Livelihoods strategies, deforestation and biodiversity conservation : a micro econometric analysis using rural households survey in the Tridom transboundary conservation landscape

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THESE

A Thesis submitted for the degree of Doctor of Philosophy (Ph.D) in Economics of the University of Lorraine

DISCIPLINE : ECONOMICS

LIVELIHOODS STRATEGIES, DEFORESTATION AND BIODIVERSITY CONSERVATION

A Microeconometric Analysis using Rural Households' Survey in the Tridom Transboundary Conservation Landscape

Presented and publicly defended on
Monday, December 12, 2016 at 14 h at the "Salle des Actes" of the FSJPEG by

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Monday December 12, 2016

In memoriam of my father

Moïse POUFOUN
09/20, 1948 - 03/10, 1998

Declaration

I hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original to the best of my knowledge and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other university. This dissertation is my own work and contains nothing which is the outcome of work done by others unless referenced or specified in the text or acknowledgements.

Jonas Ngouhouo Poufoun
December 12, 2016

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Abstract

This thesis investigates the key drivers of rural households' choices of livelihoods, and how these choices impact forest clearing and biodiversity conservation under a landscape approach. Using a novel and unique database obtained from a face-to-face survey with a representative sample of 1035 households in the Dja-Odzala-Minkébé trinational transboundary conservation landscape (Tridom-TCL)- Congo basin , this PhD thesis address three main questions investigated in three chapters. Using a spatial probit model, the first chapter investigates "how do local and indigenous households formulate their preferences among livelihoods strategies?" Using a spatial lag model, the second chapter investigates "how and how much do these livelihoods strategies, given wildlife constrains such as human-wildlife conflicts, impact small-scale deforestation?" Using corner solution models, the third chapter investigates "how the nature of the interactions among households and wildlife, the households' main activities as well as their land holdings impact their willingness to pay to prevent endangered forest elephant extinction?"

Among other, we find that livelihoods strategies are determined by autochthonous status, financial assets (money transfer and access to loan), distance to market and larger crop losses resulting from human-wildlife conflicts. Further, we show that livelihoods strategies are important for deforestation. Therefore, the commitments to reducing small-scale deforestation may be favored by a good consideration of factors that drive households' livelihoods strategies. We find out that spatial issues seem to be important. Proximity among households yields spatial shift effects and spatial spillover effects that are likely to amplify small-scale deforestation.

We also argue that, cross-cutting solutions towards a sustainable landscape considering these three crucial issues involve optimizing trade-off between households' livelihoods strategies, forest and the natural habitats of fauna. Therefore, the issues of community land security, of where natural habitat is needed and of how it should be managed are at the core of the problem. For example, decision-makers should proceed with the integration of large mammals mobility corridors far away from the community settlements in order to enhance zero-conflict-oriented elephant habitats; corridors should be consistently placed relatively to high elephant-concentration zones without crossing into zones with denser human populations.

Keywords : Households' livelihoods strategies, Deforestation, Human-wildlife conflict, Endangered forest elephant conservation, Landscape, Spatial Econometrics

JEL Codes: C11 & 21 & 23 & 24 & 25 & 31; D12; Q12 & 24 & 23 & 29 & 57; R14.

Résumé

Cette thèse examine les principaux déterminants des stratégies de subsistance des ménages ruraux. Elle cherche à comprendre comment ces stratégies impactent la déforestation à petite échelle et la conservation de la biodiversité suivant une approche paysagère. A partir d'une base de données uniques obtenues grâce à une enquête en face-à-face auprès d'un échantillon représentatif de 1035 ménages dans le paysage transfrontalier de conservation du Trinational Dja-Odzala-Minkébé (Tridom-TCL)-Bassin du Congo, cette thèse vise à répondre à trois questions et s'organise en trois chapitres. Le premier chapitre analyse "comment les ménages autochtones et locaux formulent leurs préférences parmi les stratégies et moyens d'existence" à l'aide d'un model Probit autorégressif spatial. Le deuxième chapitre examine "comment et à quelle amplitude ces stratégies impactent la déforestation à petite échelle" à l'aide d'un modèle de décalage spatial. Compte tenu de la nature des interactions entre les ménages et de la faune, de leurs principales activités, le troisième chapitre examine "les préférences des ménages pour la conservation des éléphants de forêt" à l'aide des modèles à variable qualitatives limitées.

Les actifs financiers (transfert d'argent et emprunts), la distance au marché, les dommages résultant des conflits homme-éléphant et l'ethnicité, plus précisément, l'autochtonie comptent parmi les facteurs déterminants des choix de stratégies de subsistance des ménages ruraux dans le Tridom-TCL. Nous montrons en outre que l'intensité de déforestation des ménages varie significativement en fonction de ces stratégies de subsistance. Par conséquent, les engagements en faveur de la réduction de la déforestation peuvent être favorisés par une bonne prise en compte des facteurs qui gouvernent les choix des modes de subsistance opérés par les ménages. Ils peuvent également être favorisés par la prise en compte les interactions entre ménages ainsi que leur localisation dans le paysage. En effet, nous trouvons qu'il existe des effets d'imitation, dans la décision de déforestation, entre les ménages d'un même voisinage, avec des effets spatiaux indirects susceptibles d'amplifier la déforestation à petite échelle.

Les solutions transversales, aux trois questions abordées dans cette thèse, en faveur d'un paysage durable devraient viser l'optimisation des compromis entre les stratégies de subsistance des ménages, les forêts et/ou les habitats naturels de la faune. Les décideurs devraient, par exemple, procéder à l'intégration des corridors de mobilité de grands mammifères dont les éléphants de forêt, dans des zones à forte concentration de la faune et loin des espaces communautaires afin de réduire le risque de conflits hommes-faune.

Mots Clés : Strategies de subsistance des ménages, Déforestation, Conflits homme-faune, Conservation des éléphants de forêt, Paysage, Econometrie spatiale

JEL Codes: C11 & 21 & 23 & 24 & 25 & 31; D12; Q12 & 24 & 23 & 29 & 57; R14.

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General Introduction

Background and issues

In tropical forested landscapes, agricultural expansion for livelihoods (Deakin *et al.*, 2016; Laurance *et al.*, 2014) and trade (Leblois *et al.*, 2016) have transformed and fragmented forest habitats at alarming rates. It has proximately driven around 80 percent of deforestation worldwide (Gibbs *et al.*, 2010; KissinGer et Herold, 2012), contributing for 10 to 12 percent of the total global annual anthropogenic emissions of GHGs (Verchot, 2014; Pachauri et Reisinger, 2008). As a result, the destruction of large-scale natural habitats has led to the endangering of multiple biodiversity species, while the ability of ecosystems to provide some services also depends both on the number and type of species (Tilman *et al.*, 2002, 2001). There is a significant regional variation among the responsibility of commercial agriculture and subsistence farming. Commercial agriculture accounts for almost 70 percent of deforestation in Latin America, while, in tropical Africa, forest land conversion for small-scale agriculture is known as one of the main drivers (FAO, 2016; Hosonuma *et al.*, 2012). In 2005, Africa showed a continued net loss of forest area with 21.4 percent, compared to 23.6 percent in 1990 and small farming has been responsible for more than 50 percent of this forest loss (Delacote, 2012). Particularly, in Sub-Saharan Africa, where many people are poor, rural households adopt low-risk, immediate and low-return agricultural and other income-generating strategies (FAO, 2015). In the same vein, when property rights are insecure, deforestation can be seen as a risk management strategy (Araujo *et al.*, 2009). Small-scale agriculture is relatively inefficient, since it is based on obsolete agricultural technologies resulting to large yield gaps compared to potential agricultural production (Masters *et al.*, 2013; Laurance *et al.*, 2014).

Environmental resources are important to millions of poor households in developing countries (Angelsen, 2011). As pointed out by Ellis (2000b); Scoones (1998), rural households develop further livelihoods strategies, beside agriculture, including forest resource extraction, hunting bushmeat and/or mixing among them. In many places in the developing world, rural households adopt various sets of livelihood strategies (Delacote, 2009). Some of them specialize in one activity, while others tend to diversify their activities portfolios. Motivations behind these choices can depend on households' characteristics (education, productivity, etc.), on the economic and environmental context (access to markets, access to land, quality of environmental resources, etc.) and on preferences (profit-maximizing or safety-first approaches, etc.). Unsustainable harvesting of non-timber forest products (NTFPs) observed in these countries can lead to forest degradation (Belcher et Schreckenberg, 2007;

Hosonuma *et al.*, 2012; KissinGer et Herold, 2012). Together with agriculture, this can reduce the ability of ecosystems to provide goods and services (Tilman *et al.*, 2002).

In these conditions, there are strong interconnections among, (1) socioeconomic issues including households' livelihoods as well as rural development, (2) forest cover and (3) biodiversity and environmental issues into a whole system.

A broad range of literature has investigated the issue of livelihoods and deforestation (Babigumira *et al.*, 2014; Belcher *et al.*, 2015; Vedeld *et al.*, 2007; Wunder *et al.*, 2014), the issue of small scale farming and deforestation (Angelsen, 1995; Angelsen et Wunder, 2003) and the issue of deforestation and biodiversity conservation (Amin *et al.*, 2014; Pfaff *et al.*, 2015), targeting poverty reduction mainly at the national and global level. These studies did not explicitly address these issues as interconnected, while issue-specific solutions would lead to adverse effects among these components of the landscape and contribute to worsen rather than to improve the system (Holmgren, 2013). This is especially true in situation with competing and often contradictory uses among forest, biodiversity and productive land-uses.

For instance ignoring human-wildlife conflicts when pursuing compatibility between households' livelihood strategies and less deforestation would undoubtedly worsen the perception of wildlife conservation by households. In the meantime, some wild species have became endangered species. For instance, *loxodonta africana cyclotis* (forest elephants) has been subject to a devastating decline during the last two decades (Maisels *et al.*, 2013; Blake *et al.*, 2007). Also, disregarding the issue of biodiversity conservation would contribute to a weakening of the rural livelihoods system and the forest ecosystem as well. As an example, the forest elephant, as a flagship species, contributes to ecological, cultural and socio-economic equilibria (Blake *et al.*, 2009). It contributes to indigenous people's cultural and spiritual enrichment in tropical Africa (Lewis, 2002; Kent, 1996). (2) It is considered as a tree planter, disseminating seeds of some species over long distances (Blake *et al.*, 2009; Wang, 2008; Beaune *et al.*, 2013). (3) It also make some fleshy fruit like *Baillonella toxisperma* (moabi) available for rural communities' livelihoods.

In view of the foregoing considerations, there is a need to build diagnostics and research in order to guide decision-makers to adopt cross-cutting solutions towards sustainable development combining different transmission channels such as sustainable livelihoods, biodiversity conservation issues and forest restoration. This thesis thus seeks to answer the following question : what are the key drivers of rural house-

holds livelihoods, and how do those choices impact forest clearing and biodiversity conservation?

This question can give rise to several side issues. Yet, this thesis considers three crucial questions that comply with rural households' behavior in a landscape: (1) How do local and indigenous households formulate their preferences among livelihoods strategies? (2) How and how much do the different livelihoods strategies developed by households, given wildlife constrains such as human-wildlife conflict impact small-scale deforestation? And finally, (3) given the nature of interaction among households and wildlife, given their main activities and their land holding, how much are local households willing to pay to prevent endangered forest elephant extinction?

The aim of this work is to investigate interactions among households' livelihoods strategies, their ecological footprint in terms of deforestation and their sensitivity to biodiversity conservation using our recent household's survey in the Dja-Odzala-Minkébé trinational conservation landscape (Tridom-TCL) - Congo Basin. The main interest is to improve an integrative perspective of the governance of this multifunctional landscape.

Conceptual and Theoretical Approaches

This thesis adopts as main point of view, the landscape approach. It is a framework for cross-cutting and combined solutions that help integrate agriculture and forestry issues and reduces or even remove externalities among components (Holmgren, 2013). The landscape approach helps to better understand and recognize the interconnections between different land uses and different stakeholders by integrating them into a joint management process (GLF, 2015). Following (Sayer *et al.*, 2013), the landscape approach is viewed in this thesis as a framework for convenient management of forest land by local households to achieve (1) sustainable forest and non-forest-based livelihoods, (2) spiritual and cultural enrichment of local and indigenous populations, (3) sustainable forest-related businesses and (4) biodiversity conservation, inclusive of the issue of endangered forest elephants. The landscape approach is consistent with the framework proposed in the literature for analyzing households' strategies, deforestation and ecosystem services.

