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Valuing the Potential of Non-timber Forest Products in Financial Valuation of Savannah Formation in Sudanian Region

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Abstract This study assesses the financial value of one hectare of savannah vegetation in Sudanian region of West Africa based on the potential extraction of Non Timber Forest Products (NTFPs). Our methodology provides multiple estimations of NTFPs production from each species for two years and also takes into account variation in NTFPs prices. Given the regeneration capacity of harvested species for some NTFPs such as bark or root, we presented the annual financial value of revenue from NTFPs in contrary to some studies which determined their net present value. Results showed that the Net Annual Value of NTFPs collection is US$368 ha^{-1} and would justify the interest of sustainable use of these resources. The most valuable products of the Pendjari Biosphere Reserve savannah were species leaves (US$164 ha^{-1}) followed by fruits (US$89 ha^{-1}) and roots (US$78 ha^{-1}). However, the Net Annual Value determined here is the potential value of the Sudanian savannah in NTFPs. The NTFPs financial valuation made in this study provided a useful details for comparing alternative land use practices. In view of the sustainable use of natural resources, a NTFP focused management system could be considered economically viable management option. However, they cannot be sustainability harvested in absence of careful species selection, yield studies, monitoring of regeneration and harvesting adjustments. Therefore, there is a need to know more about useful species availability, biology and reaction to harvesting impact, especially for those exploited for their roots, flowers or fruits.

Keywords Land Use Option, NTFP, Financial Valuation, Savannah Vegetation, West Africa

1. Introduction

The Earth Summit in 1992 led to increasing political attention to environmental problems resulting from global deforestation [1]. To mitigate this situation, many efforts were undertaken to conserve forests. But in many part of the word, these efforts, mainly based on a strictly natural science orientation, have experienced failure [2]. This failure can be explained in part by the fact that the conservation issue has not only ecological considerations. Decisions on logging, management or conversion of forestlands are most frequently determined on economics criteria such as the demand for timber, for agricultural land or the need to export forest products to earn foreign exchange [3].

Moreover, valuation of tropical forests has been traditionally based on a financial appraisal of its timber stock [4]. Empirical research on non-market forest benefits in the latter case has focused on recreational and existence values held by urban consumers. This spurred the development of non-market estimation techniques appropriate to such values [5]. And yet, in developing countries, forest values related to production and subsistence remain relatively important. Rural communities living in and around forest areas often rely heavily on Non-Timber Forest Products (NTFPs) for both subsistence and cash income [5, 6].

With changing political economy of forest resources around the world, benefits of NTFP are increasingly discussed in valuing tropical forests [7]. Several studies therefore argued in favour of NTFP focused forest management to reach sustainability that can reconcile economic, cultural and ecological values of tropical forests [8, 9]. A basic premise is that if proper economic values are assigned to biodiversity, then rational decisions are possible, especially in the case of resources such as forests, which have alternative land use options [10, 11, 12]. Therefore, valuation will help society make informed choices about the trade-offs [13].

Furthermore, the majority of NTFPs valuation made so far are from Latin America. However, the results obtained from these studies cannot be extended to all tropical settings [14]. The value of any single site will depend on many factors of which the useful species richness at the local level, the extent of NTFPs knowledge in the area or the proximity of markets [15, 6]. Therefore, an assessment of NTFP stocks in Africa and Asian region is essential where different forest types, harvesting methods and economies ascribe different values to the products and services from forests [see review of 4]. This study will fill in this gap by estimating valuation of NTFPs in Benin savannah (West Africa). Results from this study which has been carried out within Pendjari Biosphere Reserve could help managers and local people know the financial potential of NTFPs and make efficient land-use decisions.

The National Park of Pendjari which is part of the Pendjari Biosphere Reserve is the most important protected areas in Benin. After its notification as a Game Reserve in 1954, upgraded to a National Park in 1961 and Biosphere Reserve in 1986, the Reserve dwellers have still retained much of their traditional lifestyles and had extensive knowledge of the wildlife resources of the area [16]. Moreover, despite the ban of CENAGREF (Centre National de Gestion des Resources Forestières: the institute in charge of the Pendjari Biosphere Reserve management) to log or converse reserve land to large-scale agriculture, population are steadily motivated to continuous. They don't understand the well-being of sustainable natural resource exploitation that advocate responsible in charge of this reserve. Knowing that in Africa like in other parts of the world, establishment and maintenance of protected areas have increasingly been regarded as essential for stemming the habitat loss and preserving the exceptional rates of plant and animal endemism, it urges to develop strategies which can help assume their sustainability [17]. Indeed, putting values to NTFPs which often do not enter monetary economic system would allow foresters, local communities and policy makers to choose an appropriate mix of outputs of timber, non-timber and environmental benefit while dealing with forest land [4].

Our study determined the importance of NTFPs in the financial valuation of savannah formation of the Pendjari Biosphere Reserve and estimated the value of 1 ha of savannah formation of the Pendjari Biosphere Reserve based on returns from NTFPs. 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 (e.g. 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. By describing the diversity of NTFPs used in the Pendjari Biosphere Reserve and estimating financial value of Pendjari savannah in NTFPs, our study becomes relevant to help increase local community awareness on the importance of biodiversity conservation.

2. Non Timber Forest Products Valuation Methods: Per Hectare Economic Returns

Since many critics were directed at ecological negative impacts of agriculture and livestock production in tropical forest areas, more attention has shifted to the economic value of NTFPs. Studies are beginning to demonstrate that the sustainable extraction of these resources may provide significant benefits to local people [18, 14, 4].

