ASSESSMENT OF OPTIONAL LAND USES AS ALTERNATIVE STRATEGY FOR BIODIVERSITY CONSERVATION IN PENDJARI BIOSPHERE RESERVE IN BENIN (WEST AFRICA)

Final Report

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Abstract

Pendjari Biosphere Reserve is a protected area in the northern part of Benin. Despite many efforts undertaken to conserve this area, people are still motivated to continuous to log and convert reserve land to small-scale agriculture. To mitigate this situation, the present research tries to raise population awareness in the reserve biodiversity conservation in determination the importance of Non-Timber Forest Products (NTFPs) in the financial valuation of savannah formation of the National Park of Pendjari and estimating in comparative manner the value of 1 ha of savannah formation of the National Park of Pendjari based on returns from NTFPs and agricultural activities (especially cotton production). Most clearly, the objectives of the study were to estimate financial value of Pendjari savannah in NTFPs, analyze the benefits of cotton production (main exportation crop produce in the area) and compare the financial value of Pendjari savannah in NTFPs to the revenues obtained from cotton production.

Results show that NTFPs collection is 1.74 times more profitable than cotton production around National Park of Pendjari. The Net Present Value of cotton production (US$ 2118 ha^{1}) is significantly lower than revenue obtainable from NTFPs collection (US$3685 ha^{-1}) and would justify the interest of sustainable use of these resources. The NTFPs financial valuation made in this study provide a useful benchmark for comparing alternative land use practices for the National Park of Pendjari lands in West Africa. This finding is a powerful tool for responsible in charge of the protected areas and other Non Governmental Organization strongly involved into conservation of nature to raise awareness about the importance of their activities.

1. INTRODUCTION

Since the Earth Summit in 1992, many efforts were undertaken to conserve biodiversity through forest preservation (IUCN, 1992). In Benin, this results in the better control of a lot of protected areas like the National Park of Pendjari. However, despite many efforts undertaken to conserve this reserve, recent reports indicate that populations are still motivated to continuous to log or convert reserve land to large-scale agriculture. This failure may be explained partly by the fact that the conservation issues have not only ecological considerations but also by economical bottlenecks such as the demand for firewood or agricultural land (Adgers *et al.,* 1995).

The main question of this research is: “Conversion of the National Park of Pendjari land for small scale agriculture is there economically favorable option compared to sustainable extraction of NTFPs that could preserve the natural forest?” The present study answered this question in determination the importance of NTFPs in the financial valuation of savannah formation of the National Park of Pendjari and estimating in comparative manner the value of 1 ha of savannah formation of the National Park of Pendjari based on returns from NTFPs and agricultural activities (especially cotton production). This savannah financial valuation determination was done considering only its use value. Those values ascribed to natural resources such as option value (future direct and indirect uses) indirect use value (eg. watershed protection, nutrient cycling, air pollution reduction, micro-climatic regulation, and carbon storage) and non-use value (biodiversity, heritage, intrinsic worth and bequest value) were not considered.

Most clearly, the objectives of the study were to 1) estimate financial value of Pendjari savannah in NTFPs, 2) analyze the benefits of cotton production (main exportation crop produce in the area) and 3) compare the financial value of Pendjari savannah in NTFPs to the revenues obtained from cotton production.

The premise is that the choice of sustainable harvest of NTFPs option can permit them to improve their livelihoods and in the same time to contribute to sustainable use of natural resources and consequently to support the biodiversity conservation.

2. STUDY SITE

The National Park of Pendjari is located in the north west of the Benin (10°30’ to 11°30 N; 0°50’ to 2°00’ E) close to the border with Burkina Faso Republic. It is bordered in south-west and south-east respectively by national highway Tanguiéta-Porga (61 km) and country road Tanguiéta-Batia (42 km). In the North and East, the River Pendjari forms a natural border of the National Park of Pendjari that in the North is also the country’s border to Burkina Faso (Brucker, 2001) (Fig. 1). Apart Atakora chain (400-513 m above sea level) in the South, the topography of the reserve is mostly ranges between 150-200 m above sea level.