Our starting point to analyze livelihoods strategies is the sustainable livelihoods framework. "A livelihood comprises the capabilities, assets and activities required for

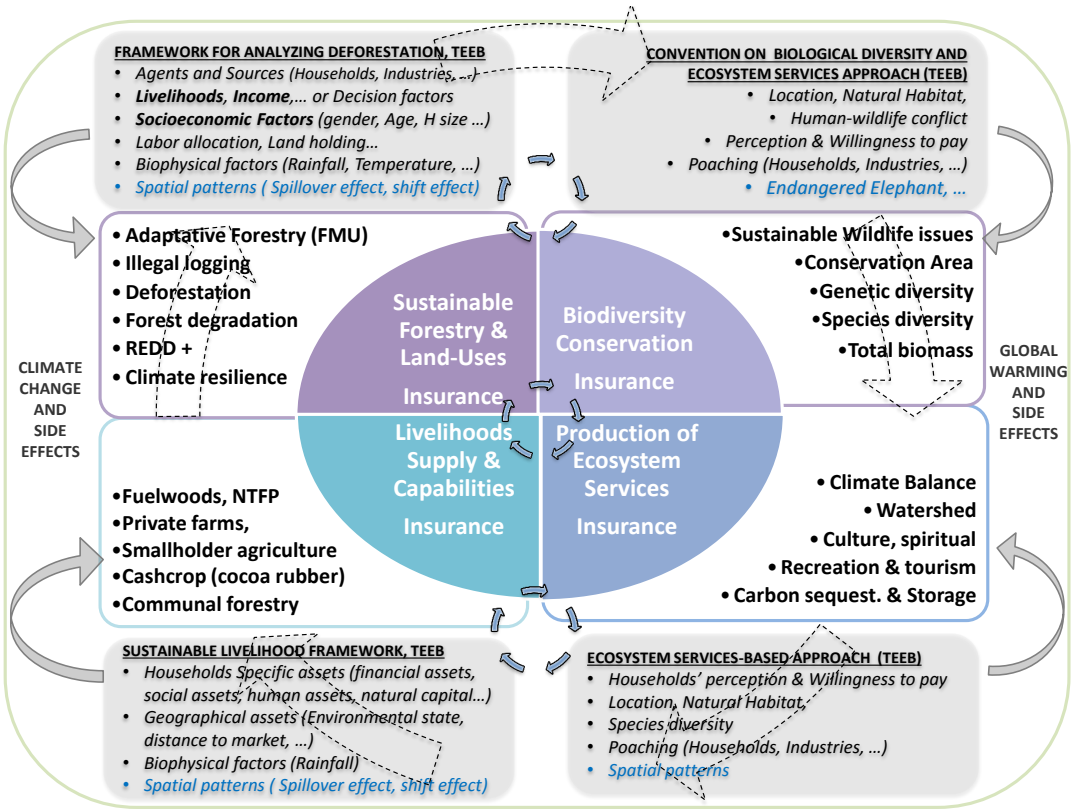
means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (DfID, 1999; Chambers et Conway, 1992). According to Scoones (1998); Ellis (2000a); Jansen *et al.* (2006); Soltani *et al.* (2012); DfID (1999), the ability to sustainably pursue different livelihoods strategies relies on households specific assets, such as social, tangible, intangible assets and geographical assets that people have in their possession.

Investigating the link between different livelihoods strategies developed by households and small-scale deforestation requires considering the framework for analyzing deforestation developed by Angelsen et Kaimowitz (1999); Geist et Lambin (2002); Combes *et al.* (2015). According to Angelsen et Kaimowitz (1999), when analyzing households' deforestation inputs, microeconomic models have to be considered with a focus on immediate causes such as socioeconomic characteristics and decisions parameters including income, given the livelihoods strategy, financial asset, to name a few.

In order to investigate the sensitivity of rural households to the endangered forest elephant conservation given the nature of interaction with wildlife, we use the ecosystem services framework developed by MEA (2005) . This framework helped to provide a synoptic description of the ecosystem services and the total economic value of an environmental asset.

Finally, spatial interactions are among the crucial components of the landscape approach. Neighborhood interactions should be considered when analyzing landscape. Indeed, green spaces can contribute to the strengthening of the local social cohesion (Felbinger et Jonuschat, 2006) which require considering the location of households. Proximity among households may lead to social interactions and strengthen or worsen their social cohesion. We rely on the strategic-interaction models and more precisely on the spillover model and the resource flow model developed by Brueckner (2003) to explicitly account for the effect of neighborhood interactions. According to Anselin (2002), both models are suitable when a farmer would determine the amount of farmland devoted to a crop by taking into account the amounts allocated by the other farmers in the system. From the conceptual and the theoretical approches presented above, we built a tentative framework, displayed in Figure 1, that should be applied when investigating issues related to a multifunctional landscape.

Figure 1: Tentative landscape approach for analyzing households' livelihoods strategies, deforestation and conservation in the Tridom-TCL



Source : Author

The case study and households survey

The Dja-Odzala-Minkébé Trinational Landscap

The household's survey was held in the Dja-Odzala-Minkébé transboundary conservation landscape (Tridom-TCL). It is a cross-border conservation landscape covering a geographical area of 191,541 km^2, representing 7.5 percent of the total area of the tropical forests in the Congo Basin of Central Africa. It was created in 2005 by an agreement between Cameroon, Gabon and Congo governments called "Tridom Agreement", as one of the twelve "priority landscapes" of the Congo Basin Forest Partnership (CBFP)[1]. The management of the Tridom-TCL is entrusted to a Re-

[1]The Congo Basin Forest Partnership (CBFP) was launched as a multi-stakeholder partnership (with 70 partners, including African countries, donor agencies and governments, international organizations, NGOs, scientific institutions and the private sector) at the 2002 World Summit on Sustainable Development in Johannesburg, South Africa. It aims to enhance natural resource management and improve the standard of living in the Congo Basin (http://www.pfbc-cbfp.org/)

gional Management Unit (RMU) with representative members in each of the three countries. Each representative member manages the corresponding segment of the landscape according to the national law. The RMU is prepared to act beyond national borders with the following missions: (1) sustainable management of transboundary biodiversity in the inter-zone, (2) maintaining the ecological, economic and social connectivity of the complex, (3) ensuring long term conservation of its protected area system and (4) fostering local development with reduced impact on environment.

The Tridom-TCL is located very close to the Equator, the climate is bimodal. There are two seasons with less rainfall, around January and July, and two rainy seasons, around October and April-May. It lies on a plateau at an altitude of 300 to 1,000 m above the see. In many places, especially in the regions of Minkébé in Gabon and the Dja in Cameroon, the plateau is punctuated with inselbergs. Regarding the hydrology, The Gabonese section is drained by the Ivindo, the Djidji and the Langoué that are tributaries of the Ogooué; and by the Ntem. The Cameroonian section is drained by the Ntem and more significantly the Dja and the Boumba, tributaries of the Congo River. The Congolese section is drained by the Mambili and pertains entirely to the basin of the Congo River (De Wachter *et al.*, 2009).

The majority of the Landscape is covered with forests. The Tridom-TCL consists of a network of 10 protected areas, namely, the Dja biosphere reserve, the Boumba-Bek NP, the Nki and the Mengamé gorilla sanctuary (Republic of Cameroon), the Odzala-Kokoua NP and the Lossi NP (Republic of Congo), the Minkébé NP, the Ivindo NP, the Lopé NP and the Mwagne NP (Gabonese Republic). These protected areas spread over 37,498 km^2 and are connected by a wide inter-zone of more than $111,000 km^2$ with 40,000 km^2 of thelivable area. The Tridom-TCL includes rich and diversified flora and fauna and is abundant in highly commercial valuable timber species. It houses the largest population of *loxodonta africana cyclotis* in the world, with the highest density in the Minkébé National Park. It also has a relatively high density of other large mammals, such as *Gorilla gorilla gorilla* (western lowland gorilla), *Syncerus caffer* (buffaloes), *Tragelaphus eurycerus* (bongo) *Manis gigantea* (giant pangolins) and *Cephalophus* (duikers), to name a few.

Households in the landscape

The inhabited inter-zone of the Tridom-TCL is home to indigenous and local people who depend on slash and burn agriculture and forest-based activities. The human

population density is between 1-7.9 inhabitants per km^2 and is currently growing due to resource exploitation Ngoufo *et al.* (2012). The Tridom-TCL hosts industrial activities such as forest management units; industrial agriculture, safari hunting zones and industrial mining. The landscape also include illegal logging of timber with high commercial values, illegal mining and intensive poaching. From a quick look into our data set, about 78 percent of the indigenous and local communities declare relying on small-scale farming (40.9 percent), Cash-cropping (19.6 percent), Hunting-Gathering bushmeat and NTFP (14.8 percent) as well as Traditional gold-mining (3 percent) as predominant livelihoods activities with full-time employment.

In the Tridom-TCL, there is a competition for land among households. Land holding is almost considered as an indicator of renown and honor. Thus, economic rationality is not always the motive behind land clearing. After removal or selling the softwood lumber in surrounding forests, all the remaining plants and material in the forest are burnt and the land is used for extensive agricultural and cash-crop production with very poor yield.

Regarding the interaction with wildlife, local households undergo many conflicts with wildlife resulting in damage to their livelihoods. For instance, evidence from our survey reports that about 28 percent of local households have been victim of crop damage by forest elephants. These conficts may lead to a poor perception of forest elephant conservation. Also, this may drive the involvement of local households to the slaughtering of this iconic species.

Considering the above, the "Tridom agreement" is still far from meeting the intended objectives stated in sub-section , contrariwise, the ongoing practices often contribute to environmental degradation, increased deforestation, fragmentation and disintegration of the protected area network within the landscape. Hence the Tridom-TCL is a prime example of a landscape that urgently needs research and evaluations for cross-cutting solutions.

Households survey

There is a common understanding among scientists with regards to the lack of reliable subnational and households-level data relating to households livelihoods, deforestation and biodiversity conservation in Sub-Saharan Africa (Ferretti-Gallon et Busch, 2014; Palo, 1999; Geist et Lambin, 2002). This thesis was made possible thanks to a novel and unique database that we gathered from the field to debar and

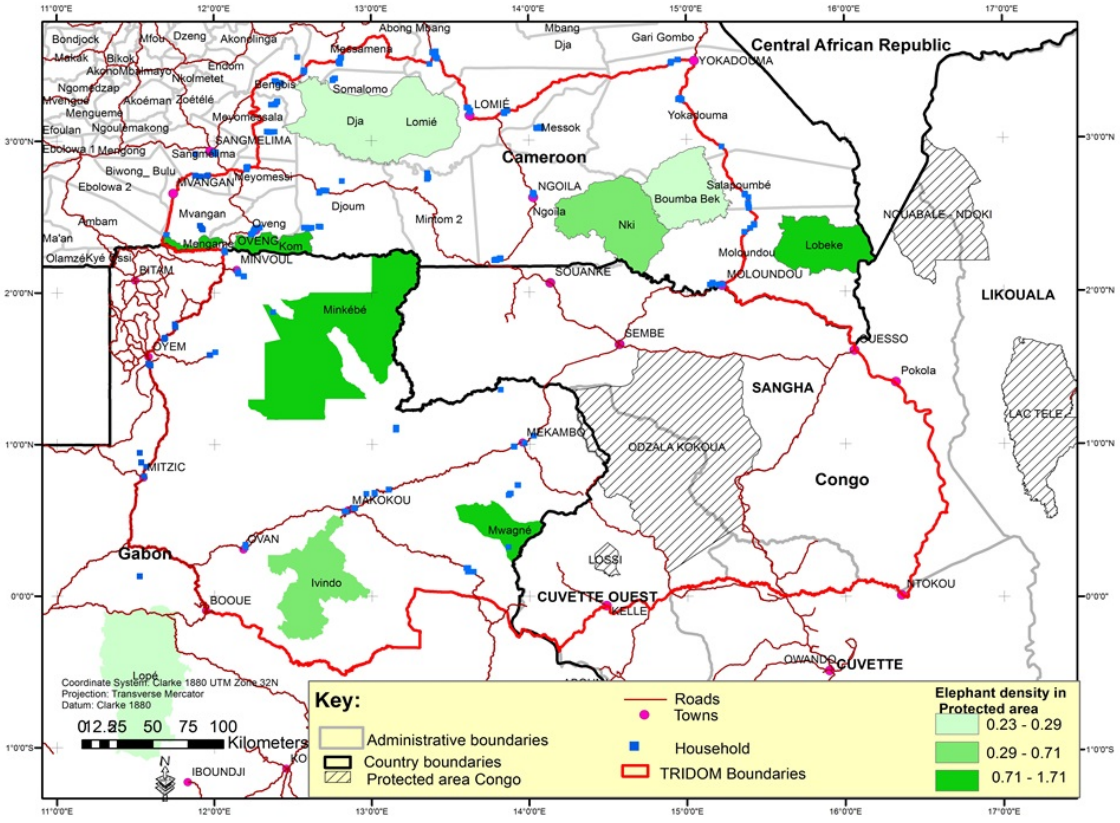


Figure 2: Study area and location of households surveyed

overcome the lack of data. Because of administrative constraints and limited funding for field work, the survey was conducted in the Cameroon and Gabon segments but not in the Congo segment of the Tridom-TCL. These segments are inhabited by more than 43 tribes which are dominated by the Bantu compared to indigenous Baka tribe who is a minority group.

Sampling, survey design and implementation

The organisation and the realization of the survey were realised in a way to minimize the survey implementation problems when measuring households livelihoods and deforestation as advised by Angelsen (2011). (a) After defining the sample and designing the questionnaires, (b) we recruited and adequately trained the enumerators. (c) We did the questionnaire pre-test on the field, (d) we proceeded further to the main survey. (e) We proceeded to data entry and finally we checked and used them for analysis.

This thesis uses data obtained from a representative face-to-face survey of a random, stratified sample of 1035 households. The total number of households in the study area is approximately 65,140 (Gabon, 2010; Bucrep, 2010). The statistical sample size required at a confidence level of 95 percent with the typical value of 1.96 was 384. We expanded the sample size to 1035 for two reasons. First, it was important to have a statistically valid sub-sample's size per sub-division to improve the accuracy of analysis considering social interaction among households. Secondly, it is statistically true that, the larger the sample size, the more representative is the sample. The questionnaire was designed based on a literature review on the research issues. The questionnaire was organized into sixteen topics, including, among others, the drivers of households choices concerning land use, households use right and livelihoods production, land use conflicto; the multi-functionality of the landscape, the contingent valuation design as well as the cultural value and biodiversity conservation. The questionnaire was checked by experts and researchers before pre-test and survey. The questionnaires were prepared at the Laboratory of Forest Economics in Nancy, and the field work preparation was done at the Central African hub of the Center for International Forestry Research (CIFOR) in Yaounde, Cameroon.

