneration of the species by municipality was calculated by the formula of H. Poupon (1980) [11]:

$$RR(\%) = \frac{Total\ number\ of\ young\ plants}{Total\ number\ of\ the\ settlement} \times 100 \quad (7)$$

The total stand size includes both young plants and adult plants.

The interpretation of the value of the different regeneration rates calculated from the study data was carried out according to P. Rothé (1964) [26]. For this author:

- If the regeneration rate is less than 100%, the species has regeneration difficulties;
- If the regeneration rate is between 100 and 1000%, the regeneration is good;
- If the regeneration rate is greater than 1000%, the regeneration is very good.

The methodological approach presented in this part made it possible to obtain results.

Research Results

The results of the study deal on the one hand with the spatial analysis of the population and dendrometric characteristics and, on the other hand, with the state of regeneration of *Ceiba pentandra (l.) Gaertn* and local conservation strategies.

Spatial analysis of the stand and dendrometric characteristics

Regarding the spatial analysis of the settlement, a total of 688 feet distributed in the 6 communes of the Banwa province were counted (Figure 3).

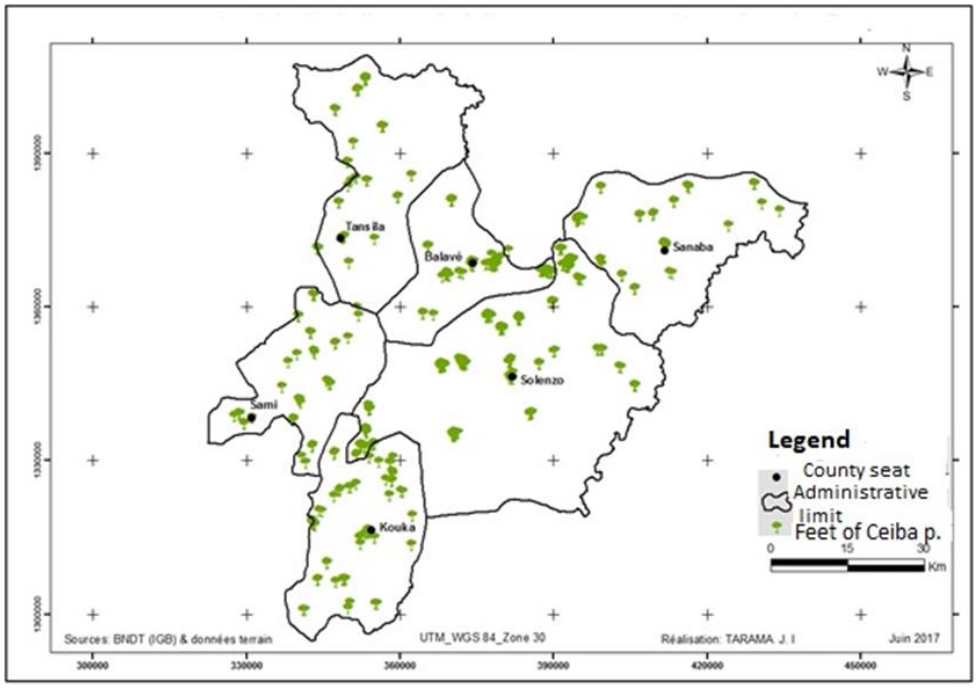
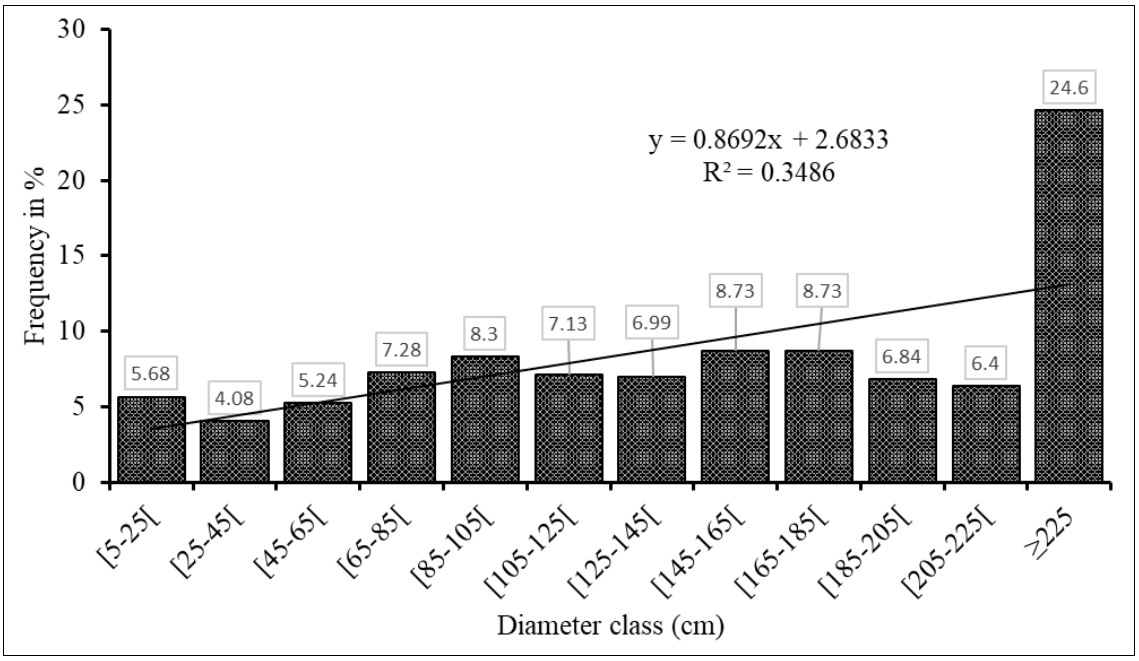