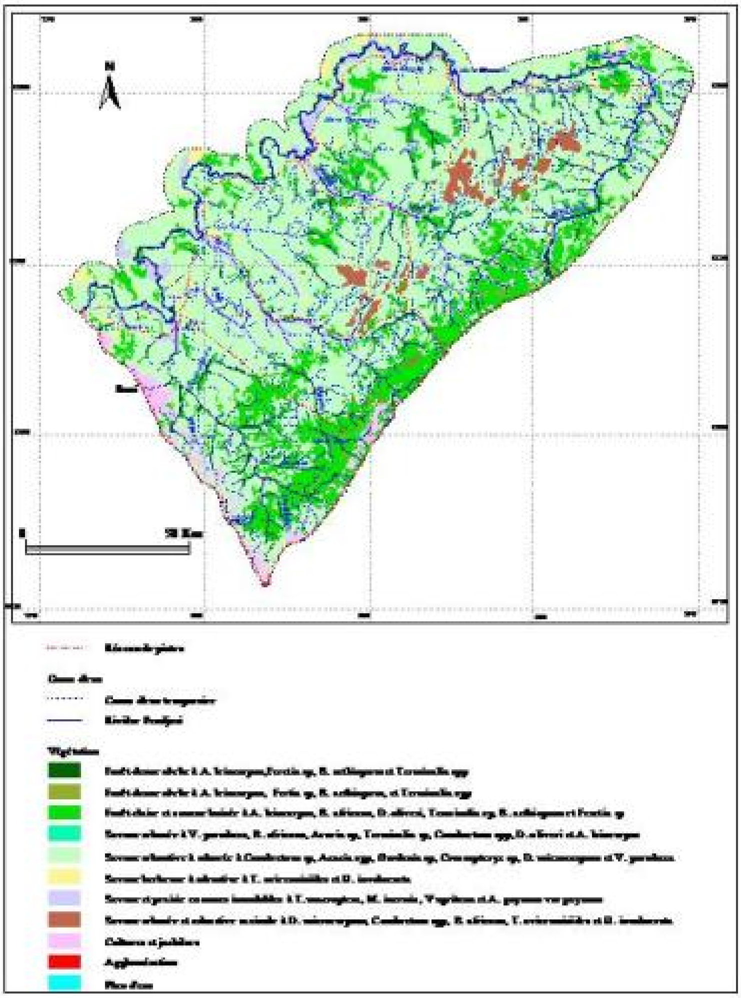

Fig. 1: Map of the National Park of Pendjari showing surrounding villages, different vegetation types and different zones as suggested by the Biosphere Reserve concept.

The National Park of Pendjari has a Sudanian climate with a seven month dry period. The mean annual precipitation is 1,000 mm with tendency in fall beginning from 1950. Most of the rain is falling during a period between late May and early October. The mean annual temperature is 27 °C (Adomou, 2005).

The vegetation of the National Park of Pendjari is a mixture of different savannah types, mostly open shrub and tree savannahs (IUCN, 2002) with in places forests (Adomou, 2005).

3. METHOD

3.1. Data collection

To estimate the economic value of savannah, we measured NTFPs yield from one hectare and calculated its monetary value. The study was carried out on 12 permanent sample plots (100 x 100 m) in savannah formation of the National Park of Pendjari from 2008 to 2009. The plots were sampled randomly using the Global Positioning System (GPS) and National Park of Pendjari map with the help of responsible of CENAGREF to mitigate the probable effect of unequal distribution of plant diversity trough the park on the NTFPs financial valuation assessment.

For NTFPs financial value estimation, within the sample plots we enumerated in collaboration with local people all trees of 10 cm or greater d.b.h (Diameter at Breast Height). We recorded from all individuals data on diameter at breast height, height and crown size. To estimate the yield of fruit and flowers, we selected some branches of each tree within the sample plot, harvested fruits or flowers as done by local communities, weighted and used theses sample for the whole tree production estimation. Species which were not in production were marked and their production estimated in appropriate seasons. Concerning bark valuation, we measured the height of the trunk of species from which this organ is exploited and estimated the quantity of bark likely to be harvested. The same thing was done for species used for their roots. In addition, to enumerate useful herbs and bushes of less than 10 cm d.b.h, we marked in each corner and in the centre of the plots quadrants of 10 x 10 m size where we harvested and weighted all herbs and bushes used for their leaves, flowers, fruits, barks or roots during appropriate seasons (Fig. 2). To make sure that the collection is ecologically sound and sustainable and to take into account losses for wildlife, regeneration and wastage, we reduced by 25% the harvest levels for each tree, bushes and herbs. We collected these data by involving in the research team ten local people (ranging from 20 to 60 years old) known for their knowledge of NTFPs and familiarity with harvesting methods. To have species use validated by the entire community, we used the sample of species identified within the plots and asked participants during focus groups discussion on their knowledge about the species. In total, we organized about 60 focus group discussions.

Concerning cotton production in the study site, secondary data were collected each year from the regional council of agricultural promotion “Centre Communal de Promotion Agricole - CeCPA“, the institution in charge of agricultural production in the area. Data collected concerned cotton yield, selling price, total cost of different input (fertilizer, pesticides, plowing, hoeing, fertilizer and pesticides applications, cotton packaging). We didn’t considered tool used cost in cotton production valuation because the same tools were used for different activities from which NTFPs harvesting and it will be difficult to calculate its amortization for specific activity.

Fig. 2: Data collection on species Diameter at Breast Height

Fig. 3: Data collection on herbaceous species.

