The Bouaflé Protected Forest conservation, in Côte d'Ivoire: Estimating the Total Economic Value.

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Abstract

Forests are disappearing over time. According to FAO (2005), deforestation is responsible for the loss of 13 million hectares of the world's forests. Africa is the most affected continent. Data covering the period 1990-2000 shows that the highest rate of deforestation is in Africa 0.8%, before Latin America with 0.4%, and Asia with 0.1% (Naoto, 2006). South America and Africa are still ranked first in deforestation rates today, with 4 million hectares and 3.4 million hectares respectively recorded per year between 2000 and 2010. However, forests are recognized for their role in the ecosystem balance. They participate in the hydrological cycle, Carbone cycle and biodiversity conservation. It's worth to estimate the value of the forest.

In order to evaluate the total benefits, we used the contingent valuation method, especially the willingness to pay method for local population direct benefits estimation. A questionnaire was addressed to 159 households inside and around the Bouaflé protected forest. We measured their median and mean WTP estimated to 1000 CFA FRANCS (~ 1.5 Euros ~ 2$) and 1658.491 CFA FRANCS (~2.53 Euros~ 3$) respectively. Next, the raw material production was an estimate provided in SODEFOR plans. Then, the indirect benefits were computed. The non-use value was approximated using estimates of tropical forests-related benefits per hectare provided in the literature as a proxy. The indirect benefits encompassing climate regulation; disturbance regulation and water regulation; erosion control and sediment retention; soil formation; nutrient cycling; waste treatment; genetic resources were 2,579 million; 57.83 million; 69.39 million; 2,833 million; 115.66 million; 10,664 million; 1,006 million; 474.21 million respectively (all in CFA FRANCS and per year). The carbon sequestration was estimated to 56,425 million CFA FRANCS/ha/year based on an annual estimate per hectare for the Ivorian forests in the literature. Water supply computed based on an annual estimate of the groundwater replenishment, is 461,800 CFA FRANCS billion/year. This study is a scientific justification of forests conservation based on a local case-study from West Africa. The study implies rural population participation in forests conservation by developing and promoting some best practices like the use of cook stoves, intensive agriculture, and ecological tourism for a sustainable management of forests.

Key words: Protected forest, TEV, Willingness to Pay, climate change mitigation.

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Résumé

Les forêts disparaissent progressivement. Selon la FAO (2005), la déforestation est responsable de la perte de 13 millions d'hectares de forêts dans le monde. L'Afrique est le continent le plus touché. Les données couvrant la période 1990-2000 montrent que le taux le plus élevé de déforestation est en Afrique 0,8%, devant l'Amérique latine avec 0,4%, et l'Asie avec 0,1% (Naoto, 2006). L'Amérique du Sud et l'Afrique se classent aujourd'hui au premier rang des regions où les taux de déforestation sont les plus élevés, avec 4 millions d'hectares et 3,4 millions d'hectares respectivement enregistrés par an entre 2000 et 2010. Cependant, les forêts sont reconnues pour leur rôle dans l'équilibre des écosystèmes. Ils participent au cycle hydrologique, au cycle Carbone et à la conservation de la biodiversité. Il est donc impérieux d'estimer la valeur de la forêt.

Afin d'évaluer les avantages totaux, nous avons utilisé la méthode d'évaluation contingente, en particulier la méthode du consentement à payer (CAP) pour l'estimation des avantages directs de la population locale. Un questionnaire a été adressé à 159 ménages à l'intérieur et autour de la forêt classée de Bouaflé. Nous avons mesuré leur CAP médian et moyen estimé à 1000 FRANCS CFA (1,5 euro et 2$) et 1658,491 FRANCS CFA (2,53 euros et 3$) respectivement. À cela s'ajoute la production de matières premières qui est une estimation fournie dans les plans de la SODEFOR. Ensuite, les avantages indirects ont été calculés. La valeur de non-usage a été estimée à l'aide d'estimations des avantages liés aux forêts tropicales par hectare fournies dans la littérature comme indicateur. Les avantages indirects, à savoir la réglementation climatique ; réglementation des perturbations et de l'eau ; la lutte contre l'érosion et la rétention des sédiments ; la formation du sol ; le cycle des nutriments; le traitement des déchets; les ressources génétiques sont estimées respectivement à 2 579 millions; 57,83 millions ; 69,39 millions; 2 833 millions; 115,66 millions; 10 664 millions; 1 006 millions; 474,21 millions respectivement (tous en FRANCS CFA et par an). La séquestration du carbone a été estimée à 56 425 millions de FRANCS CFA/ha/an sur la base d'une estimation annuelle par hectare pour les forêts ivoiriennes dans la littérature. L'approvisionnement en eau, calculée sur la base d'une estimation annuelle de la recharge des eaux souterraines, est de 461 800 milliards FFRANCS CFA /an. Cette étude est une justification scientifique de la conservation des forêts basée sur une étude de cas d'une forêt classée d'Afrique de l'Ouest. Nous recommandons la participation de la population rurale à la conservation des forêts en développant et en promouvant de bonnes pratiques comme les foyers améliorés, l'agriculture intensive et le tourisme écologique pour une gestion durable des forêts.