The first study which changed the world's perception of NTFPs economic values goes back to Peters et al [18]. Their study in Mishana (Peru) combined botanical survey data from a 1-ha forest plot with monthly retail prices for fruits and latex in the Iquitos market. The gross annual per hectare value of fruits and latex was estimated at US$ 650 while the time-discounted net present value of present and future harvests of these products alone was US$ 6330 for the single hectare; and the authors concluded that the extraction of NTFPs for sale in local markets in Iquitos, Peru, was more profitable than timber harvesting [18]. However, this study has been the target of a scattered academic critique [14, 19, 20]. Some authors point out concerns about the objections to the underestimation of post-harvest losses and marketing costs of perishable NTFPs, and to the assumption of an infinite time horizon with a low discount rate (5%) in a situation in which land tenure and market insecurities abound[20].Doubts were also raised about the generality of results extrapolated from the chosen location and whether the density of fruit trees was typical for the Amazon forest[21, 20]. Moreover, Peters et al [18]looked at potential values of NTFPs based on inventories; while further studies have emphasized that realized production is generally much lower [see 22 review]. To correct these uncertainties and reveal a real NTFPs values, Sheiland Wunder [20] advised that series of questions should be asked about any landscape valuation study. These concern the objectives and definition of the study, the uncertainties involved (i.e., omissions, sampling concerns, methodological biases, and errors), contexts, extrapolation, generality, and ultimate interpretation.

In this way, some years after Peters and colleagues' research, Grimes et al [14] published a study on forest economic values in Ecuador. Their work improved Peters et al [18] methodology by developing separately valuing trees on an individual basis, rather than at a per species level. This allows them to better account for the wide variations in production levels and harvesting costs among individual trees of the same species. Indeed, in order to estimate the annual yield of potentially valuable fruit-producing trees, they surveyed each tree with at least two groups of guides. This provided them multiple estimations of the production from each tree. To further ensure that the reported sustainable collection rates are ecologically sound, they reduced the reported harvest levels by 25% to take into account losses for wildlife, spoilage, and regeneration. To supplement their field and market data, they interviewed several marketing actors who regularly used the NTFPs found in the plots.

However, according to Sheiland Wunder [20], these studies fail to consider many other cautions. For example, a single plot, such as used by Peters et al [18], is inadequate as an objective basis for generalization. Objective replication in space is required for spatial generalization, whereas replication in time is similarly required for formal temporal generalization [20]. Mahapatra and Tewari [4] in their valuation of dry deciduous forest of India addressed space concern by investigating 12 sample plots in two districts but this study didn't take into account the temporal uncertainty revealed by Sheiland Wunder[20].In the present study, our methodology addressed this issue and many other concerns revealed by Sheiland Wunder (sampling concerns, methodological biases, results extrapolation, etc.).

3. Methods

3.1. Study Site

The Pendjari Biosphere Reserve 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 Pendjari Biosphere Reserve that in the North is also the country's border to Burkina Faso [23, 24] (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 [25].

The Pendjari Biosphere Reserve is established in tropical climate area in the Sudanian region with a seven months 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 [26].

The vegetation of the Pendjari Biosphere Reserve is a mixture of different savannah types, mostly open shrub and tree savannah [16, 26]. Small islands of dry forests are situated in the areas of former villages. Tree savannahs are dominated by genus *Combretum*, *Terminalia* (Combretaceae) and *Acacia* (Mimosaceae) while in flooded areas they are *Mitragyna inermis, Acacia sieberiana* and *Terminalia macroptera* in swampy savannah [27]. The Poaceae is the most representative family in all herbaceous stratums except gallery forest of Bondjagou. The main grass genera are *Andropogon* and *Hyparrhenia* [28]. In the periphery of the Pendjari Biosphere Reserve the landscape is dominated by fields and fallows.

The border of the Pendjari Biosphere Reserve is lined with about 20 small villages. Population density in this area is low (13 inhabitants per km2) compared with the whole country and it is estimated at 30,000 inhabitants [29].

3.2. Data Collection and Analysis

Firstly, 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.

Secondly, 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 Pendjari Biosphere Reserve for two years (Fig. 2). The collection of data through two years provided multiple estimations of the production from each tree and also helped to take into account NTFPs prices variation. It permitted to address the temporal issue shown by Sheil and Wunder[20].The plots were sampled randomly using the Global Positioning System (GPS) and the vegetation map of the Pendjari Biosphere Reserve with the help of the reserve staff. This sampling method permitted to mitigate the probable effect of unequal distribution of plant diversity through the reserve on the NTFPs financial valuation assessment. The high number of plots investigated contrary to previous studies makes us comfortable for results generalization [18, 4]. The idea of choosing savannah in the Pendjari Biosphere Reserve is motivated by its richness in species which produce NTFPs and it's the main formation in the reserve [29].Given the regeneration capacity of harvested species for some NTFPs such as bark or root, we presented the annual financial value of revenue from NTFPs in contrary to some studies which determined their net present value [18, 14, 4].

For NTFPs financial value estimation, within sampled plots we enumerated in collaboration with local people all trees of 10 cm or greater DBH (Diameter at Breast Height). We recorded from all individuals data on DBH, height and crown size. To estimate the yield of fruits 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 samples for the whole tree production estimation. Species which were not in production were marked and their production estimated in the same manner 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 DBH we marked in each plot 5 quadrants of 10 x 10 m size (Fig. 2). Within the quadrants, we harvested and weighted all herbs and bushes used for their leaves, flowers, fruits, barks or roots during appropriate seasons. We determined the average quantity of NTFPs harvested from each species identified within the 5 quadrants and extrapolated to the plots. 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, shrubs and herbs [14].