3.2. Data analysis

To assess the market value and cost of NTFPs extraction, we visited every two weeks the five most important markets in study area (Tanguiéta, Matéri, Dassari, Porga and Tanongou) for ascertain the market prices of various products marketed. For NTFPs valuation we considered the selling cost obtained from collectors to minimize error due to processing or other cost estimation. To do it, we bought each marketable species product from collectors and weighted to know the price per unit weigh (kg). The prices were estimated for each species at different time during the year and we used the annual mean price to calculate each NTFP gross revenue using equation 2. For multiuse species, we determined the gross revenue by summing up the trading value of each NTFP harvested from the species.

Let P_{b1}, M_{b1} and T_{b1} be respectively the annual mean price of one kilogram of NTFP collected from species B, NTFPs produced on species B and the gross revenue obtained from this species during year 1

$$\mathbf{T_{b1}} = M_{b1} * P_{b1} \quad (1)$$

In the study area, the major cost involved at the producer level is the time spent to collect NTFPs. We obtained the total cost of harvesting by multiplying local wage rate (1500 FCFA/man-day) with the time required for extraction, transportation and sale (£ 1=797 FCFA). Then, the net annual market value ($\prod_{b1}$) of NTFP obtained from species B during year 1 was determined as followed:

$$\prod_{\mathbf{b1}} = T_{b1} - C_{b1} \quad (2)$$

with

C_{b1} the total cost involved in species product collection during the year 1

The net annual value ($\prod_t$) of NTFPs collected in one hectare was:

$$\prod_t = (\prod_{\mathbf{1}} + \prod_{\mathbf{2}})/2 \quad (3)$$

$$\prod_{\mathbf{1}} = \prod_{\mathbf{a1}} + \prod_{\mathbf{b1}} + \ldots + \prod_{\mathbf{n1}} \quad (4)$$

with

$\prod_{1}$, $\prod_{2}$, respectively the net annual market value of NTFPs during year 1 and 2

$\prod_{a1}$, $\prod_{b1}$ and $\prod_{n1}$ the net annual market value of species A, B, … n during year 1

To estimate the net annual value of non-marketed species, we used the Contingent Valuation Method. Therefore, for knowing the financial value assigned to species B leaves for example, we harvested and weighted a bundled of this organ and ask population during the focus group discussions to know how many francs they are agree to pay to someone who accepts to harvest this quantity of leaves for them. The answers were requested respectively if the extraction site is far from the house (3 km) or close to house (less than 3 km). Harvesting sites situated at more than 3 km were identified by local people as too far away to go on foot. The net annual market value of species B for example ($\prod_{b1}$) was obtained by summing up all answer and divided by the number of responses (equation 5). This operation was done each year for non marked species.

$$\prod_{b1} = CV_1 + CV_2 + CV_3 + CV_4 \qquad (5)$$

with

CV_1 the value attributed to species B during available period if the extraction site is far from the house,

CV_2 the value attributed to species B during unavailable period if the extraction site is far from the house,

CV_3 the value attributed to species B during available period if the extraction site is close to house,

CV_4 the value attributed to species B during unavailable period if the extraction site is close to house.

The estimations of cotton net annual market value and production costs were done by way of market observations and considering government-controlled price. Indeed, the costs of fertilizer and pesticides used to produce cotton and the cotton selling price in Benin were fixed by state government. In opposite, the other costs such as plowing or fertilizer applications costs were established according to the labour availability in the area. We collected information about different costs during focus group discussions. They didn't vary slightly from one year to another. We didn't take land rent into the calculation. Therefore, the cotton net annual value ($\prod_{cotton}$) was obtained as follow:

$$\prod_{cotton} = (Qt * Pt) - \sum_{i=1}^{k} Xi * Pi \qquad (6)$$

Qt = mean yield of cotton per ha during the two years (t)

Pt = mean cotton selling price (FCFA/kg)

Xj = quantity of production factors used by the farmers (fertilizers, pesticides .etc)

Pj = unitary price of production factors (FCFA)

k = number of production factors

We estimated the Net Present Value (NPV) of each land use option to make comparison. The NPV signifies the value of future income in today's money (Grimes *et al.*, 1994). We assume that NTFPs harvesting and cotton production provide constant annual returns and are sustainable.

$$\mathbf{NPV} = \prod_n / r \qquad (8)$$

with

$\prod_n$, the net annual revenue from NTFPs collection or cotton production. For NTFPs collection $\prod_n = \prod_t$ and $\prod_n = \prod_{cotton}$ for cotton production.

r is the discount rate of annuities. In our study, we used 10% discount rate, taking into account the lending rate of Benin bank.

The net revenue obtainable from sale of cotton ($\prod_{cotton}$) was then compared with the potential revenues from NTFPs stocks ($\prod_t$) on 1 ha plot by way of Chi-Square test (χ^2). The NTFPs and cotton NPV were also compared.