Mots clés: Forêt classée, Valeur Économique Totale, Consentement à payer (CAP), atténuation du changement climatique.

Introduction

'Forest' has different definitions depending on the concerning actor. The Food and Agriculture Organization of the United Nations (FAO) considers forest to be "land with a tree canopy cover of more than 10%, which has a larger area than 0.5 ha and is not specifically under a non-forest land use" (FAO, 2001). Clear-felled land that can be used for re-planting are considered as forest land. Forest classification includes also higher canopy cover extending from 10% to 30% as "sparse trees and parkland" (UNEP-WCMC, 2000). According to FAO (2005), deforestation is responsible for the loss of 13 million hectares of the world's forests. Africa is the most affected continent. Data covering the period 1990-2000 shows that the highest rate of deforestation is in Africa 0.8%, before Latin America with 0.4%, and Asia with 0.1% (Naoto, 2006). South America and Africa are still ranked first in deforestation rates today, with 4 million hectares and 3.4 million hectares respectively recorded per year between 2000 and 2010.

As is the case of other countries in West Africa, Côte d'Ivoire has suffered severe deforestation.

Since the 1960s, Côte d'Ivoire's total forest area has fallen from around 16 million hectares to 4 million hectares (FAO, 1999). Moron (1994) estimated that this rate of forest reduction is close to 90%. Côte d'Ivoire is ranked at the top of the most deforested tropical African countries. In 2005, the primary forest represented less than 2 % of the country's land area, while less than a third of Côte d'Ivoire was forested at all. More recently (1990-2007), the annual rate of depletion was estimated at 3.1%, confirming that Côte d'Ivoire has one of the highest rates of deforestation in West Africa (Beke, 2010). If nothing is done to regulate forest loss, the state of forest in Côte d'Ivoire will worsen.

Forest conservation is an important issue worldwide. The Food and Agricultural Organisation (FAO) reports that the most diverse terrestrial ecosystems are located in primary forests, especially tropical moist forests (FAO 2010). Since forests store carbon, their destruction releases greenhouse gases (GHGs) into the atmosphere, at the rate of one fifth of the global anthropogenic GHGs emissions and so contribute to global warming. Deforestation is classified second for carbon emissions after fossil-fuel combustion. It contributes to between 12

and 20% of global carbon dioxide into the atmosphere. Forest conservation should be included in mitigation of global warming schemes at an international level (Van der Werf, 2009).

In order to address the issue of deforestation, many actions are taken globally and locally, one of which is the implementation of protected areas within countries. Forest conservation measures put restrictions on the access of local communities to forest services. However, local communities supplement their daily livelihood from forests resources, especially from timber and non-timber forest products. Tropical forests are a major income source for these communities and they contribute between 20% and 40% of total household income for people living in forest areas. The dependence on forest-related services is higher for the poor population, especially on fuel wood and fodder.

The current study estimates the benefits of the Bouaflé protected forest conservation. It focuses on the Bouaflé protected forest (*forêt classée de Bouaflé*) located in the western part of Côte d'Ivoire. The forest is 20350 ha and was made a protected forest in 1974. It is one of the most deforested protected areas in the country.

The methodology applied was the Total Economic Value developed by Pearce (1990). The forest direct benefits were evaluated using a contingent valuation approach, particularly the Willingness to Pay (WTP) methodology added to data on timber production and the indirect benefits were computed. We evaluate the non-use value, using estimates provided in the literature.

1. Context

Côte d'Ivoire with a surface area of 322,463 km^2, is in Sub-Saharan Africa precisely in West Africa. Geographically, Côte d'Ivoire is between the 4°30' and 10°30' N latitude and between 2°30' and 8°30' W Longitude.