To ensure high data quality, we organized five training seminars in Cameroon and five training seminars in Gabon with 20 post-graduate students covering all the topics addressed by the questionnaire. The training seminars included the use of GPS by a GIS expert for successful geo-localization of all the households surveyed. At the end, 10 participants were selected to perform as enumerators under the supervision of the PhD Candidate.

The survey started by two questionnaires pre-test with 40 households in four villages from two different sub-divisions in Cameroun. The first pre-test was held in Eboman and Endon villages in Oveng sub-division from December 20 to 24, 2013. This step helped in redefining and controlling some indicators embedded in the questionnaire. The second pre-test took place in the Kongo and Mbieleme villages in the Meyomessi sub-division from January 26 to 29, 2014. This step helped further to check the questionnaires' validation.

The geographical coverage of the survey included 108 villages from all the 26 administratives sub-divisions and districts of the Cameroonian and the Gabonese part of the landscape (Figure 2). The villages were chosen so as to represent the sub-division. In each sub-division, we chose one to three groups of villages geographically far apart from each other. Each group was inclusive of two to four consecutive villages. All the

villages were displayed in 42 geographical maps using ArcGIS before the beginning of the field work to draw the route map of the whole survey.

Figure 3 presents an example of the a group of villages located in the Ngoyla-Mintom forest (in Mintom sub-division, Cameroun). The survey was fielded over 8 months between December 2013 and July 2014. The visited villages are spread over nearly 27,000 km^2, which represent two third of the landscape's livable inter-zone. The random sampling of the households in the villages was based on the inhabitants' registry held by the village chiefs. The interviews lasted between 1 and 3 hours. The survey was facilitated by introductory letters provided by the ministers of forest and fauna of both countries. These letters helped legitimating access to reliable data. Each village provided us with at least two local translators in case the household heads could not communicate in French. Beside Household's survey, numerous interviews were held with the sub-prefects and the mayors of the 26 sub-divisions.

As regard the post-field work, 50 percent of the data entry was made in Cameroon by six bachelor students and three master students. The remaining data entry was done by the PhD Student. The whole dataset was verified questionnaire-by-questionnaire and a part of the dataset was cleaned for the PhD dissertation. This final step from data entry to data clearing lasted from September 2014 to April 2015. In the next subsections, we present the measurement of the households' livelihoods and deforestation, and the measurement of their references for endangered forest elephant.

Households' Livelihoods measurement

In addition to the face to face survey, evening visits to various surveyed households were conducted to quantify and measure daily, weekly and *per annum* livelihoods production. The *per annum* value of livelihoods were derived in two ways. Some well organized household's heads have the habit of recording their daily, weekly and *per annum* livelihoods statistics. We trusted and collected these statistics. This information was cross-checked using our daily measurement. For the remaining households, we considered the daily and weekly measurement which we realised using contextual material. We extrapolated to obtain the per-annum livelihoods' production according to the recall data they provided and the seasonality of each species or product. The seasonality and the production irregularity of each species was defined during the design of the questionnaire and was validated during the pre-test steps. For instance, among the forest-based livelihoods, (1) *Ricinodendron*

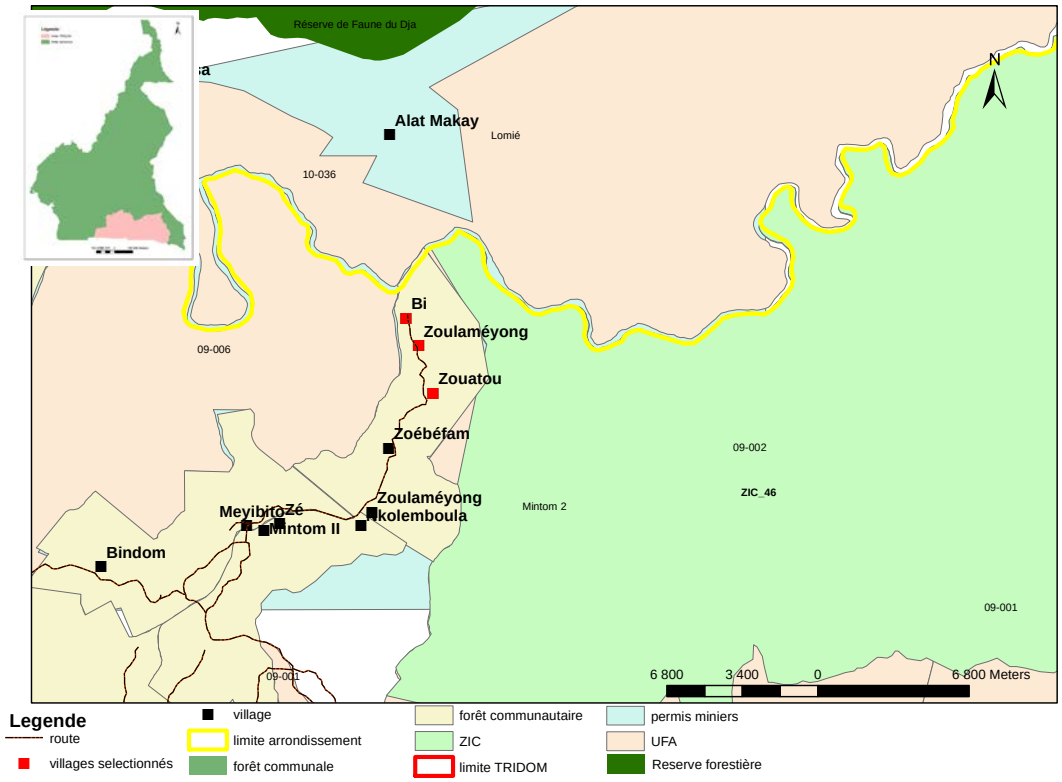


Figure 3: One of group of villages surveyed in Ngoyla-Mintom forest

Heudelotti is harvested every year for a two-month period, it is measured with a five liters pail that weight 7.5kg, and a bag of 90kg is made of 12 pails. The total value for two months were considered as the *per annum* value. (2) Likewise, *Irvingia gabonensis* is harvested every year for a three-months period. Some products are harvested during 12 months (*Gnetum africanum, Piper nigrum, Afromomum dalzeillii etc.*) and other are harvested every year for two to three months periods (*Fungi, Corylus avellana, Garcinia cola, Monodora myristica etc.*). Table A.2.1 in appendix shows the measurement indicators for the 20 NTFP, including fuel wood extraction that account among forest-based livelihoods. We also used a mechanical dynamometer to weight bushmeat, crop (banana, casava, potato, vegetables etc.) and cash crop (including rubber and cocoa) daily and weekly production. We used the average local sales price to estimate the value for such livelihoods resulting from each strategy. Indeed, price variation within rural area is normally too small (Angelsen et Kaimowitz, 1999).

Deforestation Measurement

Regarding deforestation measurement, households were asked to fill the information about their land-holding in a table. After that, we randomly chose one plot among the total plots declared by the household to visit. The visited plot was tracked with a GPS to obtain the real area. A total of 3338 plots of land were declared by overall sample, that is on average 3.2 plots held by each household. A total of 526 plots were tracked with a GPS. The data declared were adjusted using the tracked data to obtain the value used in this thesis. On average, the household's head declared holding 4.75 ha of forest. We found after correction a land holding of 4.41 ha. Table 1 displays additional descriptive statistics comparing both the declared and the adjusted values of households deforestation.

Table 1: Descriptive statistics: Declared deforestation VS Ajusted value

	Mean	St. Dev.	Min	Max	Percentiles								
					1%	5%	10%	25%	50%	75%	90%	95%	99%
Deforestation declaration	4.76	5.39	0	64	0	0	0.5	1.55	3.34	6	10	14	23
Deforestation ajustement	4.42	5.24	0	56.24	0	0	0.4	1.36	2.88	5.59	9.67	12.99	23.71

Preferences for endangered forest elephant measurement

We used the contingent valuation (CV) technique to assess the preferences of households for endangered forest elephant conservation. We first described the socio-economic and ecological attributes of the elephant, as well as the potential change in socio-cultural services associated with the possible extinctions, given that forest elephants are currently only present in the Congo Basin. Respondents were asked to state their preferences for the entire bundle of services provided by forest elephants because addressing services separately leads to double counting (Loomis et Larson, 1994; Bandara et Tisdell, 2003).

Next, we proposed the following hypothetical scenario, given that we are valuing a non-market good without an implicit market. "*Considering the trend towards the extinction of forest elephants, if action is not taken quickly, this multiple-used iconic species will disappear in the next few years. To stop this tendency towards extinction and make the species more abundant, the Tridom-TCL Regional Project Management Unit may develop a 10-year elephant conservation program that aims to seize weapons currently used by poachers and to effectively fight cross-border poaching by (1) creating joint checkpoints at the landscape scale and (2) recruiting more young people from villages and involving them in a communication network to improve anti-poaching*

control strategies and prevent human-elephant conflicts". Then, each respondent was asked whether *he would be willing to contribute to the program by paying some monthly amount if the Regional Management Unit were to demand financial support from all the inhabitants of the village.* The payment vehicle presented was direct cash payment of secure funds that would be held by the Tridom program. This means of payment is the most familiar, credible and feasible based on the economic situation in the area.

We used both the closed-ended and open-ended elicitation format. We first apply the closed-ended format, particularly, the Double-bounded dichotomous choice model (DBDC) proposed by Hanemann (1985) and Carson (1985). This technique involves asking the respondent whether he would be willing to pay an initial amount for elephant conservation. A lower bid was presented to those with a negative answer and a higher bid was presented to those with a positive answer. In the OE format, respondents were asked to specify their WTP. To minimize "Yea-saying" and "Nay-saying" bias[2] as well as the starting point bias, (1) we asked each respondent to consider their monthly income, their sources of income, and their usual monthly expenditures, and (2) we asked each respondent to be realistic, making sure that he/she could actually pay the stated monthly amount for the next 10 years before answering. Furthermore, the respondents were randomly assigned to one of six starting bids developed and validated during the pre-test steps. Finally, we asked follow-up questions to examine the reasons for zero observations to be able to identify protest bidders in the database before model estimation (Arrow *et al.*, 1993).

A full description of this technique as well as the data are imbedded in the third chapter. The following sub-section present our contributions and the organisation of this thesis.

Contribution and thesis organisation

Our contribution is multiple. First, following the reasoning presented in section 1, it provides a complete analysis of households behavior as regard to their livelihood and environment. Indeed, we first consider the households' livelihoods strategies choice. Then we investigate how those livelihoods strategies influence their land-use

[2]Yea-sayers and Nay-sayers are respondents who try to please or to counter, respectively, the interviewer without considering the specific amount they are asked about (Carson et Hamenann, 2005; Frew, 2010).

decisions and deforestation, and thus their environmental impact. Finally, we adopt the reversal analysis, i.e. how do they value wildlife conservation.

Our approach is essentially micro-econometric, with a strong emphasis on spatial issues. Indeed, we showed earlier that spatial interactions are important to take into account in our context of interest. Yet, the lack of reliable data prevent from implementing such type of analysis. We present in this piece of work much evidence that, indeed, it is essential to investigate spatial spillovers in order to fully understand the environment-development nexus which rural households of developing countries are confronted to.

This thesis is organized around three chapters.

(1) **What drives livelihoods strategies in rural areas? Evidence from the Tridom-TCL using Spatial Probit Analysis**

The first chapter investigates the factors which drive the household's livelihoods strategies in rural regions, using a Spatial Probit Model. Very few scientific studies have focused on the determinants of such choice in the Congo Basin. More precisely, the role of human, financial, natural and location assets in the portfolio choice is investigated. A unique dataset is used from our recent survey with random and stratified 1035 households in 108 villages of the Tridom-TCL to investigate household preferences between (1) specialization and diversification strategies, (2) land-conversion and non-land-conversion activities, and (3) between strategies relying on forest vs other strategies. The Spatial Autoregressive Probit Model shows a significant similarities on the likelihood of closer households to prefer a given livelihoods strategy. Beside socioeconomic characteristics, the existence of human-wildlife conflict as well as the indigenousness directly lead households heads to make the choice of diversified strategies including activities related to land-conversion with some significant spillover effects on the likelihood of neighboring households heads to adopt the same strategies.

(2) **Households livelihoods and deforestation in the Tridom-TCL : A spatial analysis**

This chapter aims to examine the determinants of household' deforestation in the Tridom-TCL. It investigates the role of household livelihoods strategies. It also tests the effects of crop damage caused by elephant (human-elephant conflict) in the households' decision of deforestation, using a unique dataset

gathered with 1035 households in the Tridom-TCL. The results of the spatial autoregressive model state that: (1) households tend to imitate deforestation decisions of their neighbors. (2) When account is taken of cash crops in a diversification livelihoods strategy, households' deforestation increases significantly with a significant indirect impact on neighboring households' deforestation. In fact, a one-unit increase in the income of such households leads to six to sevent times increases in households' deforestation compared to other strategies. Also, (3) the indirect effects of these choices on neighboring households' deforestation have almost the same magnitude as the direct impact sesulting from other strategies. (4) In addition, there is no substitutability between leisure and work in land use choices. Indeed, the Pygmies, who constitute the pincipale labor with low cost, are employed in activities related to larger deforestation, while household labor duration do not significantly drive households' deforestation. The share of household self-consumption is associated with a low deforestation, therefore, a better integration of the market can lead to increased deforestation, if practices remained unchanged.