To describe the link between plant botanical families, organs harvested and uses, Principal Component Analysis was applied to a matrix of frequencies of species recorded within each families, organ collected and different uses. The species' botanical families were projected in the system axis defined by the principal components in order to describe the species according to the organ exploited and uses.

4. RESULTS

4.1. Non-Timber Forest Products recorded from the sample plots

During the field survey, a total of 72 species (27 families) were found as useful to communities around the Pendjari National Park (see appendix 1). The most represented family was Leguminoseae with 14 species followed by Combretaceae (nine species), Rubiaceae (six species) and Poaceae (five species). The thirteen most represented families were shown on Fig. 4. Fourteen families were represented by only one species. Species were harvested mainly for medicine (46.2%), food (20.5%), construction materials (11.5%), ceremony (8.3%) and other use (toothbrush, art object: 13.5%). The majority of species recorded (65.28%) were multiuse species. The most harvested organs were leaves (32.2 %) followed by roots (30.2%), bark (26.8 %), fruits (9.3 %) and flowers (0.9 %).

Results of the Principal Component Analysis performed on the plant organ harvested and their uses showed that the first two axes explained 79.5 % of the overall information on species families (Fig. 5). We noticed from this figure that species exploited for their leaves, fruits and bark were mainly used for medicine, food, toothbrush and art objects (axis 1). Axis 2 shows that the species harvested for flowers were used for ceremonies in contrary to those harvested for roots.

The projection of the species' families in the system axis defined by the principal components (Fig. 6) shows that species from Combretaceae and Leguminosae families were harvested for their leaves, fruits and bark used for medicine, food, toothbrush and art objects. Species from Bombacaceae and Tiliaceae families were harvested for flowers and were mainly used in traditional ceremonies.

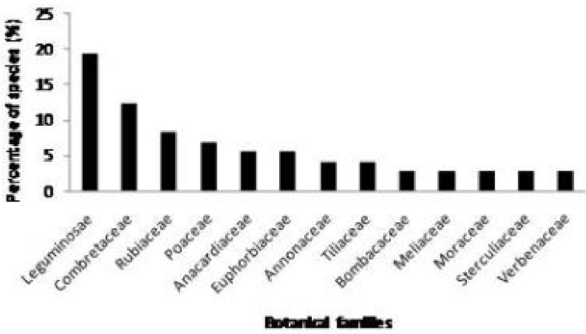

Fig. 4: The most represented families in NTFPs identification. The number of species identified within these families varies from 2 to 14 species.

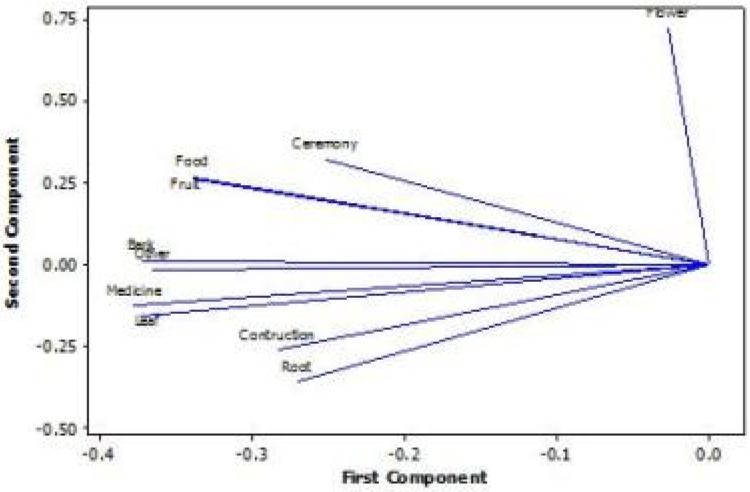

Fig 5: Projection of the different parts harvested from the species and their uses.