1.1 The state of the forest in the country

The country is shared in two parts by the 8th Parallel. The Northern part from the 8th parallel is the savannah area. The Southern part of the country up to the 8th parallel constitutes the forest area. This part is covered by wet forest (*forêt dense humide sempervirente et forêt mésophile*). Some specific types of the Ivorian forests are the mountain forests at the border with

Guinea and the mangroves at the coastal areas. It encompasses guinea savannah which has been replaced mostly by export plantations such as palm trees, coconut trees, and rubber trees. The forest area covered by primary forests has been converted to secondary forests mostly, many fallow and savannah lands. Little primary forest remains. The forest land area has collapsed since the 19s. In fact, from 16 million ha of forests in 1900, the primary forest has shifted to 12 million ha in 1960, down to not more than 4 million ha today. The remaining natural forest is around 10 % of the country land surface.

1.2 The Ivorian protected areas: institutional framework

In Côte d'Ivoire, two types of protected areas exist. On one hand, there are national parks and reserves. On the other hand, there are "protected forest" (called in French, "forêts classées"). Each category has a specific aim assigned by the State of Côte d'Ivoire. The first category is implemented for biological diversity conservation. The second category is created for forest conservation and sustainable management.

The national parks and reserves are under the responsibility of the ministry of environment. They are managed by a state-owned company named OIPR (*Office Ivoirien des Parcs et Réserves*). National parks and reserves are either for the conservation of the fauna, either for the conservation of the flora. They could be located in forest areas or savannah regions. National parks could be subject to tourism activities, but reserves cannot. The protected forests are under the responsibility of the ministry of Water and Forests and managed by another state-owned company named SODEFOR (*Société de dévéloppement des forêts*).

The main difference between these two types of protected areas is related to the nature of the protection. The national parks and reserve benefit from strict protection. The rising of an area to the status of national park or reserve is definitive, irreversible whereas the implementation of a "protected forest" is more flexible and could change over time. The government could decide to "declassify" all or one part of the protected forest for some reasons such as exponential demographic growth for example. Protected forests are subject to wood trade regulated by the government through SODEFOR to ensure a sustainable management of the forest.

The permanent forest area of Côte d'Ivoire represents approximatively 8% of the country land area, which is estimated to be 6,267,730 ha. It encompasses protected forests, National

parks, reserves and perimeters for protection. The permanent forest area is broken down as follow, 231 protected forests covering 4,196,000 ha; eight (8) national parks and five (5) reserves covering a total of 2,071,730 ha. The protected forests are affected by degradation and exposed to anthropological activities like plantations and illegal settlements of rural population.

On the opposite side, there is the rural domain which represents 70% of the national territory. The rural domain is the most affected forest part, now evaluated between 2 and 3 million ha of forests. The rural domain is the supplier for agriculture and wood exploitation. It provides 90% of total wood manufactured. In this area, there is no need for certification in order to proceed to reclamation for new agricultural land. Agriculture has the priority of the land disposal.

2. Litterature review

Forests play an important role in the hydrological process and Carbone cycle. Hetherington (1987) supports the effects of forests in the water cycle through evaporation, transpiration, soil freezing and the stock of snow. In fact, the reducing forest cover leads to an increasing amount of solar radiation that reaches the ground, since forest that could act as an intercept is lacking. The declining forest cover decreases soil moisture and reduces soil storage capacity. So, water availability for stream flow is increased.

Moreover, protected areas are recognised for their role in providing good quantity and quality of water. There is an attempt to monetarise these water-related benefits of forests. In fact, Athanas A. et al (2001) valuated the role of China's forests in storing water to be 7.5 trillion yuan at the country level. This estimate is three times the value of the timber of the Chinese forests. Emerton L. (2001) estimated to more than $US 20 million the water related benefits of the Mount Kenya forest which covers 130,559 ha. This forest protects the catchment of two of the main rivers of the country (Tana and Ewaso Ngiro) and so, contribute to their recharge.