(3) **The value of endangered forest elephants to local communities in a transboundary conservation landscape**

The last chapter seeks to determine and characterize social and cultural preferences for the conservation of endangered forest elephants in the the landscape, given the households activities. We combine double- bounded dichotomous choice with open-ended elicitation formats to assess the willingness-to-pay (WTP) for EFE conservation. We find that local households are willing to pay CFA 1,139.4 (€1.74) per month to prevent EFE extinction. This totals CFA 753.9 million (€1.15 million) per year for all inhabitants. Indigenousness positively influences the WTP for EFE conservation. Spatial data suggest that local communities prefer that elephants remain far from their crops. The existence of human-elephant conflicts has a neutral effect on preferences for EFE conservation. Therefore, our study suggests that local communities would engage in biodiversity preservation when the public benefits of conservation are accompanied by private benefits, such as human-elephant conflict avoidance.

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Chapter 1

What drives livelihoods strategies in rural areas? Evidence from the Tridom Conservation Landscape using Spatial Probit Analysis

Co-author : Philippe Delacote

Working paper "*Les Cahiers du Lef*"

Sommaire

Abstract

Very few scientific studies have focused on the determinants of households' livelihoods strategies in the Congo Basin. The aim of this paper is to understand which factors drive the choice of portfolio activities in rural regions. More precisely, the role of human, financial, natural and location assets in the portfolio choice is investigated. A unique dataset is used from our recent survey with 1035 random and stratified households in 108 villages of the Tridom landscape to investigate household preferences between (1) specialization and diversification strategies, (2) land-conversion and non-land-conversion activities, and (3) between strategies relying on forest vs other strategies. Our results show significant similarities on the likelihood of households living in the same neighborhood to prefer a given livelihoods strategy. Beside socioeconomic characteristics, the existence of human-wildlife conflict, as well as the indigenousness, directly lead household's heads to make the choice of diversified strategies, or to choose activities related to land-conversion. These choices lead to some significant spillover effects on the likelihood of neighboring household's heads to adopt the same strategies.

keywords : Forest-based livelihoods, Agriculture and cash crop, Diversification strategies, Deforestation, Spatial Spillover Effects, Spatial Autoregressive Probit.

JEL Codes: C11 & 21 & 25, D12; Q12 & 23

1.1 Introduction

Most rural households in the Congo Basin rely primarily on small-scale agricultural activities, harvesting and direct use of forest ecosystem goods and services for their livelihoods[1] including food security, fuelwood, water supply and primary healthcare (Sonwa *et al.*, 2009; Megevand, 2013; Verchot, 2014). In the Tri-National Dja-Odzala Minkébé trinational conservation landscape (Tridom-TCL), approximately 78% of indigenous and local communities declare slash and burn small-scale farming (40.9%), cocoa and rubber or cash crop (19.6%), game hunting for bushmeat and NTFP gathering of or (14.8%) as well as traditional gold mining (3%) as predominant subsistence activities with a full time employment. A more detailed look of household heads' behavior in this landscape shows that an important share of household heads develop survival strategies based on activities portfolios, mixing two or three of above activities. Factors governing the decision to adopt a particular land-use or livelihood's strategy and the extent of their effects are complex and vary considerably from one place to another (Angelsen et Kaimowitz, 1999; Babigumira *et al.*, 2014; VanWey *et al.*, 2005). These individual decisions will have significant impact on the household's wellbeing, on the environment, and on the economic value of the landscape (Brown, 2004) and should therefore be taken into account by policy makers (Carrión-Flores *et al.*, 2009).

In these conditions, there is a crucial need to investigate the factors that drive households' livelihoods portfolio in rural areas. Therefore, this paper seeks to investigate how do local and indigenous households formulate their preferences among livelihoods strategies? We state that this decision depends on several strategical trade-offs: (1) specialization vs diversification, (2) land-converting activities vs non-land-converting activities, (3) forest-based activities vs non-forest-based activities. Our contribution is multiple: (1) As a pioneering study on the households' survival strategies in a transboundary conservation landscape, this paper tests the reliance on the ability to pursue livelihoods strategies on natural, economic, human, physical and social assets in order to shed light on the validity of the traditional Sustainable Livelihoods Framework (SLF) in the Tridom-TCL. (2) Our research accounts for both types of location assets (environmental state and infrastructure) introduced

[1] A livelihood comprises the capabilities and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance households' capabilities and assets, and provide sustainable livelihood opportunities for the next generation (Chambers et Conway, 1992). However, in this paper, the term livelihood is restricted to subsistence goods and services from small-scale farming and from forest-based activities.

by Jansen *et al.* (2006) and Soltani *et al.* (2012). Indeed, we consider the distance to the nearest protected area as an indicator of environmental state, and distance to the market as infrastructural asset. (3) Except for the Poverty and Environment Network (PEN)[2] and the Peruvian Amazon Rural Livelihoods and Poverty (PARLAP) initiatives, studies of forest peasant economies have been based on small and non representative samples of households due to practical, historical and financial reasons. As a result, very few generalizations can be made about spatial or social variations (Coomes *et al.*, 2016). Our study uses a unique dataset collected in the field with 1035 geocoded households in 108 villages from the Tridom-TCL. The survey covered all the 26 administrative subdivisions of the Cameroonian and Gabonese segments of the landscape. Our study helps to address the lack of data at the landscape and the household levels. (4) Our survey with representative samples and subsamples in all the subdivisions allows us to account for shift effects as well as spatial spillover effects in a household neighborhood resulting from geographical proximity and related social interactions. To the best of our knowledge, no existing peer reviewed study has attempted to account for the effect of endogenous and exogenous interactions on households' livelihoods strategies, yet geographical determinants including household location were explicitly investigated by Soltani *et al.* (2012); Jansen *et al.* (2006) and Wunder *et al.* (2014).

We test following hypotheses.

- Household specific assets, including social capital (Community group membership, autochthonous, household's size and marital status), human capital (education, age and seniority[3]), access to natural capital (land-use conflict, human-wildlife conflict) and financial assets (loan and money transfers) drive household' heads preferences among livelihoods strategies.

- Geographical assets including environmental state (distance to the nearest protected area) and infrastructure (distance to market) influence household's heads preferences among livelihoods strategies. Indeed, beside household-specific assets, location is supposed to significantly influence households' livelihoods choices (Soltani *et al.*, 2012). Further, distance to market can be considered as cost of market access (Losch *et al.*, 1954; Von Thünen et Hall, 1966)

[2]The PEN is an initiative with more than 50 research partners that built a dataset containing detailed socio-economic data collected quarterly. It contains more than 8000 households at the village level in 40 study sites from 25 developing countries. (http://www1.cifor.org/pen)

[3]Seniority is the quality of households that has settled long ago in the village.

- Finally, we hypothesize that preferences among livelihoods strategies of proximal households are correlated and changes in the level of household assets and characteristics will impact both own preferences and neighbouring household preferences over strategies. Indeed, according to the strategic-interaction models, a farmer's decision is supposed to indirectly affect other farmers' decisions within the same neighbourhood (Brueckner, 2003; Anselin, 2002).

This paper is structured as follows. Section (1.2) presents the literature review. Section (1.3) describes the case study. Section (1.4) presents the theoretical framework, and section (1.5) specifies the Spatial Autoregressive Probit (SAR-Probit) econometric model. Results are presented in section (1.6). Finally, section (1.7) present discussion and conclusions.

1.2 Literature Review

Households' livelihoods strategies have been a subject of numerous papers, encompassing the framework for investigating sustainable rural livelihoods, global studies and case-specific analysis. Literature on the SLF asserts that the ability to pursue different livelihoods strategies is dependent on the basic material and social, tangible and intangible assets that people have at their possession (Scoones, 1998). In different contexts, sustainable livelihoods can be achieved through access to natural, economic, human, physical and social capitals or resources. Jansen *et al.* (2006) have contributed to framing the livelihoods analysis by introducing geographical determinants as a sixth fundamental factor. Soltani *et al.* (2012) argued that, beside specific assets, location has a important effect on households' livelihoods strategies. They propose dividing this location asset into infrastructures and environmental state. These assets are often combined to define different livelihoods strategies including agricultural intensification, specialization or diversification (Ellis, 2000a; Scoones, 1998; Knutsson, 2006; Coomes *et al.*, 2004; Angelsen, 2011; DfID, 1999).

Among the numerous case-specific studies on livelihoods strategies, Soltani *et al.* (2012) examined poverty and forest degradation in rural areas of Zagros (Iran) accounting for location assets beside the traditional SLF approach in other to identify the most sustainable households' livelihoods strategies. They studied three continuous indices of poverty, over-grazing and over-harvesting on a stratified random sample of 79 households. They found that 64% of the households surveyed adopt mixed strategies, while, the livelihoods strategies of poorest households (27%) are highly

dependent on forest extraction and livestock grazing and that the remaining 9% combine cash crop with non farm work and earn higher income. They also found that locational capitals namely, development and marginality are important drivers of choice among livelihoods strategies in addition to household traditional assets. They finally found some evidence of an Environmental Kuznets Curve. Indeed, over-harvesting and overgrazing indices are the highest for households in the mixed cluster and lowest for households in the non-farm/commercial one.

These diverse strategies have some key characteristics of interest. They can be decomposed in a set of diverse choices. In this paper, we focus on three types of strategic choices: choice of diversification, choice of land conversion and choice of relying on forest resources.

Diversification: depending on available assets, households may prefer to diversify their activities as a survival strategy or safety net to cope with shocks in order to maintain or enhance their capabilities or for income motive, while, contextual effects can lead to specialization in a particular activity (Ellis, 2000b; Scoones, 1998). A range of global level studies have been focussing on the reliance on environmental income for gap-filling and as a safety net to cope with risk. Indeed, agriculture is subject to myriad risks including weather, price, pests, diseases and fire (Pattanayak et Sills, 2001), and diversification activities can be seen as a way to cope with risk, in a context of lacking insurance and credit markets. Angelsen *et al.* (2014); Delacote (2009, 2007); Vedeld *et al.* (2007) and Wunder *et al.* (2014) are among the main researchers who pointed out the importance of environmental amenities and income for seasonal gap-filling and as rural safety net to shocks. They found that households with poor human, natural and social capital were more likely to go to the forest after a shock; while forest extraction has limited importance for seasonal gap-filling (Wunder *et al.*, 2014). They found that forest income contributes between 22.2% to 27% of total households' income with large and systematic variations among regions, and that, the poor rely more heavily on subsistence products such as wood fuels and wild foods, and on products harvested from natural areas other than forests (Angelsen *et al.*, 2014; Vedeld *et al.*, 2007; Nguyen *et al.*, 2015). A similar result was found by Belcher *et al.* (2015) in a case study in Jharkhand (India). However, this category of households (poor households) are more likely to be trapped in common-property resources extraction activities, that provide only minimum requirement. This is especially true for households with a large need of insurance (Delacote, 2009).

Land conversion: the choice of land-conversion activities has been investigated, mainly through forest clearing and deforestation choices for example, using the PEN dataset. Considering the SLF presented above, Babigumira *et al.* (2014) introduced mediating and vulnerability indicators to examine the factors that influence rural household decisions to clear forestland in 24 developing countries and to identify robust global correlation between forest clearing and rural livelihoods. They found that shock patterns do not drive forest clearing, and that male-headed households with abundance of male labour living in recently settled places with high forest cover, as well as households with medium to high asset holdings and higher market orientation were more likely to clear forest than the poorest and vulnerable households.

Forest reliance: Coomes *et al.* (2016) used a large scale census with 919 communities in four major river sub-basins in eastern Peru under the PARLAP initiative to analyse the drivers of the economic orientation of rain forest communities. The authors found that initial environmental endowments and market access of communities are important in shaping their economic orientation, however, they interact in different ways depending on the key natural resource upon which they rely. Further, they found a strong correlation between rich endowment of terrestrial activities components and participation in land-based extractive activities including hunting, non-timber-forest product (NTFP) and timber extraction. An important proportion of case-specific analysis of livelihoods strategies has been carried out in Southern and Eastern Africa. Some results are similar to those from global studies stated above in terms of the importance of forest income for the poorest households (Mamo *et al.*, 2007; Kamanga *et al.*, 2009), the differential influence of livelihoods assets on the choice of households strategies (Babulo *et al.*, 2008) in Ethiopia and Malawi.

One of the very few scientific publications in the Congo Basin on this issue was carried out by Nielsen *et al.* (2012). They used data collected in a typical CIFOR-PEN study in Democratic republic of Congo to point out the importance of including asset-based measures of wealth in studies of poverty–environment relations with poverty groups of households. Considering poverty as a transitory phenomenon resulting from an array of push and pull factors, and considering the importance of assets' wealth for seasonal gap-filling, four poverty groups were identified by dividing the sample into five annual income quintiles and into five equally sized productive asset quintiles. The authors found a strong reliance of the chronic poor on forest income and a strong reliance of richest households on business. They also found that the transient poor

consume a higher share of harvested forest products, while the transient rich have higher agricultural productivity and absolute forest income.