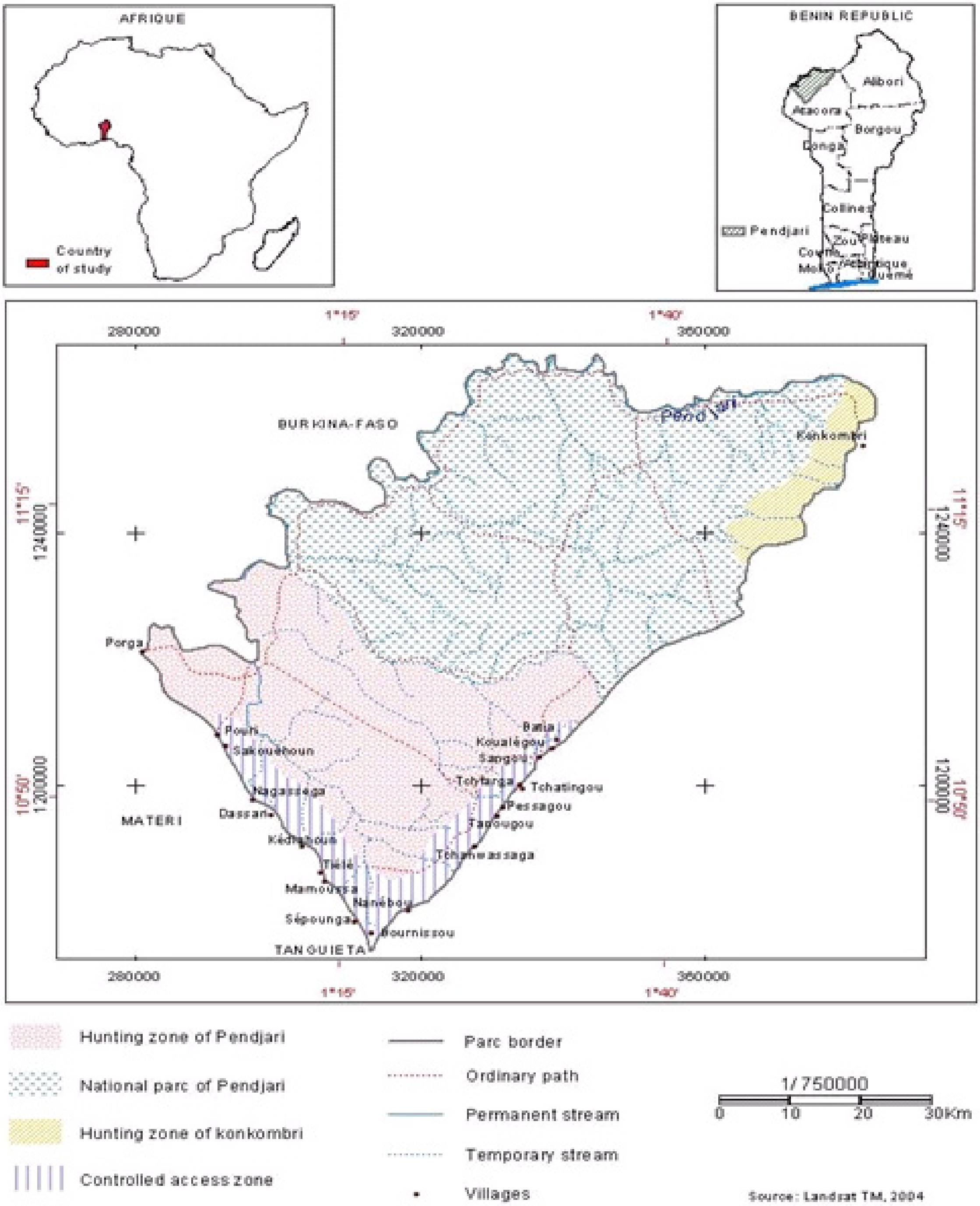


Figure 1. Maps showing the location of the study country Benin in West Africa as well as the study area Biosphere Reserve of Pendjari in Northern Benin. The Atakora chain is the southern border of the reserve whereas it is the Pendjari River which constitutes its north- western border..