Hein (2011) working on the benefits provided by Hoge Veluwe forest in Netherlands valuates the benefits in term of water provided by that forest. By using the replacement costs method, the author measures the avoided costs of maintaining the forest for groundwater supply. In fact, application of the replacement cost approach was based on 3 assumptions described by NRC (2004). First, an alternative does exist that supply a similar service. Second, drinking water users would opt for that alternative in case the forest does not provide this service. Third, this

alternative service is the most cost-effective one. The study reveals that the alternative to infiltration service provided by the forest is using water from the closest river and purifies it to get drinking water. Data justify the average incremental cost of 0.41 Euros per m^3. This price was applied to the total amount of groundwater supply by the forest of 16.8 million m^3/year among them 29% is used for producing drinking water. The economic value of the infiltration service of the Hoge Veluwe forest was evaluated to be 1.95 million Euros per year.

Among other valuation technics used to valuate environmental benefits, CVM is widely used. In fact, when we are evaluating directly the total economic value of an ecosystem, CVM is the appropriate method (Lescuyer, 1998). The popularity of CVM is related to some of its advantages. First, CVM provides directly a monetary valuation of the environmental commodity. Second, CVM gives the monetary valuation of non-use values. Since it is difficult to capture the non-use values of the environmental good based on the market which does not exist sometime, CVM helps capture these components. Third, CVM is a flexible technique. It allows an ex-ante valuation. CVM valuates the benefits related to the environmental good according to some scenarios. These states of nature do not need to occur before the valuation is possible. CVM can also help in policy decision-making.

Forests are widely recognized for their role in the Carbon cycle. This role is revealed in climate change mitigation processes occurring through carbon emission reduction by preventing deforestation and forest degradation on one hand; and through carbon capture by mechanisms such as afforestation and sustainable forest management on the other hand. (FAO 2010)

Forests contribute to climate change mitigation by absorbing carbon emitted by anthropogenic activities. This ability of forests to store Carbon will lead to the reduction of the stock of Carbon into the atmosphere. Climate change is less likely to occur in such conditions. Conversely, deforestation releases Greenhouse gases into the atmosphere and so contributes to climate change.

3. Methodology

3.1. Theoretical model

In order to access the benefits, we will follow the Total Economic Value (TEV) approach developed by Pearce (1990). This approach tries to attribute economic values for both present and future uses of the protected areas. Generally, TEV is split up as follow:

TEV = UV + NUV

such as **UV = DUV + IUV+OV**

NUV = EV+BV+ QOV

where

TEV: Total Economic Value

UV: Use Value

NUV: Non-Use Value

DUV: Direct Use Value

IUV: Indirect Use Value

OV: option value

EV: Existence Value

BV: Bequest value

QOV: Quasi-Option Values

3.2 Benefits approaches used

Three main approaches were used for benefits valuation. First the contingent valuation method, especially the willingness to pay was applied for direct use value estimation, to which we add data on timber production. Second, we use some computation to determine the indirect use value (Carbone sequestration and water supply). Third, the estimates per ha provided in the literature were used as a proxy to valuate non-use value of the protected forest.

We applied the following steps for the contingent valuation method which are justification of the method; method implementation; description of the environmental quality; contingent market description; Willingness to pay question and socio-demographic characteristics of the respondents. The method implementation has followed three steps. First, we described the environmental quality. Second, we asked for the willingness to pay of the respondents. Third, we asked for the socio-demographic characteristics of the respondents. In order to capture the environmental quality in our case study we asked some questions to the respondents related to the importance of the Bouaflé protected forest. These questions reveal the perception of the population of the forest-related benefits to them. The current state of the conservation is that local people supplement their daily livelihoods with forest-based products. Forest provides them food, fuelwood and medicines. Forest provides rainfall and reduces the local heat. Forest provides fertile soil. Bush meat is not more consumed because the Government made a law to forbid all the activities related to bush meat as a measure to prevent the Ebola disease. As a contingent market, we design a hypothetical market such that the answers of the respondents could be the same as if they were on the real market. The payment mean they will use to express their WTP is the local currency CFA Franc (CFA F). It is a lump sum payment that would be used by the protected forest authorities to finance that forest conservation. For the willingness to pay question, we asked each household head of our sample population which amount he is willing to pay at most for the conservation of the Bouaflé protected forest so that it could still provide them the resources they mentioned. The WTP question was a discrete choice question. The socio-demographic characteristics of the respondents were addressed by collecting the following information on the respondents related to their social status: Marital status; age; sex; level of education (ability to read, to write, level at school); permanent residency; ethnic, origin, religion, household size, number of active persons per household. The economic information collected on the households were: current economic activities, main activity, second activity, source of financing of economic activities.

4. Results and discussion

4.1 Benefits estimation

This section includes the estimation of the forest benefits that include direct-use value, indirect-use value and non-use values.