1.3 Case study: The Tridom-TCL in the Congo Basin

The Tridom-TCL is a cross-border conservation landscape created in 2005 by an agreement between Cameroon, Gabon and Congo governments, as one of the twelve "priority landscapes" of the Congo Basin Forest Partnership (CBFP)[4]. The management of the Tridom-TCL is entrusted to a Regional Management Unit (RMU) with representative members in each of the three countries. Each representative member manages the corresponding segment of the landscape according to the national law. The RMU is prepared to act beyond national borders with the following missions: (1) sustainable management of transboundary biodiversity in the inter-zone, (2) maintaining the ecological, the economic and the social connectivity of the complex, (3) ensuring long term conservation of its protected area system and (4) fostering local development with reduced impact on environment. The Tridom-TCL consists of a network of 10 protected areas, namely, the Dja biosphere reserve, the Boumba-Bek NP, and the Nki-Mengamé gorilla sanctuary (Republic of Cameroon), the Odzala-Kokoua NP and the Lossi NP (Republic of Congo), the Minkébé NP, the Ivindo NP and the Mwagne NP (Gabonese Republic). These protected áreas, spread over $35,968$ square kilometers, are connected by a wide inter-zone of more than $111,000 km^2$ of which 36% (40,000 km^2) is inhabited. It represents 7.5% of the total area of the Congo Basin Tropical Forests in Central Africa. The inhabited inter-zone hosts indigenous and local people. These people depend on slash and burn agriculture, and forest-based activities such as hunting, NTFP gathering, fishing, traditional forest management and traditional mining for their survival. The human population density is between 1-7.9 inhabitants/km^2 and is currently growing due to resource exploitation (Ngoufo *et al.*, 2012). The field work was carried out in the Cameroon and Gabon segments as shown in the figure (A.1.1) in appendix. Both

[4]The Congo Basin Forest Partnership (CBFP) was launched as a multi-stakeholder partnership (with 70 partners, including African countries, donor agencies and governments, international organizations, NGOs, scientific institutions and the Tridom-TCL private sector) at the 2002 World Summit on Sustainable Development in Johannesburg, South Africa. It aims to enhance natural resource management and improve the standard of living in the Congo Basin (http://www.pfbc-cbfp.org/)

segments are inhabited by more than 43 tribes, dominated by Bantu, with a minority group of the indigenous baka tribe.

1.3.1 Data

The paper uses data from a representative face-to-face survey with a random and stratified sample of 1035[5] households. The total number of households is approximately 65140[6]. The survey lasted 8 months between December 2013 and July 2014 in 108 villages representing all the 26 administrative units of the Cameroonian and the Gabonese part of the landscape. The villages visited are spread over nearly 27,000 km^2, which is two third of the landscape livable inter-zone. The random sampling of households in the villages was based on the village inhabitants' registry held by the chief of the village.

The interviews lasted between 1 to 3 hours. In addition, there were evening visits in various households surveyed to quantify and measure daily, weekly and *per annum* livelihoods production. The survey was supervised by the first author. Ten Masters students selected after five training seminars participated as surveyors. Every village provided at least two local translators in the case the household's heads could not communicate in French. Every household was geo-localized with a GPS.

The *per annum* value of livelihoods were derived in two ways: Some well organized household's heads usualy record their daily, weekly and *per annum* livelihoods statistics. We trusted and collected these statistics. For the remaining households, we used contextual material to measure daily and weekly production. We extrapolated to have the *per annum* livelihoods production according to the recall data they stated and the seasonality of each species or product. For instance, among the forest-based livelihoods, (1) *Ricinodendron Heudelotti* is harvested every year for two-months period, it is measured with a 5 liters pail that weights 7.5kg, and a bag of 90kg is made of 12 pails. The total value for two months were considered as the *per annum* value. (2) Likewise, *Irvingia gabonensis* is harvested for three-months period a year. Some products are harvested during 12 months (*Gnetum africanum, Piper nigrum, Afromomum dalzeillii...*) and others are harvested during three to four months (*Fungi, Corylus avellana, Garcinia cola, Monodora myristica etc.*). The table A.2.1 in appendix shows the measurement indicators for the 20 NTFP, including fuel wood,

[5]The sample size required at a confidence level of 95% (typical value of 1.96) is 384.

[6]The aggregate population size in both segments of the Tridom-TCL is 418,855 inhabitants (Bucrep, 2010; Gabon, 2010). Considering the mean household size of the sample (6.43), the number of households is around 65,140.

that account for forest-based strategies. We also used a mechanical dynamometer to measure and to weight bushmeat, crop (banana, casava, potato, vegetables etc.) and cash crop (including rubber and cocoa) daily and weekly production. We used the average local sales price to estimate the value of such livelihoods resulting from each strategy. Indeed, price variation within rural areas is normally quite small (Angelsen et Kaimowitz, 1999).

1.3.2 Livelihoods portfolios

Based on an initial analysis we defined the households as member of one of six groups. Indeed, as illustrated in the figure A.1.2 in appendix, 35% of the Tridom-TCL households base their livelihoods strategies on small-scale agriculture and forest products extraction (AF). Besides these two activities, cash crop is included as a third activity in a mixed strategy with three activities (ACF) by 17% of the households. 14 % mix small-scale agriculture and cash crop (AC) and the remaining households specialize in forest-based (F, 27%), cash crop (C, 4%) and small-scale agriculture (A, 3%). The figure (1.1) below displays the distribution of the livelihoods strategies on the Tridom-TCL.

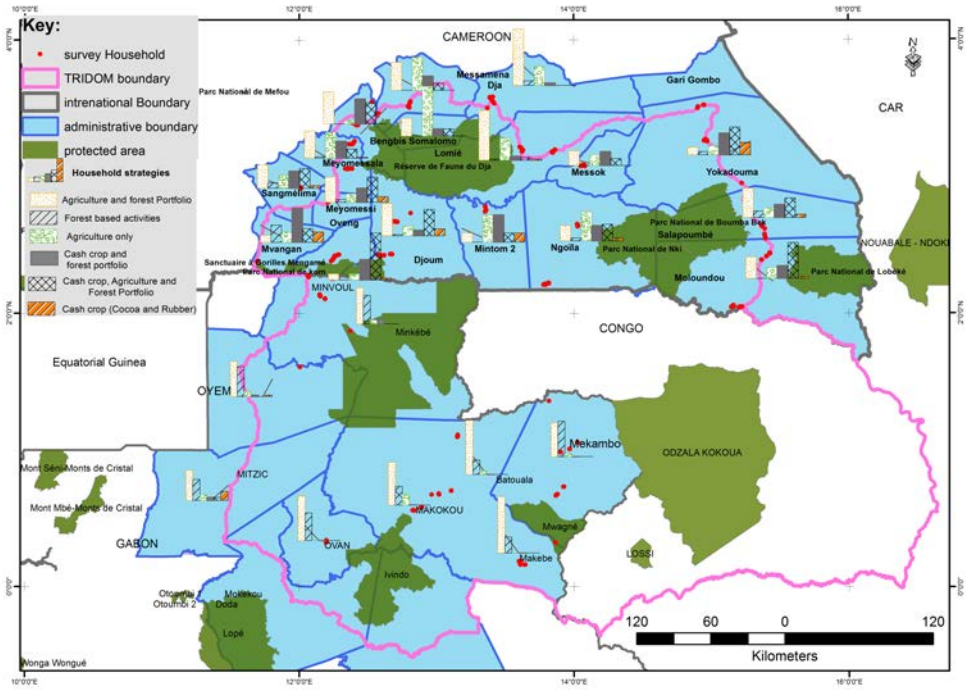


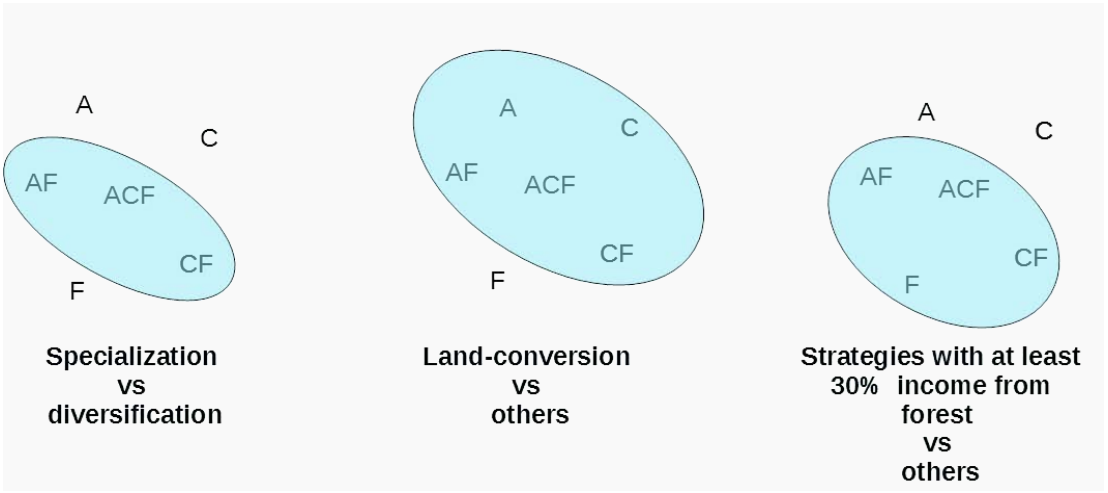
Figure 1.1: Livelihoods strategies on the landscape

1.4 Theoretical Model specification

1.4.1 Strategic trade-offs in livelihood portfolio selection

Several interesting development and environment strategic trade-offs (s) can be investigated when considering the livelihoods portfolio selection (see figure 1.2). First, one can consider that those choices oppose specialization strategies and diversification strategies: $[A, C, F]$ vs $[CF, AF, ACF]$. The development literature generally considers that specialization strategies may be closer to profit-maximizing behaviors (the household's head selects the most profitable activity), while diversification strategies are likely to be the consequence of risk-minimization behaviors (the household's head diversifies his/her portfolio in order to mitigate risk). Investigating this trade-off allows us to analyze the factors that influence the household heads' behavior and especially how they balance profit-maximizing versus safety.

Figure 1.2: Trade-offs in livelihoods strategies



Another matter of interest relates to land-use. Some portfolios encompass land-conversion activities, such as agriculture and cash crops, while others do not, such as forest-based activities including hunting bushmeat and gathering NTFP: $[A, C, CF, AF, ACF]$ vs $[F]$. This trade-off allows to understand which factors lead household's heads to make their choice of activities related to land-conversion. The relying results can bring evidence on the deep factors influencing deforestation behaviors.

Finally, one can distinguish portfolios relying on forests and the others: $[A, C]$ *vs* $[F, CF, AF, ACF]$. This distinction allows us to investigate which factors leads household heads to engage in forest-related activities. This is a matter of interests, as when household heads consider forests as assets, they may be more likely to consider them as valuable and thus be actors of forest protection.

1.4.2 A simple microeconomic model of livelihoods portfolios

Consider a household's head i that chooses among a set of livelihoods portfolios $L_i = [A, C, F, CF, AF, ACF]$ to maximize his/her utility U_i. X_i is a vector of the household's head i socio-economic variables, Z_{ip} stands for observed attributes of the activity portfolio p for the household's head i (Lancaster, 1966)[7]. Household i's utility function may encompass income derived from the livelihoods portfolios, but also other non-observable outcomes such as household's vulnerability. Thus, the household characteristics X_i may influence not only the economic return from the portfolios, but also other households matters of interest. Furthermore, we consider that household i's utility may be influenced by his/her neighborhood. L_j is the livelihoods portfolios selected by household i's neighbors, that are likely to influence his/her decision. The household maximisation problem is given by:

$$\max_{L_i} U_i(L_i, X_i, Z_{ip}, L_j) \tag{1.1}$$

The first-oder condition implicitly gives the optimal portfolio $L_i^*(X_i, Z_{ip}, L_j^*)$ for household i:

$$\frac{\partial U_i(L_i^*, X_i, Z_{ip}, L_j^*)}{\partial L_i^*} = 0 \tag{1.2}$$

As suggested by the trade-offs described in the above sub-section, households portfolio choice can be substituted by sets of binary strategies ($S = 1, 2$). Henceforth, S will be used for livelihoods strategies instead of L. The model described in equation (1.1) leads to binary or discrete outcomes. Models of discrete choices have been known since McFadden (1974); Bhat (1997); Horowitz (1991); Schnier et Felthoven (2011);

[7] According to Lancaster's theory, consumers derive their utility from the attributes that describe the product.

Albert et Chib (1993) and Thurstone (1927) and formulated as Random Utility Model (RUM). Basically, the theory of random utility assumes that the utility function is comprised by two components. The first is a systematic component representing the observed attributes of different strategies, the socioeconomic characteristics of an individual as well as the neighboring characteristics. The second is a random component that captures the effects of unobserved attributes and characteristics that may influence individual choices. Therefore, the utility function U_i presented in equation (1.1) driven by household i's livelihoods strategy becomes:

$$\begin{cases} U_{is} & = V_{is} + \epsilon_{is} \\ V_{is} & = aZ_{is} + b_s X_i + c_{s'} f(S_j^*) \end{cases} \tag{1.3}$$

Where $i = 1, 2, 3...n$ and $s = s' = 1, 2$.

In equation (1.3), V_i denotes the systematic component of the RUM, Z_{is} is the vector of characteristics of the binary strategy S adopted by household 's i, X_i is the vector of household i socioeconomic characteristics. a, b and c denote parameters associated to the covariates and ϵ_{is} is the random variable that captures the random component of the utility function and / or the unobserved attributes of the strategy S.

1.5 Spatial Probit Model

1.5.1 The model

The household i's head will adopt the optimal livelihoods strategy S_i^* that provides him/her with the greatest utility. Since binary dependent variable observations can be treated as indicators that relate to underlying latent or unobservable level of utility (Albert et Chib, 1993; LeSage et Pace, 2009), the decision to choose or not to choose, or to choose among two strategies can therefore be guided by the difference in utilities brought about by both realizations. Therefore, assuming the couple $(0, 1)$ as the observed choice indicator of the strategy S by household i, the following holds:

$$\begin{aligned} S_i &= U_{1i} - U_{0i} = a\left(Z_{i1} - Z_{i0}\right) + \left(b_1 - b_0\right) X_i + \left(c_1 - c_0\right) f\left(S_j\right) + \left(\epsilon_{i1} - \epsilon_{i0}\right) \\ S_i &= a \bigwedge Z_s + \beta X_i + \rho f\left(S_j\right) + \mu_i \end{aligned} \tag{1.4}$$

In equation (1.4), S_i is not observed. It is considered as an unobserved latent dependent variable, representing the relative utility derived by the household i's head from his/her observed strategy S_i^*.