Fig 3: Spatial distribution of individuals of *Ceiba pentandra (L.) Gaertn* in Banwa province

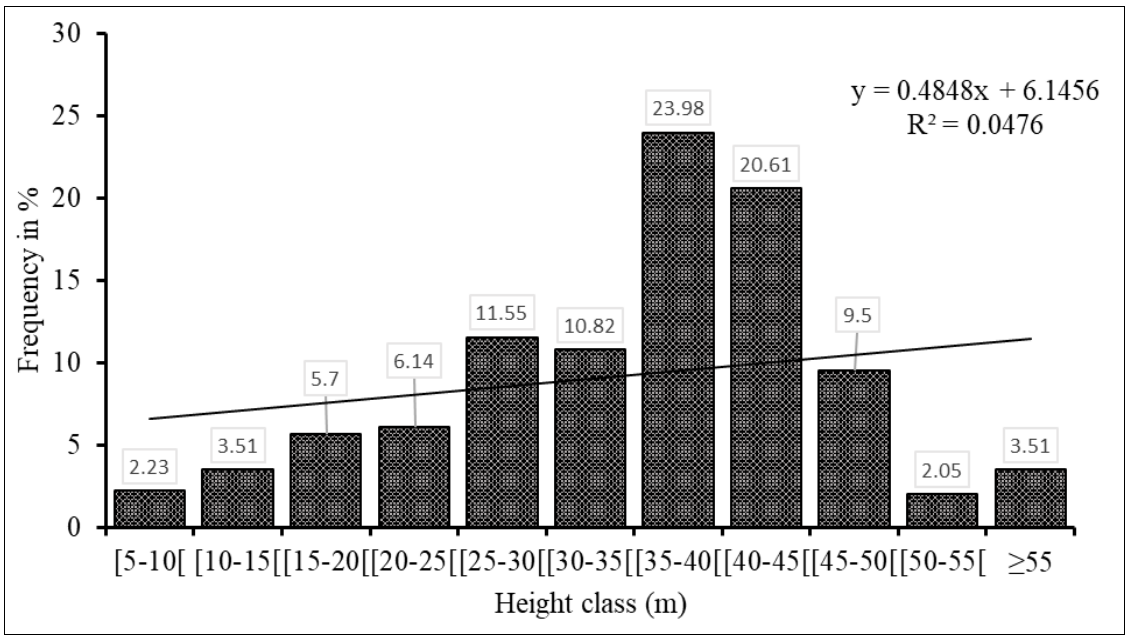
The municipalities with the highest number of *Ceiba pentandra (L.) Gaertn* plants are Solenzo (325 plants) and Balavé (103 plants). Concerning the settlement of the species, they are more represented in the municipalities of Solenzo and Sanaba with respectively 26 and 7 settlements of the species. Thus, *Ceiba pentandra (L.) Gaertn* is sufficiently well distributed in the province. This cast is random.
Concerning the dendrometric characteristics, the curve of distribution of the number of feet of the species according to the classes of the retained diameter, presents the pace (figure 3).