The direct benefits of the Bouaflé protected forest was estimated using the Willingness to pay approach. For our sample size, the estimated values for the median WTP and mean WTP are 1000 CFA FRANCS (~ 1.5 euros ~ 2$) and 1658.491 CFA FRANCS (~2.53 euros~ 3$) respectively. Fifty percent of the households of the sample are able to pay the amount of 1000 CFA Francs. Our sample size of 5 localities represents 7516 inhabitants. On average, they are 6 individuals per slot. And we assume each slot to be a household for our computation. So, the number of households of our sample size is 1253 (in fact, 7516/6= 1252.66). Assuming this sample size represent 10% of the entire population of households around and inside of the Bouaflé protected forest, we deduce the entire population to be 12 530 households. The application of the median WTP amount of 1000 CFA Francs to the 12 530 households will result in a benefit of 12.53 million CFA Francs which corresponds to the benefit perceived by the population living around and inside the Bouaflé protected forest. To these benefits, we add the annual estimation of timber production provided in SODEFOR plans for the decade 2014-2023.

The direct benefits are evaluated by summing up the food production and timber production estimates. The food production was evaluated using the results of the contingent valuation study. So, the household Willingness to pay (1000 CFA FRANCS) times the number of households estimated (1250 households). The raw material was evaluated using the estimations of timber production of SODEFOR for the period 2014-2023.

Estimation of indirect benefits provided by the Bouaflé protected forest

The indirect benefits of the Bouaflé protected forest are the water supply; the carbon sequestration; the regulation services (climate regulation, disturbance regulation and water regulation); erosion control and sediment retention; soil formation; nutrient cycling; the waste treatment and genetic resources preservation.

The Bouaflé protected forest contributes to the groundwater replenishment. We will estimate in monetary term the benefits related to this ecosystem service. BGR/UNESCO (2008) provides an estimation of groundwater recharge of more than 100 mm for the region which encompasses our study area. According to Fiedler (2007), the Bouaflé protected forest belongs to the category of forests which recharge is between 100 and 300 mm. For the purpose of our study, we consider the mean value of the groundwater replenishment. We do the computation as follow: (100+300)/2=200. The amount of groundwater refilled (Q) is determined as follow:

Q= S*R Where:

S refers to the surface of the forest (in m^2)

R refers to the recharge or refill of the groundwater (in m)

In this case study the surface of the forest land is 20,350 ha so 203,500,000 m^2 by conversion (1ha equals 10,000 m^2). The refill of the groundwater is 200 mm so 0.2 m by conversion (ie. 1 mm= 0.001 m). Finally Q= 203,500,000*0.2= 40,700,000 m^3. For the monetary valuation, we used a shadow price which is the market price of the company in charge of the treatment and distribution of water in the country named SODECI (*Société de dévelopement de l'eau en Côte d'Ivoire*). The price is 403.3 CFA FRANCS per m^3. The amount of groundwater recharge times the shadow price of 403.3 CFA FRANCS provide the value of the water related benefits of the Bouaflé protected forest which is 461,800 billion CFA FRANCS.

Protected forests are also recognised for their role in Carbon emission reduction and sequestration. The increase in Carbon emission is regarded as the main cause of Global warming, the current manifestation of Climate Change. The negative impact of Climate Change

and the increase of Carbon stock into the atmosphere is matter of international concern. Strategies to reduce Carbon emission or to increase Carbon sequestration into biomass and soils should be considered. This idea is referred to by “Land use and land use change and forestry” by the articles 3.3 and 3.4 of the Kyoto Protocol (IPCC, 2000).

Forests sequester Carbon through five compartments which are the aboveground biomass (trunks; branches; leaves; climbers; lianas and shrubs); the underground biomass (in the roots); dead organic matter; litter and soils (IPCC, 2006). Soils capture more Carbon than vegetation (650 Pg) and the atmosphere (750 Pg). There are two types of Carbon flows between the soils and the atmosphere which are positive flow (sequestration) or negative flow (emission). Sequestration refers to Carbon captured or kept in the soil, whereas emission refers to Carbon released or rejected into the atmosphere. Methods for Carbon sequestration valuation include the terrestrial ones (survey, allomeric equation) and the aerial ones (GIS, satellite images)

Zian G.A. (2012) used an allometric model to estimate the stock of Carbon in the Tai National Park in Côte d’Ivoire. He used three ecosystems samples (Eco 1, Eco 2 and Eco 3). Eco 1 represents an old secondary forest and Eco 2 is a primary forest while Eco 3 is an agricultural ecosystem which encompasses dominantly cocoa trees. All the species with a DBH (Diameter at Breast Height) higher than 10 cm in the forests placettes and higher than 5 cm in the cocoa farms were used for the analysis. These species were identified and measured. It results that the estimated carbon stock was on average 134,9±18,3; 174,7±26,3; 41,3±1,4 (ton C/ha) for the ecosystems Eco 1; Eco 2 and Eco 3 respectively.