The microeconomic model of livelihoods strategies developed above defines the household i's strategies and the resulting utility as function of neighboring households' matters of interest. Hence, the observed choice of a household may be similar or dissimilar to strategies of nearby households. Modeling such discrete variables generated by spatially interdependent processes requires defining a spatial weight matrix and an operator that help accounts for the intensity of spatial interaction among households as well as the resulting spatial spillover effects. In this paper, we are interested in the strength of spatial interdependence among households as well as its impacts on households' likelihood to choose a particular livelihoods strategy. Therefore, the spatial lag discrete dependent model is the most convenient among the spatially explicit econometrics models (Anselin, 2007). In the following, we removed the component $a \bigwedge Z_s$ from the model. Indeed, the main characteristics of households strategies are themselves the matter of the study.

Thus, equation (1.4) becomes:

$$\begin{aligned} &S = X\beta + \rho WS + \mu \\ &\mu \sim \left(0, \sigma_\mu^2 I_n\right) \end{aligned} \tag{1.5}$$

In equation (1.5), β is a kx1 vector of parameters to be estimated, ρ denotes the intensity of spatial interdependence, W is the spatial weight matrix and $WS(n\text{x}n)$ is the spatial operator that denotes the mean dependant variable of neighboring households. The term μ is a multivariate normal distribution corresponding to a Probit model. Under the hypothesis $\rho \neq 0$ and $(1 - \rho W) \neq I_n$, the matrix notation of the data generating process is given by equation (1.6) below:

$$S = (1 - \rho W)^{-1} X\beta + (1 - \rho W)^{-1} \mu \tag{1.6}$$

The observed value of the limited dependent variable S_i^* is defined as follows:

$$S_i^* = \begin{cases} 1 & \text{if } S > 0 \\ 0 & \text{if } S \leq 0 \end{cases} \tag{1.7}$$

Following LeSage et Pace (2009), the probability of choosing a particular strategy is given by:

$$Pr\left(S^* = 1 \mid X, W\right) = Pr\left(S > 0\right) = Pr\left(\left(1-\rho W\right)^{-1} X\beta + \left(1-\rho W\right)^{-1} \mu > 0\right) \\ = Pr\left(\eta < \left(1-\rho W\right)^{-1} X\beta\right) \tag{1.8}$$

In equation (1.8), $\eta = \left(1-\rho W\right)^{-1} \mu$. In the case where $\rho = 0$ and $\left(1-\rho W\right) = I_n$, the expression (1.8) follows a standard Probit model, and Maximum likelihood estimation (ML) techniques can be used. If $\rho \neq 0$ and $\left(1-\rho W\right) \neq I_n$, S and μ follow a Truncated Multivariate Normal Distribution, and the standard ML techniques are not suitable. Indeed, the inclusion of neighboring strategies WS as a determinant of the latent variable S involves n-dimensional integral in the likelihood function and generates some tractability and computational problems. Further, the reduced form of the latent process is nonlinear. This relates to the consistency of the model (Baltagi *et al.*, 2014). In this case, estimation can be achieved using the Bayesian Markov Chain Monte Carlo (MCMC) simulation methods by Gibbs and Metropolis-Hastings sampling (Albert et Chib, 1993; Geweke, 1991; LeSage, 2004, 2000; LeSage et Pace, 2009), using the Recursive Important Sampling (RIS) or the GHK (Geweke-Hajivassiliou-Keane) simulation methods (Geweke *et al.*, 1994; Hajivassiliou, 2000) to name a few. In this paper, we use the Bayesian approach to estimate the SAR-Probit model with MCMC simulations and Gibbs sample with 1000 drawn, 20% of the draws used as burn-in, assuming a non-informative prior distribution for β. For a detailed presentation of the Bayesian approach to modelling limited dependent variable, see LeSage (2000); Wilhelm et de Matos (2013); McMillen (1992).

As with the standard Probit model, estimates of the coefficients of the SAR-Probit do not have direct economic interpretation as the normal probability distribution is non linear. The sign of parameters is the only usable information, indicating the direction of the impact. The sensitivity of the probability to choose or not to choose a given strategy relative to one-unit change in the independent variables is measured by a single value standing for marginal effect in the standard Probit model. This does not hold for the SAR-Probit model. Indeed, the SAR-Probit model involves spatial lag of the dependent variable. This implies some spillover or indirect effect brough about by a one-unit change of the i_{th} household characteristics on the neighboring households' likelihood to adopt a strategy, in addition to the usual direct effect. Following LeSage et Pace (2009), the SAR-Probit yields three values of interest namely, the direct, the neighborhood and the total effect derived from

expression (1.9).

$$\frac{\partial E\left(S^{*} \mid X_{k}\right)}{\partial X_{k}^{\prime}}=\phi\left(\left[1-\rho W\right]^{-1} I_{n} \bar{X}_{k} \beta_{k}\right) \bigodot\left[1-\rho W\right]^{-1} I_{n} \beta_{k} \tag{1.9}$$

Where X_k denotes the k^{th} independent variable with $\bar{X}_k$ as mean value, ϕ is a standard normal distribution, and $\bigodot$ stands for element-wise multiplication.

The main diagonal elements of expression (1.9) represent the direct effect. That is the effect of a one-unit change in an independent variable of household i on the own likelihood to choose or not to choose a particular livelihoods strategy. The average value of each row results in the total impact brought about by one-unit change in the corresponding covariates. The neighborhood (indirect) effect is measured by the difference between the total effect and the direct effect. In the SAR-Probit, this number captures the effect of a one-unit change in an independent variable of the household i on the likelihood of the neighboring household to choose or not to choose a particular livelihoods strategy.

1.5.2 Spatial operator

The consideration of social interactions and / or spatial interdependence is made possible through the spatial operator WS that represents the neighboring livelihoods strategies. The spatial weight matrix W that summarizes the spatial relations between observations depends on the neighboring structures. A large body of research has used the distance weight matrix, contiguity weight matrix or K-nearest-neighbours (KNN) matrix corresponding respectively to distance-based households structure, common boundary structure and nearest neighbors structure (Bivand *et al.*, 2013). As pointed out by LeSage et Pace (2014); Fingleton et Arbia (2008), there is near universal agreement that estimates and inferences from spatial regression models are sensitive to particular specifications of the spatial weight structure.

To account for this "biggest myth in spatial econometrics" (LeSage et Pace, 2014), we consider three different structures of W, namely, the Gabriel graph weight matrix, the KNN weight matrix and the row-standardize distance-based weight matrix.

The Gabriel relative neighborhood graph is a geographic connectivity network between the sampling households. According to Matula et Sokal (1980) and Gabriel et Sokal (1969), two households i and j in the Tridom-TCL are considered to be contiguous if

and only if all other households are outside the i - j circle. In this weight matrix, two households i and j are considered contiguous unless there exists another household l such that in the triangle ijl, the distance between i and j is less than the sum of the squares of the distances to any other locality l.

The KNN weight matrix bases its estimation on a fix number of k households closest to household i. The selection of the KNN households is made possible via the euclidean distance $dij\,(x_i, x_j) = \| x_i - x_j \| = \left((x_i - x_j)'\,(x_i - x_j)\right)^{0.5}$. With $j = 1...k$. In this study, we consider 3NN, 5NN and 10NN spatial weight matrices. We choose 10 as maximum number because it is close to the minimum number of households in many villages surveyed.

In the row-standardize distance-based weight matrix, the i^{th} row contains the spatial weight of neighboring households influencing household i, such that each row sums up to unity. We consider the sparse matrices[8] in the three different structure of W we used.

1.6 What drives livelihoods strategies in the Tridom-TCL?

This section first presents descriptive statistics (2.6.1). Then, it presents the specification used for the results, choosing among the standard Probit model and the best spatial model given various types of weight matrix to control the so called "biggest myth in spatial econometrics" (2.6.2). It ends with estimates and marginal effects for each of the three trade-offs (1.6.3).

1.6.1 Descriptive statistics

Among the 1035 households surveyed, this paper considers 987 households who were successfully geo-localised with GPS, representing 95.4% of of surveyed households. Regarding the first dependent variable that opposes specialization strategies and diversification strategies as presented in the first trade-off presented in table (A.2.2) in appendix, about 66% of household's heads diversify their strategy, mixing small-scale farming, cash crop and forest. As regards the second dependent variable related to

[8]Compared to the usual dense matrix, a sparce matrix stores only non-zero elements. It generates economy in terms of memory, it reduces the complexity of systems' resolutions and greatly speed up the calculations (Erhel, 2014).

land-use, 73% of the households adopt land-conversion activities and the remaining prefer forest-based activities. The final trade-off opposes 67% of the sample choosing strategies relying on single or mixed strategies with at least 30% income provided by forest-based activities to households who do not or who rarely value forest.

the figure (A.1.3) in appendix shows that, among these trade-offs, households who diversify, those who choose land-conversion and those who rarely value forest would cause higher average deforestation ($5.26ha$, $5.57ha$ and $7.14ha$ respectively), with lower *per annum* return or yields (CFAF$0.40*10^6$, CFAF$0.40*10^6$ and CFAF$0.37*10^6$ respectively, that is \$84, \$84 and \$77.7)[9] while those who choose to specialize, to adopt forest-based activities or to rely on forest with a mixed of single strategies deforest twice less, with a two-time higher return.

Following these rough statistics, a tentative conclusion is that forest resource would be socially beneficial, and could therefore constitute a safety net for rural households. Specialization, as well as strategies that value forests would be viewed as sustainable strategies. However, this result does not provide detailed information about those who specialize, those who adopt forest-based activities, or those who value forest regardless of diversification or not. Subsection (1.6.3) below will provide further insight about the factors that lead households to make the choice of a particular strategy.

Table 1.1 displays a description of variables included in the analysis to test the hypotheses. We basically distinguish social assets, human capital, natural capital, financial assets, the environmental context, and infrastructure assets. Regarding social assets, in 2014, 70% of the households in the overall sample were married. The average household size was 6.5 with a standard deviation of 4. Twenty-six percent of the households belong to a community group of interest, households employ on average 1.87 member of pygmy society. Regarding human capital, 56% of the households have reached at least secondary-school educational level. Regarding natural capital, we choose not to introduce land-holding as a determinant of livelihoods strategies, as there is neither a market of lands nor a binding regime on access to land. Yet, we introduce human-elephant conflict which caused CFA620 mean damage cost per month. We also introduce the land conflict among households. Indeed, 18% of the households have faced conflicts with their neighbors. Both variables should also provide some information on the behavior of vulnerable households especially when facing a shock.

[9] In 2014, year of the field work, CFAF1 = $\$0,0021$)

Financial assets are approximated by loans and money transfers with a mean value of $CFA8.66 * 10^3$ per month. Regarding the environmental context, households are located on average at $29.3km$ to the nearest protected area with a standard deviation of 22.58. As an indicator of transport cost and infrastructure assets, the average distance to the subdivision's market is $51.65km$ with a deviation of 35.7. Female-headed households account for 23% of the sample, and the average age is 48.44 years. The table in appendix (A.2.2) provides a more detail description of these variables with respect to various strategies and trade-offs.

Table 1.1: Variables and descriptive statistics of overall sample

Variables	Description of variables	Mean	StDev
Social asset			
Marit_single	Matrimonial status. Dummy (1=Maried)	0.70	0.46
Hsize	Household size (continuous)	6.50	4.01
Pygmee_employmt	Pygmies employment (continuous)	1.86	2.95
CommunityGroup	Community Interest Companies . Dummy (1=yes)	0.28	0.45
Autochbaka	Indegenouesness . Dummy (1=pygmy. 0=Bantou)	0.05	0.22
Human Asset			
Age	Household's head age (continuous. in years)	48.44	14.61
Seniority	Seniority in the village (continuous. in years)	27.01	20.71
Schoolcycl	Education level . Dummy (1=secondary school)	0.56	0.50
Naturel asset (access to)			
Land holding	Deforestation per household (in ha)	4.55	5.31
Landconflict	Land use conflict . Dummy (1=yes)	0.18	0.38
Human_Wildlife	Damage cost of wildlife conflict (CFA/month)	0.62	1.45
Financial asset			
Finance_asset	Credit and money fransfert (CFAF/month)	8.66	33.54
Location asset			
Distance to PA	Distance to the nearest Protected Area (in Km)	29.30	22.58
Distmarket	Distance to market (in Km)	65.05	58.69
Other drivers			
Gender	Gender. Dummy (1=Male)	0.77	0.42
Country	Country. Dummy (1=Cameroon. 0=Gabon)	0.73	0.44

1.6.2 Spatial dependance and sensitivity

1.6.2.1 Data generation process and results' accuracy with the weight matrix type

The standard Probit model is contrasted to the SAR-probit model as suggested by LeSage et Pace (2009, 2014). Further, we check the sensitivity of the results to various specifications used for the spatial weight structure in the SAR-probit. It finally concludes on the nature of the spatial dependence in various trade-offs, considering the best model.