Source: *field works*

Fig 4: Horizontal population structure of *Ceiba pentandra (L.) Gaertn* in Banwa province

As shown in Figure 4, the population of *Ceiba pentandra (L.) Gaertn* includes a third of tall subjects that can exceed 200 cm. There is also a concentration of staff between the classes [65-85[and [185-205[. The class [25-45[is the class with the least number of employees. Figure 5shows the vertical population structure of *Ceiba pentandra (L.) Gaertn* in Banwa province.



Source: *field works*

Fig 5: Vertical population structure of *Ceiba pentandra (L.) Gaertn* in the Banwa province

The adjustment curve of the distribution of the number of feet according to the height classes has a “bell” shape (figure 5). As for the dendrometric characteristics of the population, they are presented in Table 1.

Table 1: dendrometric characteristics of the population of ceiba pentandra (l.) Gaertn in the study area.

Parameters					
Communes	**Densité feet averages of settlements**	**Hauteur feet average (m)**	**Diameter feet average (cm)**	**Surface average feet burrow (m2 /ha)**	**Diameter crowns average (m)**
Balavé	10,85	36,31	133,93	2,02	17,37
Kouka	-	30,35	133,2	2,21	13,46
Sami	-	32,88	74,69	0,93	12,15
Sanaba	16,27	36,28	145	2,42	16,5
Solenzo	32,07	33,59	161,01	2,7	20,37
Tansila	72,72	38,95	117,8	1,8	14,48

Source: filed works

The results of the current research show that the average heights of *Ceiba pentandra (L.) Gaertn* in the province vary between 30 and 39 m. As for the other dendrometric parameters, the municipality of Solenzo has the highest mean diameter. In addition to the results related to the spatial analysis of the settlement and dendrometric characteristics, this study highlights the state of regeneration of *Ceiba pentandra (l.) Gaertn* and local conservation strategies.

State of regeneration of the Ceiba pentandra (L.) Gaertn and local conservation strategies

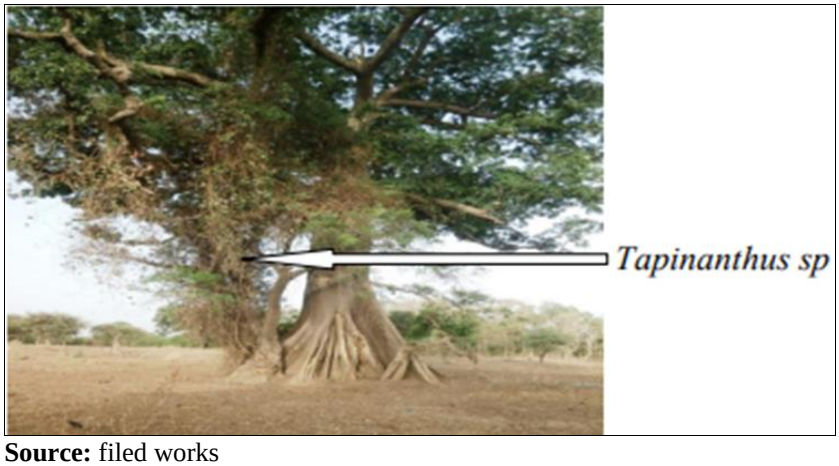
Concerning the state of regeneration of *Ceiba pentandra (L.) Gaertn*, the results of the study reveal that the regeneration rate of the species is low. The numbers by height class are presented in table 2.