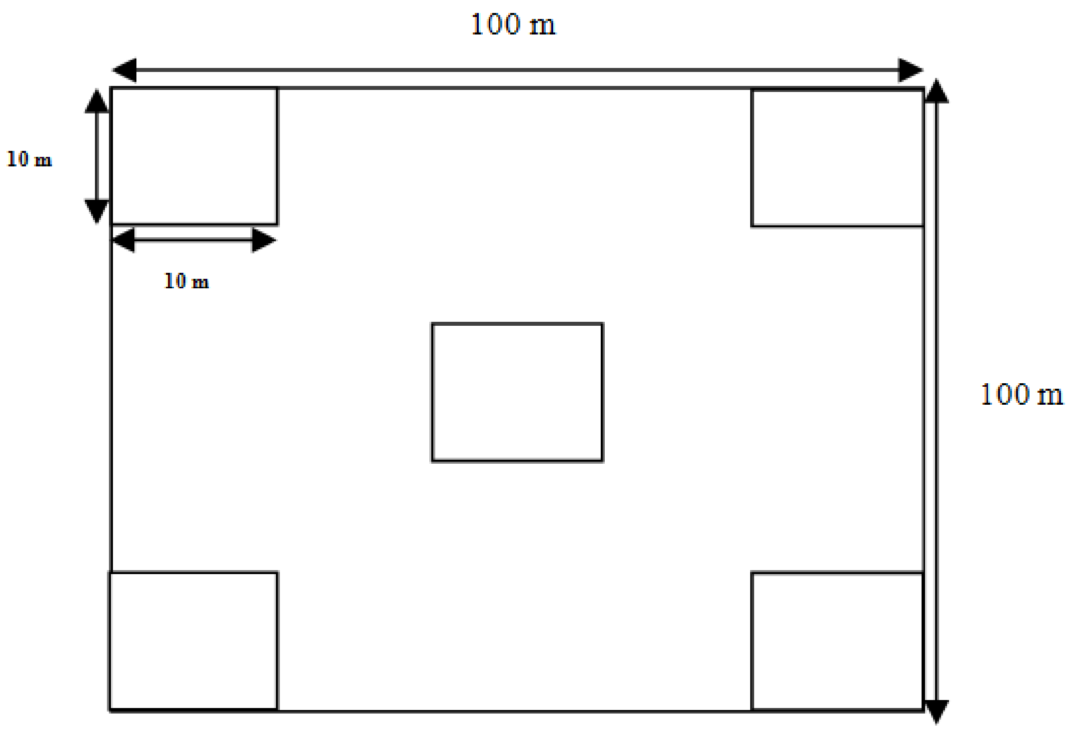
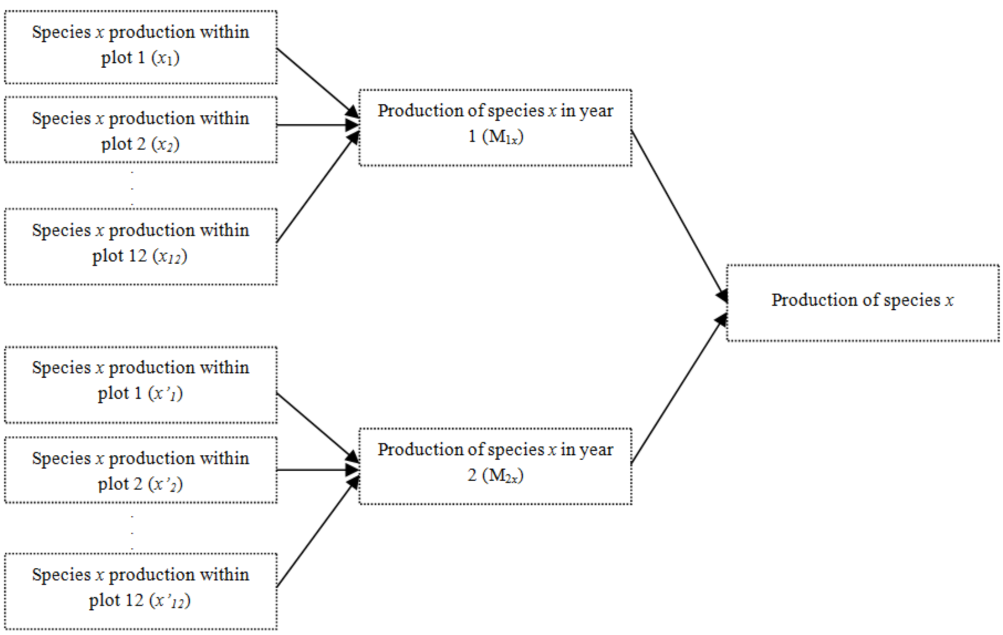


Figure 2. Sampling plots presentation



M1x and M2x are respectively the production of species x during year 1 and 2. There are obtained by summing up the production for each individual of species within the plots

x1 and x'1 are respectively the production of the individual 1of species x within the plot 1 during year 1 and 2. M1x = $\frac{\sum_{i=1}^{i=12}(x_1+x_2+x_3+\cdots+x_{12})}{12}$ (1)

Figure 3. Different steps followed to determine NTFPs production

Then, we determined for each species the mean production as shown in Fig. 3 and related equations. 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. During the data collection, each species identified as useful by local participant were sampled to make field herbarium and later identified taxonomically using an illustrated reference book of Arbonnier and Benin Analytic Flora [30, 31]. We conducted the taxonomic identification of species which were not identified directly in the field at the National Herbarium of Benin, at the University of Abomey-Calavi, where all plant species known to be native to Benin are conserved as voucher specimens. To have species use validated by the local 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 60 focus group discussions through the two years and about twenty men and women participated in each focus group discussion. Focus groups participants were randomly selected basing on their knowledge about useful species and their willingness to be involved in the study.

To assess the market value and cost of NTFPs extraction, we visited every two weeks the five most important markets in the study area (Tanguiéta, Matéri, Dassari, Porga and Tanongou) for ascertain the market prices of various products marketed. In our study area, the NTFPs commercialization is not controlled. We recorded the trading price for each item by the way of market observations. 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 revenues using equation 2. For multiuse species, we determined the gross revenue by summing up the trading value of each NTFP harvested from the species.

$$T1x = M1x * P1x \tag{2}$$

Let T_{1x}be the gross revenue obtained from species x, M_{1x}be the production of species x, and P_{1x} be the annual mean price of one kilogram of NTFP collected from species x during year 1.

In the study area, the major cost involved at the producer level is the time spent to collect NTFPs. People don't need to pay any royalty before to collect NTFPs. To calculate collecting time cost, we estimated by way of focus group discussions and field observation information on trips made to collect the item; hours spent on harvesting site and transport costs to home and from home to selling place. 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 (US$ 1=450 FCFA). Then, the net annual market value ($\prod_{1x}$) of NTFP obtained from species x during year 1 was determined as followed:

$$\prod_{1x} = T_{1x} - C_{1x} \tag{3}$$

WithT_{1x} the gross revenue obtained from species x during year 1 C1x the total cost involved in species product collection during the year 1

The net annual value (∏1) of NTFPs collected in year 1 on one hectare was:

$$\prod_1 = \prod_{1x}+\prod_{1y} + \ldots + \prod_{1n} \tag{4}$$

with n the total number of species identified∏1x, ∏1y and ∏1n the net annual market value of species x, y and n during year 1. The mean net annual value (∏t) of NTFPs collected in 1 ha was:

$$\prod_t = (\prod_1 + \prod_2) / 2 \tag{5}$$

with ∏1, ∏2, respectively the net annual market value of NTFPs during year 1 and 2