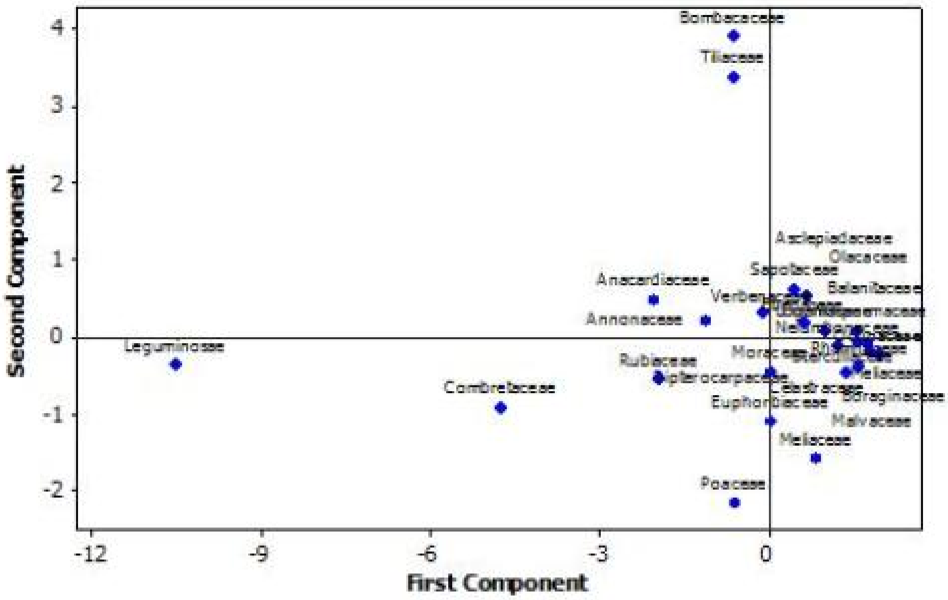

Fig 6: Projection of the species' families in the system axis defined by the principal components

4.2. Financial valuation of Non-Timber Forest Products

The Net Annual Market Value of the Pendjari National Park savannah formation in NTFPs ($\prod_t$) was estimated to be 165 817 +/- 9 127 FCFA/ha (£ 246 ha^{-1}) while the NPV of NTFPs was estimated to be 1 658 166 FCFA/ha (£ 2,463 ha^{-1}) (Table 1 & 3). The ten most valuable species were showed on Fig. 7. They concentrated 40% of the global value of the savannah vegetation and were harvested for various purposes. *H. involucrata*, *A. gayanus* and *P. pedicellatum* were locally used in house construction to fence houses or to thatch roofs while their roots were used as medicine. The fruits harvested from *P. biglobosa* and *V. paradoxa* are processed and used in the daily diet of the local people. Their barks are also used in traditional medicine. *V. doniana* and *T. indica fruits* were harvested and consumed as fresh fruits but the most important product collected from *V. doniana* was its young leaves used as vegetable in human diet. *C. glutinosum, C. planchoni and T. laxilora* were mainly used in traditional medicine.

The most valuable products of the Pendjari National Park savannah are specie leaves (2316+/-478 FCFA/ha) followed by roots (1852+/-457 FCFA/ha) and fruits (1140+/-514 FCFA/ha) (Fig. 8).

Table 1: Financial value of NTFPs in one hectare of savannah formation.

	PLOTS (1 ha)																								$\prod_t$ (FCFA/ha)
	n°1		**n°2**		**n°3**		**n°4**		**n°5**		**n°6**		**n°7**		**n°8**		**n°9**		**n°10**		**n°11**		**n°12**		
	T_1	C_1	T_2	C_2	T_3	C_3	T_4	C_4	T_5	C_5	T_6	C_6	T_7	C_7	T_8	C_8	T_9	C_9	T_{10}	C_{10}	T_{11}	C_{11}	T_{12}	C_{12}	
Value per ha (FCFA/ha)	164 539	27 423	170 845	34 169	160 794	41 687	330 312	76 226	319 184	84 490	238 974	44 686	167 282	30 166	159 925	24 395	136 973	17 866	304 903	50 817	321 531	86 837	248 688	54 400	**165 817 +/- 9 127**
$\prod_1$ (FCFA)	**137 116**		**136 676**		**119 107**		**254 086**		**234 694**		**194 287**		**137 116**		**135 530**		**119 107**		**254 086**		**234 694**		**194 287**		
Value per ha (FCFA/ha)	126 147	16 454	159 911	36 903	148 240	31 516	255 356	64 792	194 327	32 388	204 041	31 125	151 788	28 383	178 899	29 817	198 194	43 355	220 547	42 686	198 316	45 765	243 326	47 095	
$\prod_2$ (FCFA)	**109 693**		**123 009**		**116 725**		**190 564**		**161 939**		**172 916**		**123 405**		**149 083**		**154 839**		**177 860**		**152 551**		**196 230**		

£ 1 = 797 FCFA

$\prod_t$: Global Net Market Value (FCFA) +/- Standard Error

$\prod_1$ and $\prod_2$: respectively Net Annual Market Value during year 1 and 2

Table 2: Annual net value of cotton production around the Pendjari National Park

	2008-2009				**2009-2010**			
	Mean production (kg/ha)	Price (FCFA/kg)	Gross revenue (FCFA/ha)	Total cost (FCFA/ha)	Mean production (kg/ha)	Price (FCFA/kg)	Gross revenue (FCFA/ha)	Total cost (FCFA/ha)
Mean value	1 500	190	285 000	141 200	1 000	190	190 000	143 200
Net annual revenue per ha	143800				46800			
$\prod_{cotton}$ (FCFA/ha)	**95 300 +/- 48 500**							