Table 2: Number of regeneration per height class (cm)

Height class in cm	Numbers	Proportion in %
]0-25]	1	9,09
]50-75]	1	9,09
]75-100]	2	18,18
]100-125]	1	9,09
>175	6	54,55
Total	11	100

Source: field works

The regeneration rate of the species is 1.60%. The few rare regeneration subjects identified are located in the height class greater than 175 cm (total height >175 cm). As for local conservation strategies, the respondents about the regeneration strategy for the species in their locality have converging points of view. For 89.14% of those respondents, the reproduction methods of *Ceiba pentandra (L.) Gaertn* are natural regeneration, while for 18.35%, the direct sowing of seeds of the species is better indicated as a silvicultural technique to renew the repopulation of the species. Some factors were mentioned by the respondents to explain the disappearance of the species. Among these factors are the aging of the species' feet (63.67%), the rainfall deficit (41.75%), the lack of maintenance of the species' feet (24.72%), the attacks of parasites (14.60%), the low level of introduction of the species in reforestation operations (13.48%), increasing demography (9.36%), the action of certain types of invading birds such as *Bubalornis albirostris* and Turtur afer (8.23%). The first, through its defections charged with certain chemical substances and the second which carries parasitic plants (*Tapinanthus* sp.), make individuals of the species more vulnerable.



Source: filed works

Fig 6: shows a plant of Ceiba pentandra (L.) Gaertn parasitized by Tapinanthus sp.

In the specific case of increasing demography, this factor induces the clearing of new land and the construction of buildings which, in certain cases, are accompanied by the destruction of the feet of the species. The respondents consider that demography is one of the causes of the disappearance of the species in the study area.
To ensure the conservation of the species, the local forest authority carry out awareness campaigns for the populations. The themes developed relate to the ecological role played by the species (49.81%), the application of regulatory provisions prohibiting the cutting of the species (37.08%), the preservation of the feet of the species in the agroforestry parks (home fields), the protection against bush fires (23.58%), the ban on debarking the species without the authorization of customary chiefs (11.23%) and fencing (Fig 7) young plants with wooden grids (10.49%).

Source: *filed works*

Fig 7: Wood fence for a young foot of Ceiba pentandra (L.) Gaertn in the village of Gnoumakuy, in the municipality of Sanaba

In addition to these actions and given the threats to the species, people believe that special attention should be given to its conservation. They suggest the following solutions: the reforestation of the species (79.03%), the strengthening of public awareness for the protection of the species (61.42%), the production of the species in nurseries (32.20%), the protection of young plants of the species by wire netting (34.83%).