The table in appendix (A.2.3) displays the results of the standard Probit model that assumes non-spatial relationship among observations alongside with those of the spatial autoregressive model for the trade-off between specialization and diversification. This table shows some stark contrasts between the estimates and marginal effects of both standard Probit model and SAR-probit. It also suggests a significant effect of distance to market as well as distance to the nearest protected area. On the other hand, these effects are not significant for the SAR-Probit. In the latter model, the spatial autocorrelation coefficient, ρ, differs statistically from zero. It is thus clear that estimates and marginal effects of the standard Probit model are biased and inconsistent, allowing non pertinent causations as regards to both distances to the market and the nearest protected area. As result, the decision to choose among specialization and diversification is generated by spatially interdependent processes.

The table in appendix (A.2.4) contrasts the results of various SAR-Probits given the structure of neighbors to illustrate the impact of changing the type of the weight matrix. It shows that varying the type of the matrix does not lead to similar results. Indeed, the Gabriel-relative neighborhood graph (Gabgrahp) reports the absence of spatial patterns. The value of $\rho_{Gabgraph}$ is close to zero and non significant ($\rho_{Gabgraph} = 0.05$), while the KNN and the distance-based matrix report the influence of spatial effects on the households' likelihood to adopt a livelihoods strategy. Further, differing the number of neighbors yields different results. As the number of neighbors increases, the strength of spatial interaction increases. The spatial weight matrix based on 10 nearest neighbors (10NN) presents higher spatial dependence with $\rho = 0.36$ compared to 3NN ($\rho_{3NN} = 0.23$) and 5NN ($\rho_{5NN} = 0.29$). The distance-based matrix yields spatial effects that are closer to the 10NN.

This analysis validates the sensitivity of results to the weight matrix specification postulated by LeSage et Pace (2009, 2014). Therefore, a good analysis of households livelihoods strategies should involve testing and accounting for spatial effects using spatially explicit econometric models, as well as checking the accuracy of the results with the form of the spatial weight matrix. In the following, we consider the distance-based weight matrix. Indeed, as the households were geo-localized during the field work, the distance-based weight matrix (that yields almost similar results with the 10NN matrix in our study) is better. This matrix allows for the magnitude of interaction among two individuals to be proportional to the inverse euclidian distance among them, while the KNN matrix tends to attribute the same weight to all the k individuals. The quantitative explanatory variables were checked for

multi-collinearity, tables (A.2.5) and (A.2.6) in appendix suggest the independence among them.

1.6.2.2 Spatial dependence

Table 1.2 shows an evidence of spatial autocorrelation among the likelihood of proximal households to choose among livelihood strategies. Indeed, the value of ρ is positive and significant at 1%. This suggests that households tend to mimic the livelihood strategies of their neighbors.

The range of the ρ parameter suggests a difference among the strength of mimicry among the three trade-offs. Indeed, the dependence among closer households' likelihood appears to be stronger regarding strategies that value forest rather than choosing or not to choose between forest-based strategies and land-conversion based strategies, or between specialization and diversification.

1.6.3 Coefficient Estimates and Marginal Effects

Table 1.2 presents the sign and the possible variables that drive household heads' decision in various trade-offs. Tables 1.3, 1.4 and 1.5 present the magnitude or the incremental change resulting from a one-unite change in the independent variables on both own and neighboring likelihood of choosing or not to choosing a strategy in various trade-offs. As a reminder, the independent variables include households' human, social, natural and financial assets; geographical assets of location and infrastructure; remaining households characteristics and spatial spillover effects.

1.6.3.1 Specialization vs diversification

Table 1.3 displays the results for the first trade-off where households choose between specialization (either on forest activities, or on cash-crop or small-scale farming) and diversification (mixing cash crop, forest and small-scale farming). One can argue that households specializing in one activity tend to be more income-maximizing oriented, while those tending toward diversification are more risk-coping oriented. Yet, other kinds of characteristics have to be taken into account: some households may have to specialize because there are some barriers to diversification, related to low levels of some assets.

Table 1.2: MCMC SAR-Probit estimates

	Specialization VS Diversification			Forest-based VS Land-Conversion			Valuing Forest VS Non Valuing Forest		
	Estimate	Std. Dev		Estimate	Std. Dev		Estimate	Std. Dev	
Social assets									
Marit_single(1=Maried)	0.0640	0.107		-0.0310	0.106		-0.191	0.106	*
Hsize(continious)	-0.0584	0.012	***	-0.058	0.012	***	-0.014	0.011	
Pygmee_employmt(cont)	0.0095	0.015		-0.018	0.017		-0.018	0.015	
CommunityGroup(1=yes)	-0.1531	0.098		-0.12	0.109		-0.086	0.102	
Autochbaka(1=pygmy)	0.4552	0.194	**	0.651	0.201	***	0.762	0.252	***
Human assets									
Age(continious)	0.0038	0.003		0.005	0.003	**	0.007	0.003	***
Seniority(years in the vlge)	-0.0056	0.002	**	-0.007	0.003	***	-0.004	0.003	
Schoolcycl(1=2ndschool)	-0.0857	0.087		-0.08	0.095		-0.057	0.095	
Natural assets (access to)									
Landconflict.(1=yes)	0.0631	0.112		0.129	0.119		0.024	0.123	
Human_Wildlife(Damage cost)	0.0497	0.03	*	0.06	0.03	**	0.091	0.033	***
Financian asset									
Finance_asset(CFAF)	0.0036	0.002	**	0.001	0.001		-0.001	0.001	
Location assets									
Distance(in Km)	0.0023	0.002		0.001	0.002		-0.001	0.002	
Distmarket (in Km)	0.001	0.001		0.001	0.001	*	0.001	0.001	
Other drivers									
Gender(1=Male)	0.0258	0.095		-0.011	0.102		0.15	0.104	
Country(1=Cameroon)	-0.2464	0.109	**	-0.165	0.114		0.01	0.098	
ρ	0.3616	0.122	***	0.484	0.094	***	0.732	0.049	***
L_{i}(0.1)	(654. 333)			(721. 266)			(321. 666)		
AIC	1199.268			1064.261			1224.836		
logLik.sarprobi	-583.63			-516.13			-596.41		
N draws	1000			1000			1000		
burn-in	200			200			200		

- **Social asset**

  Among households' social assets, being part of a community group of interest, marital status and pygmies employment do not have any direct or indirect impact on the household's head likelihood to choose between diversification and specialization. The direct and indirect effect resulting from the household size is negative and significative. This suggests that larger households will be less likely to specialize than others. Moreover, they tend to have negative spillover on their neighborhood. Further, regarding the magnitude, a one-unit increase in household size will reduce both own probability and neighboring households' probability to specialize by 1.93% and 1.16% respectively. This leads to a total impact of 3.09%, (i.e. 1.93%+1.16%). Finally, autochthonous (wether indigenous pygmy or not) exerts a positive and significant direct and indirect influence on specialization strategy. Indeed, indigenous Baka pygmies are more

likely to specialize in forest-based activities. Being a pygmy is associated with 15.08% more chances to specialize and tends to increase his/her neighboring households' likelihood to specialize by 9.16%, leading to a total impact of 24,23%.

- **Human asset**

  With respect to human capital, the direct and the indirect effect associated with secondary school education level as well as age is not significant. Yet, households who settled long ago in villages (seniority) are less likely to specialize in their livelihoods strategies. An additional seniority year increases the likelihood to diversify by 0.18% with a positive spillover effect of 0.11% on the likelihood of neighboring households to diversify.

- **Natural asset**

  Human-wildlife conflict as well as land conflict with the neighboring households were considered as an indicator of access to natural capital. Table 1.3 also shows a non significant impact of land conflict within the household's neighborhood. It also shows that households who face human-wildlife conflict are more likely to specialize in a particular livelihood strategy. More precisely, a CFAf1000 ($2.1) additional elephants damage cost per month will lead to increasing own probability to specialize by 1.65% with a positive spillover effet of 0.98% on the probability of those living within their neighborhood to specialize, that is a total effect of 2.62%.

- **Financial asset**

  Household heads' financial capital endowment and more precisely, loan and money transfers increase both own and neighboring households' likelihood to specialize. A CFAf1000 ($2.1) increase of the household financial capital will increase own and neighboring likelihood to specialize by 0,12% and 0.07% respectively, that is a total effect of 0.19%. This result gives the insight that higher financial assets alleviate some barriers to specialization. Moreover, financial assets constitute a risk-management tool, which reduces the need for other risk-coping strategies such as diversification.

- **Geographical asset or location**

  Both location assets, including environmental state (distance to the nearest protected area) and infrastructure (distance to market), do not significantly influence households' choices between specialization and diversification.

- **Gender and Country effect**

  Gender seems to have no impact on the choice of specializing versus diversifying. Also, Cameroonian households are less likely to specialize in their livelihood strategies.

Table 1.3: Marginal effect Specialization VS Diversification

	Direct effects			Indirect effects			Total effects		
	Mean	z(1.96, 5%)		Mean	z(1.96, 5%)		Mean	z(1.96, 5%)	
Social asset									
Marit_single(1=Maried)	0.0212	0.7211		0.0133	0.764		0.0345	0.748	
Hsize(continious)	-0.0193	-6.2294	**	-0.0116	-2.0044	**	-0.0309	-3.9114	**
Pygmee_employement	0.0032	0.7392		0.002	0.7896		0.0051	0.7678	
CommunityGroup(1=yes)	-0.0507	-1.7847		-0.0306	-1.219		-0.0813	-1.7702	
Autochbaka(1=pygmy)	0.1508	2.7952	**	0.0915	2.2696	**	0.2423	2.6349	**
Human Asset									
Age(continious)	0.0013	1.7187		0.0008	1.7912		0.002	1.7292	
Seniority(years in the vlge)	-0.0018	-2.7086	**	-0.0011	-1.5184		-0.0029	-2.4753	**
Schoolcycl(1=2ndschool)	-0.0283	-1.1339		-0.0164	-0.8347		-0.0447	-1.1135	
Naturel asset (access to)									
Landconflict.(1=yes)	0.021	0.6682		0.0128	0.6911		0.0338	0.6751	
Human_Wildlife(Damage cost)	0.0165	1.9409	*	0.0098	1.9419	*	0.0263	1.9458	*
Financial asset									
Finance_asset(CFAF)	0.0012	2.6644	**	0.0007	2.3046	**	0.0019	2.6551	**
Location asset									
Distance(in Km)	0.0008	1.6009		0.0004	1.6234		0.0012	1.6066	
Distmarket	0.0003	1.8139		0.0002	1.8315		0.0005	1.8077	
Other drivers									
Gender(1=Male)	0.0085	0.3258		0.0046	0.2816		0.0132	0.3022	
Country(1=Cameroon)	-0.0813	-2.7045	**	-0.0465	-1.5516		-0.1278	-2.8956	**

1.6.3.2 Non-land-conversion activities vs land-conversion activities

Table 1.4 displays the marginal effects for the trade-off between non-land-conversion activities (which consists of forest-based specialization) vs land-conversion activities. This brings interesting insights, as it can help to understand which factors lead households to engage in activities related to land-use change and deforestation. As a matter of fact, households taking the non-land-conversion strategy were associated with average levels of deforestation of 1.78 ha, while those engaged in land-conversion activities had average deforestation levels of 5.57 ha.

- **Social asset**

  The household size and the indigenous status of the households are both the social assets that influence households' likelihood to adopt either forest-based

or land-conversion activities. Increasing household i_i's size by one unit will significantly decrease both own and neighboring households' likelihood to adopt forest-based activities as livelihoods strategy by 1.69% and 1.58% respectively. This result suggests that land-conversion activities are more labour intensive than others, and increased household size facilitates conversion. Belonging to the pygmy ethnicity is associated with a greather likelihood (18.8%) to adopt forest-based strategy, with a significant indirect spatial effect of 17.9% on the neighboring preferences for such strategy.

- **Human asset**

  This table suggests that education level does not influence households' decision between forest-based strategy and land-conversion strategy. However, the direct and the indirect, and thus the total impact of the household age and seniority on this trade-off, is significant, the first being positive and the second negative. In detail, when a household becomes one year older, their probability to practice non-conversion strategy increases by 0.15% with a positive spillover effect of 0.14% on their neighborhood. The resulting total effect is an increase in the likelihood to specialize by 0.29%. With regard to seniority, households who settled long ago in villages will be more likely to base their livelihoods strategies on land-conversion activities. They are associated with an additional 0.21% probability to keep such strategies and with 0.2% positive spillover effect on their neighborhood.

- **Natural asset**

  Among the factors that influence access to natural assets, land conflict in a neighborhood does not have any effect. Moreover, human-wildlife conflict remains non neutral as in the preceding subsection. An increase of CFA1000 in crop damage by elephants increases the likelihood of the concerned household's head to prefer non-conversion strategies by 1.74% with a 1.62% positive knock-on effect on the neighboring household likelihood to adopt the same strategies.

- **Geographical asset or location**

  Distance to the nearest protected area remains non significant as previously. In contrast, households living far from local markets are more likely to rely on non-conversion strategies for their livelihoods, with a positive spillover effect within their neighborhood. This may reflect transport costs that are larger, which leads to lower profitability of agriculture and especially cash crops.

- **Other assets**

  Financial assets, gender and country do not exert any effect on the household decision in this trade-off.