To estimate the net annual value of non-marketed NTFPs, we used the Contingent Valuation Method with open question. The Contingent Valuation Method is an example of a stated preference method which has been widely used to elicit people's preferences, especially in cases where there is no real market for a good [32, 33, 34, 35].Like any other economic methodology, contingent valuation has its limitations [36]. One of the main criticism that economists have leveled at the contingent valuation method has been that such willingness to pay estimates are inflated because respondents are prone to say yes too easily, perhaps just to please the interviewer (enumerator bias). Researchers have developed a number of ways to reduce this yea-saying tendency [37]. These ways include time-to-think experiments [38]. The hypothesis is that allowing the respondent to discuss the choice with other household members permit to receive adequate answer. In our case, by conducting the contingent valuation survey during focus group discussion we allow the respondent to discuss his willingness to pay for NTFPs harvesting with other local communities members before to answer. In the Pendjari Biosphere Reserve, the major part of NTFPs used was not commercialized [6]. People directly collect species products in the vegetation and use them for their daily subsistence. Therefore, for knowing the financial value assigned to one species leaves for example, we harvested and weighted a bundled of this organ and asked local people during the focus group discussions to know which amount of money they are agree to pay to someone who accepts to harvest this quantity of leaves for them. Information was also received on the time required for extraction. The focus group discussions were conducted in such a way that one participant answer can't affect others. While the question was asked to all participants, and times were given to them to interact, answers were recorded individually. 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 species value was estimated by subtracting from each value attributed to the non-marketed NTFPs the total cost involved in its collection. Then the net annual market value of species x for example ($\prod'_{1x}$) was obtained by summing up all values and divided by the number of responses (equation 6). This operation was done each year for non-marked species. Based on previous study in the Pendjari Biosphere Reserve which revealed that wealthier as well as poorer households were equally dependent on NTFPs [12], we assume that participant's socioeconomics characteristics cannot affect the value they ascribed to species.

$$\prod'1x = [(CV1-Ct1) + (CV2-Ct2) + (CV3-Ct3) + (CV4-Ct4)] / 4 \tag{6}$$

Where:

- $CV_1$and Ct_1 are respectively the value attributed to species during available period and the total cost needed for collection if the extraction site is far from the house,
- $CV_2$and Ct_2 are respectively the value attributed to species during unavailable period and the total cost needed for collection if the extraction site is far from the house,
- $CV_3$and Ct_3 are respectively the value attributed to species during available period and the total cost needed for collection if the extraction site is close to house,
- $CV_4$and $Ct_4$are respectively the value attributed to species during unavailable period and the total cost needed for collection if the extraction site is close to house.

3. Results

3.1. 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 in the Pendjari Biosphere Reserve (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 uses (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 %).

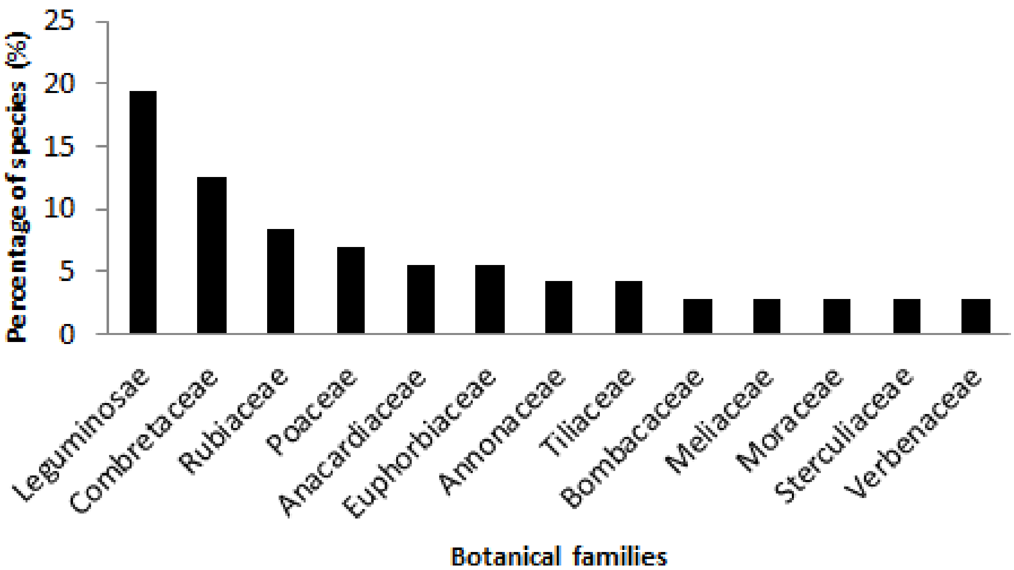


Figure 4. The most represented families in NTFPs identification. The number of species identified within these families varies from 2 to 14 species