£ 1 = 797 FCFA

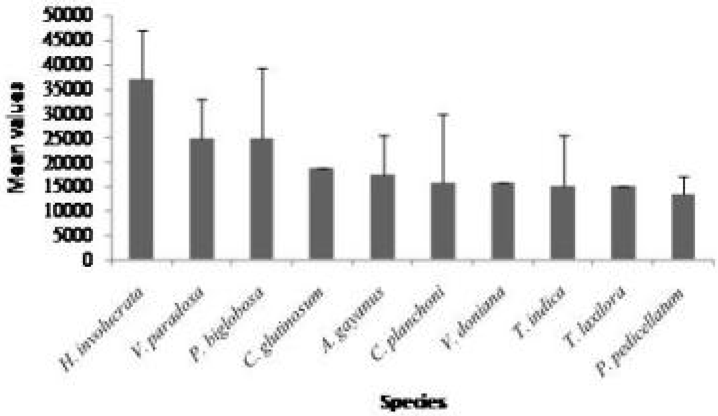

Fig. 7: The ten most valuable species within savannah by the National Park of Pendjari surrounding people.

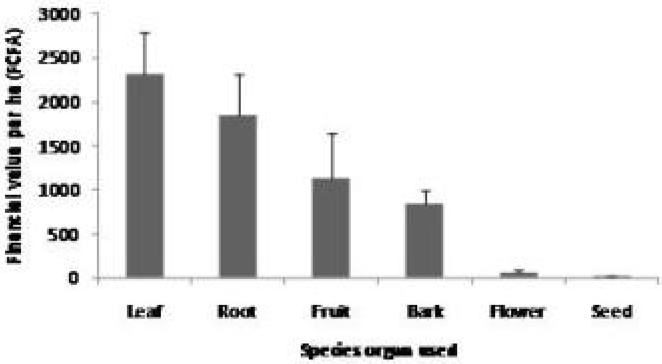

Fig. 8: Valuable products within the National Park of Pendjari savannah vegetation

4.3. Valuation of cotton production around the National Park of Pendjari

Farmers around the National Park of Pendjari make an annual profit of 95 300+/-48500 FCFA (US$ 142 ha^{-1}) per year by cultivating one hectare of cotton (Table 2). The mean cotton production in study area varied from 1 500 kg/ha (cotton growing year 2008-2009) to 1 000 Kg/ha (cotton growing year 2009-2010). The NPV of cotton production was estimated to be 953 000 FCFA/ha (£ 1,416 ha^{-1}) (Table 3).

The comparison between the potential revenue from NTFPs harvesting and cotton production revealed that the net present value of revenues from NTFPs is significantly higher than the returns from cotton production (χ^2 = 23 494.318; $p < 0.05$) (Table 3). The comparison between NTFPs and cotton NPV show that sustainable harvesting of NTFPs provide more revenue than agriculture especially cotton production (Table 3). Indeed, NTFPs collection is 1.74 times more profitable than cotton production. As shown on table 3 the total cost involved in cotton production is significantly higher than those used for NTFPs harvesting, transportation and selling ($\chi^2 = 1060.59$; $p < 0.05$).

Table 3: Comparison of revenues from NTFPs with cotton production

Revenue	Net Annual Value	Total cost	Net present value
Revenues from NTFPs (FCFA)	165 817+/-9 127	42 643+/-3 905	1 658 166
Revenues from cotton production (FCFA)	95 300+/- 48 500	142 200+/-1 000	953 000
Statistics	$\chi^2 = 23494.318$ *Df = 1* *p = 0.00001*	$\chi^2 = 1060.59$ *Df = 1* *p = 0.00001*	

£ 1 = 797 FCFA

5. DISCUSSION AND CONCLUSION

5.1. NTFPs importance in financial valuation of Sudanian savannah vegetation

The study proved that NTFPs had a competitive advantage compared to land conversion for small scale agriculture especially cotton production. NTFPs collection is 1.74 times more profitable than cotton production around National Park of Pendjari. The NPV of cotton production (£ 1,414 ha^{-1}) is significantly lower than revenue obtainable from NTFPs collection (£ 2,461 ha^{-1}) and would justify the interest of sustainable use of these resources. NTFPs have the potential to improve the livelihoods of people who depend on them for their basic needs and cash income. The comparative advantage of NTFPs is also perceptible considering the cost needed to produce cotton. While people need to invest about £ 211 ha^{-1} to produce cotton, they can get cash income from NTFPs with relatively little money (£ 63 ha^{-1}). A part the time spent to harvest, transport or sell NTFPs products, people don’t need to engage any additional charge before getting benefit from these products.