Discussion over the results

The discussion focuses on the shaping of the landscape and the risks associated with the weak regeneration of the species and the local strategy which is not proportional to the risk of extinction of the species.
In terms of the shaping the landscape, in the study area, the feet of *Ceiba pentandra (L.) Gaertn* are remarkable for their large size. They play a big role in the shaping of the local landscapes. The values of the various dendrometric parameters such as the average height, the average diameter and the average basal area make it possible to demonstrate this. Indeed, the results of this study show that the average height of individuals is 30.35m. It is close to the value of 30.76 m, obtained by Y. Tessi and *al.* (2012) [30] on the populations of *Ceiba pentandra (L.) Gaertn* in the relict forests of southern Benin. The curve of the vertical structure has the shape of a "bell". The stems of the future are less numerous to ensure the renewal of the population. Species faithful to this type of distribution in natural forests are said to be destructuring; they are threatened with extinction in the settlements (N. Sokpon & S. Biaou, 2015) [23]. The horizontal structure of the populations of *Ceiba pentandra (L.) Gaertn*, shows a numerical superiority of the large subjects. There is a total absence of individuals of the species in the lower classes. The species is getting older with diameters at 1.30 m above the ground reaching 300 cm. According to A. Ouedraogo (2006) [3], the aging of the settlements is illustrated by the low proportion of individuals in small classes. In contrast, other studies have shown a relatively stable diameter structure of *Ceiba pentandra (L.) Gaertn* settlements in relict forests in southern Benin (Y. Tessi and *al.*, 2012, *op.cit.*) [30].
The results obtained by K. Adjonou (2016) [18], indicate for the species a maximum diameter of 152.9 cm, measured as part of a study on forest management in Togo. This value is comparable to that obtained by the current study which is 145cm. The density of *Ceiba pentandra (L.) Gaertn* settlements varies between 10 to 72 trees/ha in the communes of the study area. These results are comparable to those of I. Guimbo (2010) [12]. This source notes a density of 25 *Ceiba pentandra* trees in a study of Neocarya macrophylla (Sabine) Prance and *Vitellaria paradoxa (Gaertn. C.F.)* parklands in southwestern Niger.

Risk related to the weak regeneration of the species and the local strategy which is not proportional to the risk of disappearance of the species

Regarding the risk related to the low regeneration of the species, the regeneration rate of *Ceiba pentandra (L.) Gaertn* in the province of Banwa is low. This reveals a lack of rejuvenation of its settlements. Many factors

influence the regeneration and the selection in the adult settlement. F. Russell & N. Fowler (2002) specify that these factors are, among others, low seed production, fruit predation, grazing, bush fires, light under the canopy and climate variability. The poor natural regeneration of species is often mentioned as a consequence of the shortage of seeds (J. Weber and *al.*, 2008; F. Bognounou, and *al.*,2010) [15, 7].

Regarding the local strategy which is not proportional to the risk of extinction of the species, the population of the species is highly disturbed. Excessive harvesting of timber and non-timber forest products is a danger to the sustainability of the species. According to A. Lykke and *al.* (2004) [2]; O. Lougbégnon and *al.* (2011)[20]; M. Dossou and *al.*, 2012) [], the importance given to a species does not depend on its availability but on its ability to meet the needs of populations in the different categories of use. The leaves and bark of *Ceiba pentandra (L.) Gaertn* are used by people for various purposes. Excessive harvesting of leaves can impact fruiting; also abusive debarking can promote the attack of individuals of the species by fungi, malformation of the trunk. As a result, these local practices developed by the populations of the study area vis-à-vis the species do not guarantee the sustainability of this resource. However, the local strategies implemented for the rehabilitation of the species are not adapted to the danger it faces.

Conclusion

This research carried out in the west of Burkina Faso is an analysis of the methods of sustainable management of *Ceiba pentandra (L.) Gaertn* through improved knowledge of the species.

This study made it possible, on the one hand, to highlight the spatial analysis of the population and the dendrometric characteristics of the species. This species participates in shaping the landscape in the study area because the feet of *Ceiba pentandra (L.) Gaertn* are remarkable for their large size and the values of the various dendrometric parameters such as the average height, the average diameter and the average surface burrow demonstrate this.

On the other hand, the study highlights the state of regeneration of *Ceiba pentandra* (L.) *Gaertn* and local conservation strategies. Regarding the risk related to the low regeneration of the species, its regeneration rate in the Banwa province is low. This situation reflects a lack of rejuvenation of its settlements. And as for the local strategy which is not proportional to the risk of disappearance of the species, the population of the species is strongly disturbed. Excessive harvesting of timber and non-timber forest products constitutes a danger to the sustainability of the species because the local practices developed by the populations of the study area vis-à-vis the species do not guarantee the sustainability of this resource. In addition, the local strategies implemented for the rehabilitation of the species are not adapted to the danger it faces.

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