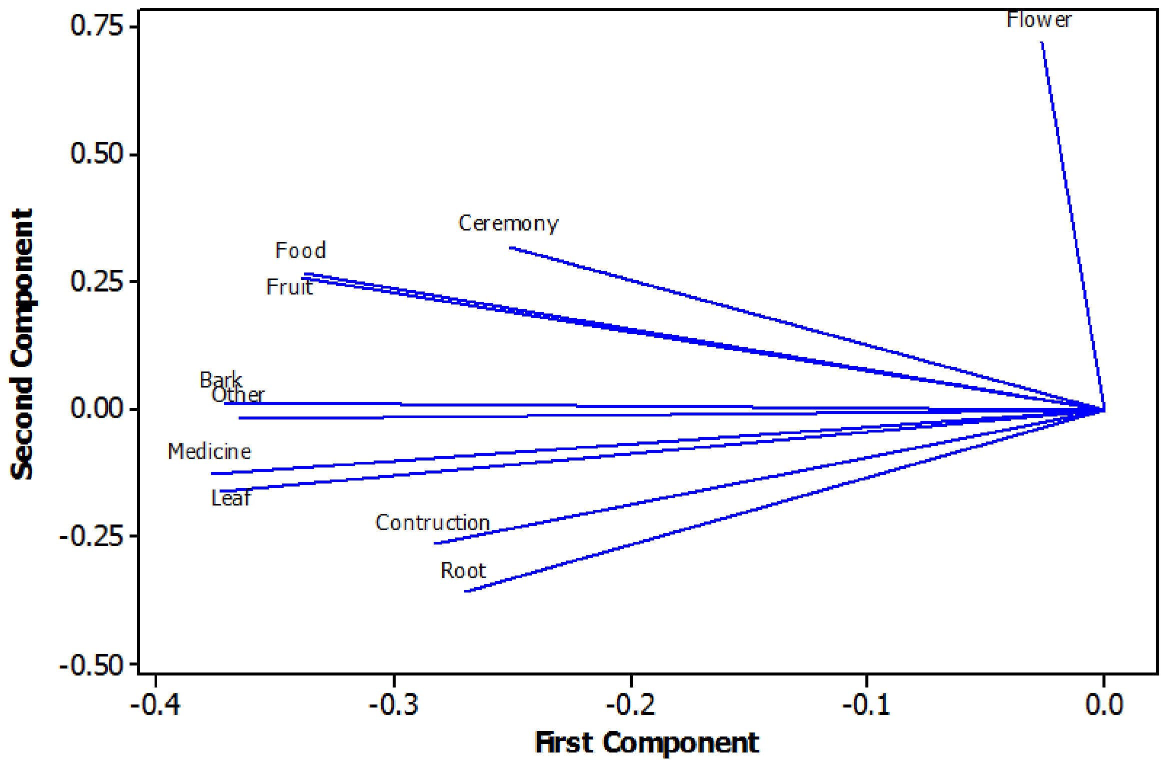


Figure 5. Projection of the different parts harvested from the species and their uses

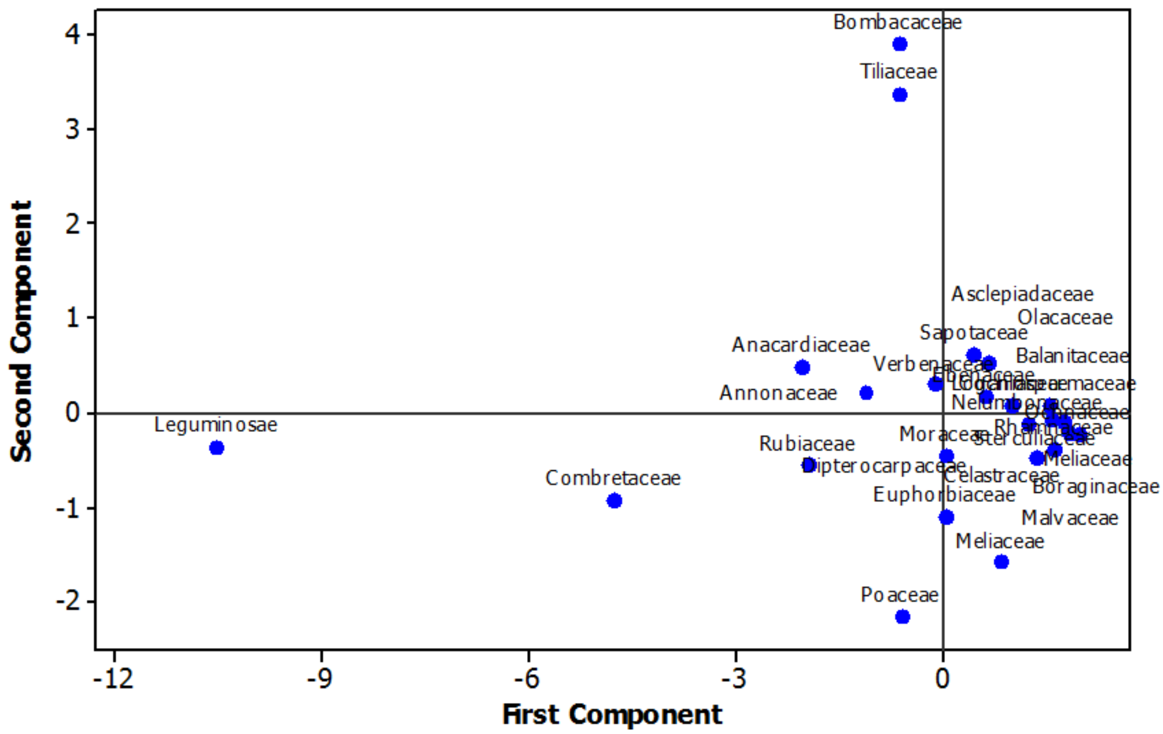


Figure 6. Projection of the species' families in the system axis defined by the principal components

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 parts (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 of Combretaceae and Leguminosae families were harvested for their leaves, fruits and bark used for medicine, food, toothbrush and art objects. Species of Bombacaceae and Tiliaceae families were harvested for flowers and were mainly used in traditional ceremonies.

3.2. Financial Valuation of Non-Timber Forest Products

The Net Annual Value of the Pendjari Biosphere Reserve savannah formation in NTFPs ($\prod_t$) was estimated to be 165 817 ± 9 127 FCFA/ha (US$ 368 ha^{-1}) (Appendix2). 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. laxiflora* were mainly used in traditional medicine. Only 48% of NTFPs identified within the plots were commercialized on local markets. Indeed, the Net Annual Value of NTFPs commercialized on the markets was estimated to be 79 595 ± 3 345 FCFA/ha (US$ 176 ha^{-1}) versus 86 225 ± 10 769 FCFA/ha (US$ 192 ha^{-1}) for non-commercialized species.

The most valuable products of the Pendjari Biosphere Reserve savannah are species leaves (74,002 ±478 FCFA/ha) followed by fruits (40,216 ±457 FCFA/ha) and roots (35,073 ±514 FCFA/ha) (Fig. 8).