The NPV of NTFPs harvesting in the National Park of Pendjari is higher than those obtained in India (NPV= £ 789 ha^{-1}; Mahapatra and Tewari, 2005) and Equador (£ 1,890 ha^{-1}; Grimes *et al.*, 1994) but lower than the sustainable fruit and latex harvest in the Amazonian rain forest (£ 4,227 ha^{-1}; Peters *et al.*, 1989). As shown by Croitoru (2007), the variations observed are influenced by various factors, such as the differences in the studies' objectives, methodology, assumptions, site biology, type of management and number of goods valued (Godoy and Lubowski, 1992). Contrary to previous studies (Peters *et al.*, 1989; Grimes *et al.*, 1994;

Mahapatra and Tewari, 2005), our research recorded and determined financial values of all NTFPs within sampling plots. Indeed, in addition to marketed species, we also include in the plot financial valuation the value of non marketed species using Contingent Valuation method. In opposite, Peters *et al.* (1989) in their study considered only commercial tree species occurring in one hectare but the high NPV obtained may be due to their methodology based on inventories to determine the potential values of used products while other studies have emphasized that realized production is generally much lower (see Godoy *et al.*, 1993 review). Grimes *et al.* (1994) considered in their valuation seven fruits, three medicinal barks, and one resin while Mahapatra and Tewari (2005) included in their study only tree with 10 cm or greater d.b.h producing marketable NTFPs (10 trees, four shrubs, one grass and one climber species). The limited number of NTFPs included in the two last studies would explain the lower NPV observed.

5.2. Implication for conservation

The NTFPs financial valuation made in this study provide a useful benchmark for comparing alternative land use practices for the National Park of Pendjari lands in West Africa. Results clearly show that NTFPs contribute more than cotton production to local communities' economies on a per hectare basis. This finding is a powerful tool for responsible in charge of protected areas and other Non Governmental Organization strongly involved into conservation of nature to raise awareness about the importance of their activities. Indeed, economic valuation of natural resources is very important to help people to make informed choices. And, knowing that in Africa, protected areas are the cornerstone of biological conservation, results obtained in this study will be useful tools to help park responsible to improve their management planning. Moreover, in view of the disproportionately low return from land use to produce cotton and current adverse criticism on environmental impact of park land conversion for agriculture, a NTFP focused management system can be considered economically viable management option.

We agree with Ros-Tonen (2000) that it will be incorrect to suggest that NTFPs can be harvested indefinitely without proper management practices to sustain their yield. In the case of the National Park of Pendjari, we could be delighted at the thought that species are mainly used for their leaves. According to Cunningham (2001), species exploited for their leaves were less vulnerable than those from which reproductive organs were harvested. However, they cannot be sustainability harvested in absence of careful species selection, yield studies, monitoring of regeneration and harvesting adjustments. Only products which can be harvested without killing the individual plants, which are abundant or which regenerate easily, offer good prospects for sustainable management (Ros-Tonen, 2000). Therefore, there is a need to know more about useful species availability and biology, especially for those exploited for their roots, flowers or fruits.

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Appendices

Appendix 1: Species identified within plots with their families, part used and major uses

Espèces	Family	Part used	Use
Lannea acida A.Rich. S.l.	Anacardiaceae	Leaf, bark, root, fruit	2,3
Lannea microcarpa Engl. K. Krause		Leaf, bark	1,2,4,5
Ozoroa insignis Delile		Leaf, bark, root	1,2
Sclerocarya birrea (A.Rich.) Hochst.		Leaf, bark, root, fruit	1,2
Annona senegalensis Pers.	Annonaceae	Leaf, bark, root	1,2,4,5
Hexalobus monopetalus (A.Rich.) Engl. & Diels		Leaf, bark, root	2
Uvaria chamae P. Beauv.		Leaf, fruit	1,2,5
Raphionacme brownii Scott-Elliot	Asclepiadaceae	Root	1
Balanites aegyptiaca (L.) Delile	Balanitaceae	Leaf, fruit, Bark, root	1,2
Bombax costatum Pellegr. & Vuillet	Bombacaceae	Leaf, Flowers, bark	1,2,3
Adansonia digitata L.		Leaf, bark, fruit,	1,2,3,5
Cordia senegalensis Juss.	Boraginaceae	Leaf, bark, root	2
Gymnosporia senegalensis (Wight & Arn.) Hook.f.	Celastraceae	Leaf, bark, root	2
Cochlospermum planchoni Hook.f.	Cochlospermaceae	Root	1,2
Anogeissus leiocarpa (DC.) Guill. & Perr.	Combretaceae	Leaf, bark, root	2,4
Combretum collinum Fresen.		Leaf, bark, root	1,2,5
Combretum glutinosum Perr. Ex DC.		Leaf, fruit, bark, root	1,2
Combretum micranthum G.Don		Leaf, fruit, bark, root	1,2
Combretum nigricans Lepr. Ex Guill. & Perr.		Leaf, fruit, bark, root	1,2
Pteleopsis suberosa Engl. & Diels		Leaf, bark, root	2
Terminalia avicennioides Guill. & Perr.		Leaf, bark, root	2
Terminalia laxilora Engl.		Leaf, bark, root	2
Terminalia macroptera Guill. & Perr.		Leaf, bark, root	2,5
Monotes kerstingii Glig	Dipterocarpaceae	Leaf, bark, root	2
Diospyros mespiliformis L.	Ebenaceae	Leaf, bark	1,2,3,4,5
Bridelia ferruginea Benth.	Euphorbiaceae	Leaf, bark	2
Flueggea virosa Willd.		Leaf, root	2,4,5
Hymenocardia acida Tul.		Leaf, bark, root	2
Phyllanthus amarus L.		Leaf, root	2
Acacia gourmaensis A.Chev.	Leguminosae	Leaf, bark, root	2,5
Acacia hockii de Wild		Leaf, bark, root	2
Afzelia africana Sm.		Leaf, seeds	2,4,5
Burkea africana Hook.		Leaf, fruit, bark, root	1,2,3,4
Daniellia oliveri (Rolfe) Hutch. & Dalziel		Leaf, bark, root	2,4,5
Dichrostachys cinerea (L.) Wight & Arn.		Leaf, bark	2,4,5
Entada africana (Guill. & Perr.)		Leaf, bark, root	2,5
Parkia biglobosa (Jacq.) R.Br. Ex Benth.		Leaf, fruit, bark, root	1,2,3
Piliostigma thonningii (Scumach.)		Leaf, bark, root	1,2,4