FAO (2011) in its inventory of forest Carbon stock of countries worldwide estimated for Côte d’Ivoire 177 ton C/ha. So, the country had the highest Carbon stock in Africa. Depending on the method of Carbon stock measurement applied, the result could be different. In fact, according to PNUE/ WCMC (2010) Ivorian forests and protected forests have less Carbon sequestration capacity. The reason is the methodology applied based on GIS which under-valuates the stock of Carbon and biomass. Satellite images do not capture biomass under the canopy level. It results a minimal estimation of the Carbon stock by GIS method.

Hein (2011) trying to evaluate the Carbon related benefits of the Hoge Veluwe forest in Netherland, proceeds by the avoided costs approach. The author estimates to 0.31 ton C/ha/year so 900 ton C/year. This total amount of Carbon stored above-ground in the biomass is

equivalent to 3280 ton CO2 /year. For the appropriate price of CO2 to consider, the author referred to the review of studies of Tol (2005) aimed to analyse the marginal costs related to Carbon dioxide emissions. The latter deduces a marginal damage costs likely to be lower than US$14/ton CO2 (or $50/ ton C). The author assumed a social discount rate of around 4% to 5% referring to government discount rates applied to long term investments. Stern (2008) was in favour of a lower discount rate. He suggests prices amounting to US$ 30/ton CO2. Hein (2011) made the assumption of a marginal damage cost per ton of CO2 of 10 Euros. Based on this unit value estimate of Carbon sequestration, the total Carbon sequestration estimated in above-ground biomass in that forest is evaluated to 32,800 Euros. The issue is that this value does not include the Carbon sequestered in soils and wood.

For our study area, we used the estimate of Carbon sequestration provided by FAO (2011) which is 177 ton C/ha. This estimate is converted into CO2 equivalent by applying the factor 3.67. Then we apply the average price per ton of Carbone equivalent used by Capoor and Ambrosi (2006) for Certified Emission Reductions (CERs) which equals $7.51 per ton. The per hectare resulting estimate of Carbon sequestration comes to $4878. This value times the total area of the protected forest is 56.425 billion CFA FRANCS.

The regulation service encompasses Climate regulation, disturbance regulation and water regulation. The climate regulation refers to the regulation of precipitation and temperature and also some climatic processes occurring at global and local scales. Disturbance regulation refers to the capacity of the vegetation cover to control the habitat in the ecosystem through flood prevention or drought recovery. The water regulation refers to the regulation of the flows of water for human activity (agriculture or industry). The water supply refers to the ability of forests to absorb and maintain water underground. Erosion control and sediment retention is the ability of the forest to lay as a barrier to wind and runoff, then avoiding erosion. Soil formation encompasses the process of decomposition of rocks and the gathering of organic matter which result in new layers of soil. Nutrient cycling refers to all the process including nutrients, their uptake and release allowed by the vegetation structure. Waste treatment refers to the capacity of the forest to capture waste particles and contribute to purify the air and the soil. Genetic resources refers to the capacity of the forest to provide genes that could be used in medicine or science development.

The regulation services were estimated by using the estimates described in the study of Costanza et al (1997). This study provides the estimates per hectare for tropical forest- related benefits. Each estimate times the surface of the Bouaflé protected forest results in the monetary value of that related benefits. These estimates are for climate regulation, disturbance regulation and water regulation $223: $5 and $6 respectively. For erosion control and sediment retention; soil formation; nutrient cycling; waste treatment; genetic resources, the monetary estimates are $245; $10; $922; $87 and $41 respectively.