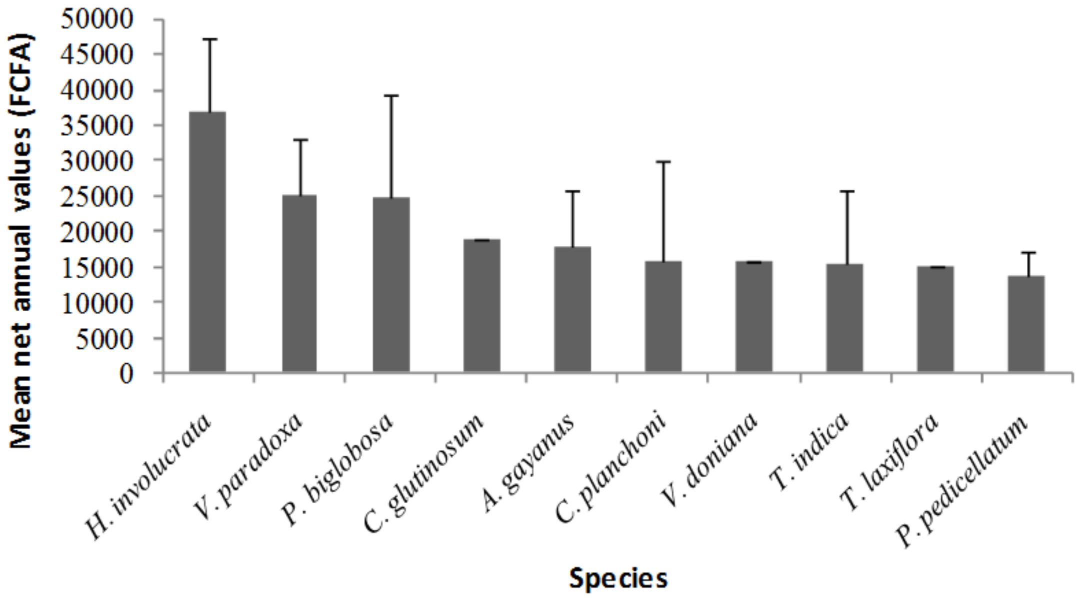


Figure 7. The ten most valuable species within savannah by the Pendjari Biosphere Reserve people

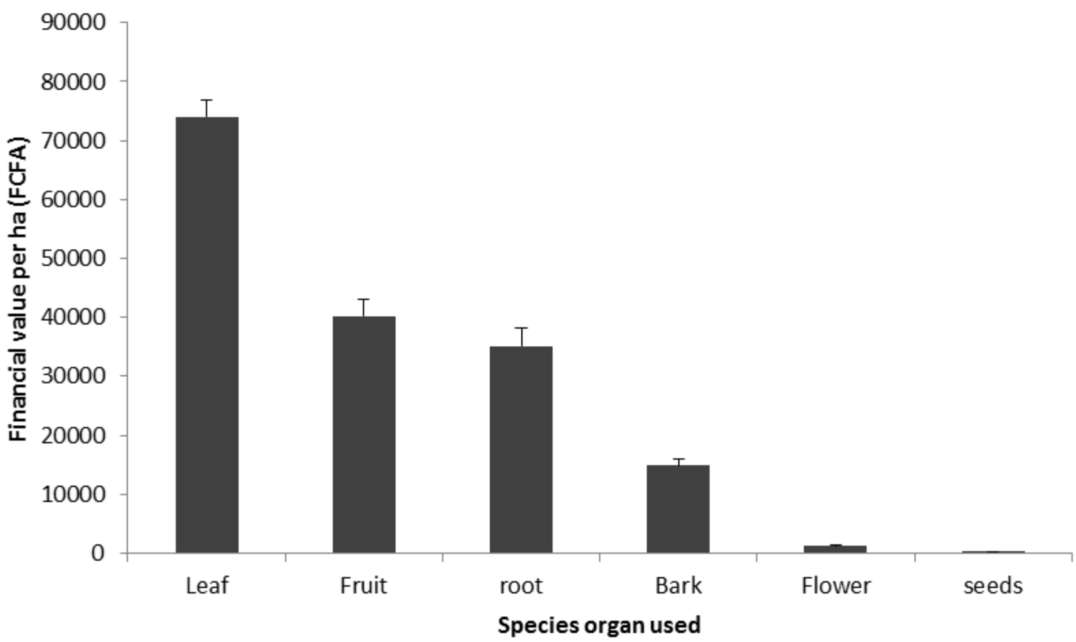


Figure 8. Valuable products within the Pendjari Biosphere Reserve savannah vegetation

4. Discussion and Conclusions

This study helped peasants know the benefits that they could gain in sustainable use of natural resource exploitation. It's a powerful tool to help the park responsible to increase local community awareness about biodiversity conservation within it. Even if the methodology used has already been under criticisms [e.g., 39, 21, 41, 19, 20], it provides a useful economic benchmark for comparing alternative land use practices and management options for the Pendjari Biosphere Reserve. Our methodology improved those used in previous studies [18, 14, 4] by providing multiple estimations of NTFPs production from each species through two years and also taking into account NTFPs prices variation. The high number of plots investigated also makes us comfortable for results generalization. Indeed, using our methodology, the financial value of savannah in NTFPs may depend on several factors from which the floristic composition of the vegetation, species density, people dependence on wild species and market demand for various plant [20, 4, 41].We address the two first issues by randomly sampling 12 plots of one hectare to estimate the financial valuation of savannah in NTFPs. Therefore, the standard error observed reflects the variation in the level of production from tree to tree and from year. From one year to another, some species production varies according to the climate, bush fire, and species phenology.