Prosopis africana (Guill. & Perr.) Taub.		Leaf, bark, root	2
Pterocarpus erinaceus Poir.		Bark, root	1,2
Tamarindus indica L.		Leaf, bark, root, fruit	1,2,3,4,5
Tephrosia bracteolata (Guill. & Perr.)		Leaf	2
Cassia sieberiana DC.		Leaf bark	2
Strychnos spinosa L.	Loganiaceae	Leaf, bark, root, fruit	1,2
Hibiscus asper	Malvaceae	Leaf	1,2
Khaya senegalensis (Desr.) A.Juss.	Meliaceae	Bark	2
Pseudocedrela kotschyi (Schweinf.) Harms		Bark, root	2
Ficus glumosa L.	Moraceae	Leaf, bark, root	1,2,4
Ficus sycomorus L.		Leaf, bark	1,2,4,5
Syzygium guineense (Willd.) DC.	Nelumbonaceae	Leaf, bark, root, fruit	2
Lophira alata Banks ex Gaertn	Ochnaceae	Leaf	
Ximenia americana L.	Olacaceae	Leaf, bark, root, fruit	1, 2, 3
Andropogon gayanus Kunth		Leaf, root	2,4
Andropogon fastigiatus L.		Leaf, root	2, 4
Hyparrhenia involucrata Stapf	Poaceae	Leaf, root	2,4
Loudetia arundinacea (Hochst. Ex A.Rich.) Steud.		Leaf, root	2,4
Pennisetum pedicellatum Trin.		Leaf, root	2,4
Ziziphus abyssinica A.Rich.	Rhamnaceae	Leaf, bark, root	2
Crossopteryx febrifuga (G.Don) Benth.		Leaf, bark, root	2,5
Gardenia erubescens Stapf & Hutch.		Leaf, bark, fruit	1,2
Gardenia aqualla Stapf & Hutch.	Rubiaceae	Leaf, bark	2
Gardenia ternifolia Schumach. & Thonn.		Leaf, root	2
Mitragyna inermis (Willd.) Kuntze		Leaf, bark, root	2
Sarcocephalus latifolius (Sm;) E.A.Bruce		Leaf, bark, root	1,2,5
Vitellaria paradoxa C.F.Gaertn.	Sapotaceae	Leaf, bark, fruit	1,2,3,5
Dombeya quinqueseta Cav.	Sterculiaceae	Leaf, bark	2
Waltheria indica L.		Leaf, root	2
Grewia bicolor Juss.		Leaf, bark	1,2
Grewia pubescens P. Beauv.	Tiliaceae	Leaf, flower, bark, fruit	1,2
Grewia lasiodiscus K. Schum.		Bark, root, fruit	1,2
Vitex simplifolia	Verbenaceae	Leaf, bark, root	2
Vitex doniana Sweet		Leaf, bark, root, fruit	1,2,3,5

Field pictures

Project principal investigator during field data collection

Fruits of *Parkia biglobosa* within sample plot

Fruits of *Vitellaria paradoxa* commercialized ion Tanougou market

Fruits of *Tamarindus indica* commercialized in Matéri market

Leaves of Hibiscus asper marketing in Porga market

Farmer weaving *Hyparrhenia involucrata* to fence its house

People participating in one focus group discussion

Local communities sharing project result during a workshop