Table 4. benefits of the Bouaflé protected forest

ecosystem good or service	**Values for tropical forests ($/ha)**	**Values for tropical forests (CFA FRANCS/ha)**	**Total value (billion CFA FRANCS)**
Climate regulation (**)	223	126746,51	2.57
Disturbance regulation (**)	5	2841,85	0.057
water regulation (**)	6	3410,22	0.069
Water supply (***)		22692898516	4.618E+5
erosion control and sediment retention (**)	245	139250,65	2.833
Soil formation (**)	10	5683,7	0.115
Nutrient cycling (**)	922	524037,14	10.664

Waste treatment (**)	87	49448,19	1.006
genetic resources (**)	41	23303,17	0.474
Carbon sequestration (****)	4878,4209	2772748,087	56.425
IUV+ NUV			461800
DUV			608.59
TEV			462408.59

Source : Constanza et al (1997) ; Krieger. D.J. (2001) (**);

P. D¨oll, K. Fiedler (2007); BGR/UNESCO (2008) (***);

FAO(2011); Capoor, K., and P. Ambrosi (2006) (****)

4.2 Discussions

The estimated TEV reveals that Forest conservation contribute to huge benefits; locally and globally**.**

The WTP was estimated to 1000 CFA FRANCS (~ 1.5 euros ~ 2$) and 1658.491 CFA FRANCS (~2.53 euros~ 3$) for median and mean values respectively. We used the median value for aggregating the direct benefit in term of food production provided by the protected forest. The median amount has the advantage of being less influenced by extreme values (high bids). In fact, 50% of the household of our sample are willing to pay 1000 CFA Francs for the conservation. If we want to apply the WTP value for policy purposes, the median amount is expected to be approved by at least 50 % of our sample individuals.

The current study suggests some policy implications:

The government should also invest in ecological civism. A positive change in behaviors could occur by sensitizing local people on the consequences of their actions on the environmental services provided by forest to them.

The government should promote ecological tourism. Ecological tourism activities will develop new type of returns for local people. By increasing their revenue due to the existence of the forests, the local people interest in the forest conservation will increase.

Famers should practice intensive agriculture, which consists in producing more by using less land. In fact, local people look for new lands for agriculture activities extension. These anthropogenic actions contribute to reduce the forest area and threaten forests-related services to the population. Promoting intensive agriculture will reduce the pressure on forests land for agricultural activities.

Another approach could be a participatory conservation where local people could act for forest conservation. The government should encourage local population participation in conservation measures design and implementation. There are several available measures of forests conservation adapted to poor people and that have shown their efficiency in forest conservation (Cookstoves, NTFP, Biofuel production using cow dungs). Local people should appropriate conservation measures. They need to be sensitized and trained to some good practices, so that they could adopt them easily. This could lead to a sustainable management of the forest.

Conclusion

Protected forests are widely spread and recognised for their multiple functions related to climate, ecology and people. They intervene in climate change mitigation through carbon sequestration and also aim to conserve biodiversity. When it comes to their benefits to local population, empirical studies are scarce.

The present dissertation aims to measure the TEV of the Bouaflé protected forest. Specifically, this study answered to the following questions:

- What is the WTP for conserving the Bouaflé protected forest?
- What are the UV, and NUV of conserving the Bouaflé protected forest?

We estimated the direct benefits of forest conservation using the contingent valuation approach, particularly the Willingness to Pay (WTP) methodology. It results that on average; people are willing to pay 1658.491F CFA (2.53 Euros). However, for the aggregation purposes of the benefits of the conservation to local people, we used the median WTP which is 1000CFA Francs (1.526 Euro). The aggregated direct benefit of the forest to local people estimated was then 12,53 million CFA Francs. We added the direct benefits related to the timber production provided by the management company (SODEFOR) data. Then, the indirect benefits related to regulation services, water supply, carbon sequestration and biodiversity conservation were added.

In this part, the sum of the Direct Use-Value (DUV), the Indirect Use-Value (IUV) and the Non-Use Value (NUV) will determine the total Economic Value (TEV). The TEV of the Bouaflé protected forest is estimated to 462408.59 billion CFA Francs.

Further studies could investigate other methods in order to estimate the indirect benefits of the Bouaflé protected forest. For the current study, we evaluate the benefits related to carbon sequestration based on the Bouaflé protected forest entire surface regardless to the vegetation cover. Further studies should consider the differences in vegetation cover distribution in order to compute more accurate estimates of the value related to such ecosystem services.

However surrounding population are aware of forest-related benefits to them, their monetary potential contribution to the conservation of that forest is low. So, we could capture

their participation to the conservation through non-monetary means (i.e. adoption of ecological friendly innovative strategies like cookstoves, biofuel).

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