4.1. NTFPs Importance in Financial Valuation of Sudanian Savannah Vegetation

The study proved that NTFPs had important value in savannah financial value estimation. NTFPs have the potential to improve the livelihoods of people who depend on them for their basic needs and cash income. The economic importance of NTFPs is also perceptible considering the cost needed to collect them. 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. However, they need to harvest species products on a sustainable basis.

The net annual value of NTFPs harvesting in the Pendjari Biosphere Reserve (US$ 368 ha^{-1}) is higher than those obtained in India (net annual value= US$ 286 ha^{-1}; [4]) and Equador(US$ 115 ha^{-1}; [14]) but lower than the sustainable fruit and latex harvest in the Amazonian rain forest (US$ 650 ha^{-1}; [18]). As shown by Croitoru[41], 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 [42, 43].Contrary to previous studies [18, 14, 4],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 [18]in their study considered only commercial tree species occurring in one hectare but the high net annual value 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 22 review]. Grimes et al[14] considered in their valuation seven fruits, three medicinal barks, and one resin while Mahapatra and Tewari[4] included in their study only tree with 10 cm or greater DBH producing marketable NTFPs (10 trees, four shrubs, one grass and one climber species). The limited number of NTFPs included in the two last studies could explain the lower net annual value observed.

Despite the difference in methodology to explain various values observed, the high value per hectare of NTFPs in the Pendjari Biosphere Reserve is mostly a result of grazing benefits, which alone account for about 35% of the per hectare NTFPs value. The main reason which explains this is the kind of vegetation studied. Savannah is an ecosystem characterized by the trees widely spaced. In this kind of vegetation, the open canopy allows sufficient light to reach the ground to support an unbroken herbaceous. The dominant herbaceous component of the Pendjari Biosphere Reserve is intensively used in house construction. The importance of herbaceous component in savannah vegetation is probably one of the most important factors to explain the difference observed comparing our finding with previous studies. This result is consistent with finding from Croitoru[41] who conclude when comparing the potential of NTFPs in the Mediterranean region that the average estimate for northern and eastern countries are considerably lower than southern countries where grazing is the most benefit for countries. Therefore we can conclude that the vegetation type would be determining factor in tropical vegetation valuation.

Moreover, this study didn't take into account the non-use value of the Pendjari Biosphere Reserve Savannah such as CO_2 storing. Considering this value will increase sustainable NTFPs use value over other land use options such as land conservation for agriculture. Indeed, when a tree is cleared, greenhouse gas emissions are released into the atmosphere. Therefore, by accepting NTFPs sustainable uses which more protect the Pendjari Biosphere Reserve vegetation, local people could benefit from the Reduction of greenhouse gas emissions into the atmosphere due to Deforestation or forest Degradation (REDD) support. Indeed, the REDD program can economically compensate local people that decide not to cut down forests for agriculture, cattle farming, mining, and other activities, and instead conserve the standing forest by using in a sustainable way, such as low-impact forest management, ecotourism, use of NTFP, and environmental services.

However it is very important to put this NTFPs valuation into perspective. The net annual value determined here is just the potential value of the Sudanian savannah in NTFPs. All NTFPs recorded and involved in this valuation are not marketed and for those marketed; the local markets demand cannot covert the supply if local communities decide to considerably increase their exploitation. Indeed, despite the high NTFPs potential for improving the livelihoods of local communities who depend on them, the promotion of their exploitation are faced many difficulties. As shown by Ros-Tonen [44], among these are lack of information on potential market and marketing channels, the fragmented nature of NTFP markets, the unpredictability of the production cycles, resulting in irregular supplies. These difficulties could explain why local communities don't actually derive the high potential incomes from these products and are still interested by other use such as land conversion into agriculture although NTFPs value exceeds this land use option. Similar remarks had been made by Mahapatra and Tewari[4] who gave as reasons the seasonal nature of NTFPs which do not provide an income throughout the year, the market demand for many items which fluctuates between years causing uncertainty in demand and price and the increase in the rural population and numbers of forest users which led to reduction in the extraction and return per household.

4.2. Implication for Conservation

The NTFPs financial valuation made in this study provide the useful information for comparing land use practices in West Africa. Results clearly show that NTFPs could contribute importantly 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 current adverse criticism on environmental impact of park land conversion into agriculture, a NTFP focused management system can be considered economically viable management option.

We agree with Ros-Tonen [44] 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 Pendjari Biosphere Reserve, we could be delighted at the thought that species are mainly used for their leaves. According to Cunningham [45], 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 [44]. Therefore, there is a need to know more about useful species availability, biology and reaction to harvesting impact, especially for those exploited for their roots, flowers or fruits.

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Appendix

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.		Leaf, bark, root, fruit	2,3
Lannea microcarpa Engl. K. Krause	Anacardiaceae	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.		Leaf, bark, root	1,2,4,5
Hexalobus monopetalus (A.Rich.) Engl. & Diels	Annonaceae	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.		Leaf, bark	2
Flueggea virosa Willd.	Euphorbiaceae	Leaf, root	2,4,5
Hymenocardia acida Tul.		Leaf, bark, root	2
Phyllanthus amarus L.		Leaf, root	2
Acacia gourmaensis A.Chev.		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
Danniellia oliveri (Rolfe) Hutch. & Dalziel		Leaf, bark, root	2,4,5
Dichrostachys cinerea (L.) Wight & Arn.		Leaf, bark	2,4,5
Entada africana (Guill. & Perr.)	Leguminosae	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

Food (1); Medicinal (2); Ceremony (3); Construction (4); Other (5)

Appendix 2. Financial value of NTFPs in one hectare of savannah formation

	PLOTS (1 ha)																								∏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-1)	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
∏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-1)	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	
∏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		

US$ 1 = 450 FCFA

∏t : Global Net Market Value (FCFA) +/- Standard Error

∏1 and ∏2 : respectively Net Annual Market Value during year 1 and 2

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