Table 1.4: Marginal effect Non-land-conversion VS Land-conversion

	Direct Effect			Indirect Effect			Total Effect		
	Mean	z(1.96, 5%)		Mean	z(1.96, 5%)		Mean	z(1.96, 5%)	
Social asset									
Marit_single(1=Maried)	-0.009	-0.3605		-0.0084	-0.3319		-0.0174	-0.3451	
Hsize(continious)	-0.0169	-5.427	**	-0.0158	-2.813	**	-0.0327	-4.6673	**
Pygmee_employement	-0.0052	-1.2117		-0.0049	-1.0165		-0.01	-1.1997	
CommunityGroup(1=yes)	-0.0347	-1.319		-0.0328	-1.0939		-0.0675	-1.2449	
Autochbaka(1=pygmy)	0.1886	3.9571	**	0.179	3.0834	**	0.3676	3.6718	**
Human Asset									
Age(continious)	0.0015	2.2978	**	0.0014	2.222	**	0.0029	2.2329	**
Seniority(years in the vlge)	-0.0021	-3.3589	**	-0.002	-2.1831	**	-0.0041	-2.8667	**
Schoolcycl(1=2ndschool)	-0.0232	-1.0763		-0.0207	-0.9471		-0.0439	-1.0341	
Naturel asset (access to)									
Landconflict.(1=yes)	0.0374	1.2849		0.0352	1.3231		0.0726	1.303	
Human_Wildlife(Damage cost)	0.0174	2.341	**	0.0162	2.2367	**	0.0336	2.3308	**
Financial asset									
Finance_asset(CFAF10^3)	0.0004	1.1673		0.0003	1.2182		0.0007	1.1754	
Location asset									
Distance(in Km)	0.0002	0.5494		0.0002	0.5213		0.0005	0.5464	
Distmarket	0.0004	2.2866	**	0.0004	2.2933	**	0.0008	2.3702	**
Other drivers									
Gender(1=Male)	-0.0032	-0.1267		-0.0029	-0.1214		-0.0061	-0.1268	
Country(1=Cameroon)	-0.0472	-1.641		-0.0421	-1.5131		-0.0894	-1.7657	

1.6.3.3 Forest-based vs non forest-based

- **Social asset**

  Social capital, such as being part of a community group of interest, pygmies employment and the household size do not exert any influence on the households trade-off between forest-based activities and land-conversion strategies; while marital status and the indigenous status of the households do. Being married decreases the household head's likelihood to expect at least 30% of his/her income from forest-based activities by 6.4% without indirect spatial spillover effect within their neighborhood. In contrast, being a pygmy household head is associated with 25.6% more chances to exert livelihood strategies that value forest. This result is consistent with the main activity of pygmy communities being related to forests, specialization and non-land-converting-activities.

- **Human asset**

  Age is the only households' human asset that impacts the likelihood to choose or not to choose among both strategies in this trade-off.

- **Natural asset**

  Land-use conflict among households does not influence household heads' choice in this trade-off. But the marginal effect resulting from increasing the cost of crop damage caused by wildlife increases the likelihood of the household to choose strategies associated with at least 30% of income from forest.

- **Other assets**

  Financial asset, geographical asset, including distance to the nearest protected área, and distance to the nearest market, gender and country do not influence the preferences within the third trade-off.

Table 1.5: Marginal effect strategies valuing forest VS Non valuing forest

	Direct effect			Indirect effect			Total effect		
	Mean	z(1.96, 5%)		Mean	z(1.96, 5%)		Mean	z(1.96, 5%)	
Social asset									
Marit_single(1=Maried)	-0.0642	-2.0832	**	-0.1713	-1.8273		-0.2355	-1.9699	**
Hsize(continious)	-0.0046	-1.4943		-0.0121	-1.3673		-0.0167	-1.451	
Pygmee_employement	-0.0059	-1.3073		-0.0158	-1.2937		-0.0217	-1.3438	
CommunityGroup(1=yes)	-0.0287	-1.0346		-0.0776	-0.9803		-0.1063	-1.0561	
Autochbaka(1=pygmy)	0.2561	3.899	**	0.6889	3.4181	**	0.945	3.6702	**
Human Asset									
Age(continious)	0.0023	3.2291	**	0.0061	3.2878	**	0.0084	3.2939	**
Seniority(years in the vlge)	-0.0014	-1.9094		-0.0036	-1.757		-0.005	-1.822	
Schoolcycl(1=2ndschool)	-0.0194	-0.7046		-0.0521	-0.6465		-0.0715	-0.6632	
Naturel asset (access to)									
Landconflict.(1=yes)	0.008	0.2375		0.0225	0.2645		0.0305	0.2547	
Human_Wildlife(Damage cost)	0.0304	3.2818	**	0.0812	3.2239	**	0.1116	3.3479	**
Financial asset									
Finance_asset(CFAF10^3)	-0.0004	-1.1009		-0.001	-1.0613		-0.0013	-1.0746	
Location asset									
Distance(in Km)	-0.0004	-0.9262		-0.0012	-0.8947		-0.0016	-0.9092	
Distmarket	0.0002	1.0903		0.0006	1.0749		0.0008	1.0843	
Other drivers									
Gender(1=Male)	0.0502	1.7329		0.1351	1.7548		0.1854	1.7539	
Country(1=Cameroon)	0.0037	0.1363		0.0108	0.1428		0.0145	0.1399	

1.7 Discussion and conclusion

In rural areas of the developing world, livelihood strategies have key choices determining population wellbeing, sustainability and natural resource management. Yet, these

choices are constrained by many types of variables, including assets at households' disposal. It is then of crucial importance to understand to what extent these assets influence the choice of livelihoods strategies. In this paper, we argue that the choice of activities portfolios can be decomposed in diverse strategic choices. We focus on the choices of diversification versus specialization, land-conversion activities versus non-land-conversion activities, and forest-based activities versus non-forest-based activities. Moreover, we give a special emphasis to spatial spillovers, relying on the assumption that individual choices have external impacts within his/her neighborhood. For that purpose, we rely on a unique dataset of households survey, conducted in the Tridom-TCL.

Our paper brings interesting insights. First, belonging to the pygmy community has some key influence on livelihood choices: Pygmies tend to specialize in forest-based activities and to avoid land-converting activities. This result is not a surprise *per se*, but it underlines that autochthonous status has a strong influence on livelihood choices. Pygmies have historically been living in the forest and depending on forest products. Their traditional livelihood strategies are hunting bushmeat and gathering NTFP; this is why they are usally labelled as hunter- gatherers.

Second, we find evidence of a few drivers of specialization. Financial assets increase the likelihood to specialize. This can be explained by the fact that such assets can be seen as a safety net in case of shocks. Thus, higher financial assets decrease households' vulnerability, and increase the need to diversify to cope with risks. Seniority and household size increase the likelihood to diversify. These factors may have two kinds of explanation: (1) a larger household may increase the need to cope efficiently for all the risks the family faces; (2) these factors can also represent a higher capacity of larger households with deep roots in the community to diversify.

Third, the choice of land-converting activities is driven by household size, newer arrivants in the community, and smaller distance to markets. Indeed we can expect larger households to be able to engage in activities that are more land extensive, as it can represent a larger labour force. Smaller distance to markets represents smaller transportation costs, and thus higher profitability of land-converting activities.

Fourth, the role of wildlife conflict has to be pointed out. Larger crops losses implicitly increase forest valuation and the need to cope with the crops losses but also increase land conversion. Following this argument, it is interesting to analyze how human-wildlife conflicts influence the household preferences for wildlife conversation (this is done in Ngouhouo Poufoun *et al.* (2016)). Environmental state is also important

when dealing with livelihood choices. Proximity to protected areas does not seem to impact these choices. This gives the insight that conservation policies do not influence much households in the neighborhood. Thus it appears that environmental protection is not carried out at the expense of setting more constraints on households' livelihood choices. Likewise, it appears that land conflicts do not influence the choice of livelihoods strategies. This can indicate that access to land is not scarce in the study area. In this case, land access does not seem to impose a strong constraint on households in their livelihood choices.

Finally, it is crucial to note the existence of spatial spillovers. In all cases, the direct effects of the assets on livelihood choices are combined with indirect effects on the neighborhood. This result can be related to agglomeration effects: households of the same types tend to live in the same neighborhood. It can be also related to mimicking or other types of spatial dissemination.

The three strategic choices that we analyse in this paper have an impact in terms of well being, but also in terms of land use. A quick look at the figure (A.1.2) in appendix shows that households that specialize have better economic outcomes, both in terms of yields and income, than those diversifying their activities. This is consistent with the fact that households choosing specialization strategies tend to be income maximizers, while those choosing diversification tend to have others objectives, such as risk coping or they make a constrained choice. In terms of land use, specialized households tend to have smaller deforestation levels than others. Thus if economic development reduces households' vulnerability to shocks (e.g., through better access to markets), this can bring larger deforestation rates if those households decide to specialize [10].

When comparing households focusing on land-conversion activities, they unsurprisingly tend to have larger deforestation levels than others. In terms of economic outcomes, they have slightly lower levels of income, which may seem surprising. In such case, it is likely that higher income from households relying on cash crops are balanced by lower income for small scale farming households. In the same manner, one can see that households relying on forest resources have lower deforestation levels, while their income is comparable to others. Thus it appears that giving incentives to households so that they rely on forest resources would help to protect forests, while not hurting their livelihoods.

[10]However, this result may be driven by the presence of cash crops in the diversified portfolios. This would require further investigations in terms of land-use analysis.

This work opens the field for further research using our database. First, the impact of the livelihood choices on deforestation requires a deeper analysis. Second, as mentioned, risk is an important matter in rural areas. Analyzing factors influencing households risk preferences, and the way those risk preferences influence livelihoods, deforestation and ecosystem services preferences is of crucial matter.

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Chapter 2

Households' livelihoods and deforestation in the Tridom Landscape : A spatial analysis

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Working paper "*Les Cahiers du Lef*"

Sommaire

abstract

This chapter aims to examine the determinants of household' deforestation in the Tridom tansboundary conservation landscape (Tridom-TCL). It investigates the role of households' livelihoods strategies. It also tests the effects of crop damage caused by elephants (human-elephant conflict) on the households' decision of deforestation, using a unique dataset gathered with 1035 households in the Tridom-TCL. The results of the spatial autoregressive model show that: (1) households tend to imitate deforestation decisions of their neighbors. (2) When account cash crops is part of a diversification livelihoods strategy, households' deforestation increases significantly with a significant indirect impact on neighboring households' deforestation. In fact, a one-unit increase in the income of households that include cash crops in their portfolio, leads to six to seven times increases in households' deforestation compared to the effect of income increase in households choosing other livelihoods strategies. Also, (3) the indirect effects of these choices on neighboring households' deforestation have almost the same magnitude as the direct impact resulting from other strategies. (4) We find no substitutability between leisure and work in land use choices. Indeed, the Pygmies, who constitute the pincipale labour with low cost, are employed in activities related to larger deforestation, while household labour duration does not significantly drive households' deforestation. The share of households' self-consumption is associated with a low deforestation, therefore, a bigger integration of the market can lead to increased deforestation, if practices remained unchanged.

keywords : Small-scale farming, Forest-based livelihood , Landscape approach, Deforestation, Spatial Spillover Effects, Neighborhood Peer Effects.

JEL Classification: C31,Q23 & 24, R14

2.1 Introduction

In most developing world, rural households rely on both small scale farming and forest-based activities to develop their survival strategies. Small scale agriculture is known as a source of livelihoods for about 86 percent of the three billion people living in rural areas (Burch *et al.*, 2007), while forests-based activities are widely recognized to provide safety nets to mitigate agricultural risk (Pattanayak et Sills, 2001) and contributes between 22.2% to 27% of total households income (Vedeld *et al.*, 2007; Angelsen *et al.*, 2014). As pointed-out by the literature on sustainable livelihoods strategies by Ellis (2000); Scoones (1998), rural households switch between specialisation and diversification to optimize their livelihoods provisioning. In the Dja-Odzala-Minkébé trinational tansboundary conservation landscape (Tridom-TCL), Ngouhouo Poufoun et Delacote (2016) investigates the variables determining the household choice to specialize or diversify its activities. The authors have also shown that choosing a livelihoods strategy in the Tridom-TCL can be seen as strategic choice between forest-based and non-forest-based portfolios including small-scale farming and/or cash cropping (cocoa and rubber). Yet, depending on the orientation between land-converting activities and forest resource extraction, effort allocation by households might either increase deforestation, increase forest degradation, or enhance both (Delacote et Angelsen, 2015). Indeed, agriculture is estimated to be the proximate driver for around 80% of deforestation worldwide, contributing for 10 to 12% of the total global annual anthropogenic emissions of GHGs (Verchot, 2014), while poaching and non-sustainable harvesting of non-timber forest products (NTFPs) can have significant adverse impacts on forest ecosystems and lead to forest degradation (Belcher et Schreckenberg, 2007; Hosonuma *et al.*, 2012; Angelsen, 2009; KissinGer et Herold, 2012), reducing the capacity of forest to regenerate and to produce ecosystem services.

Our recent household survey at the Tridom landscape-scale provides some evidence that about 85,45% of households are responsible for changing forest cover to other uses regardless of their livelihoods strategies. There is a low population density (less than 7 $inh./km^2$) and local households are less likely to practice optimal crop rotation. As there is no binding regime[1] of land acquisition in the non-permanent

[1] A binding regime or more secure property rights motivates efficient resources management by landowners (Angelsen et Kaimowitz, 2001).

forest estate[2] that is seen as common access resources, they can clear relatively large area of land at low cost.

In almost all cases, land conversion is done without revival of forest neither artificially nor naturally. Indeed, rural households do not apply any agroforestry system and they are not involved in the reforestation activities, while primary or secondary forest is progressively replaced by corkwood, whose carbon storage potential is very low. In many case, extensive and unsustainable household farming based on slash-and-burn cultivation accentuates small-scale deforestation and forest degradation. After removal or selling the softwood lumber in surrounding forests, all the remaining plants and material in the forest are burnt and land is used for extensive agricultural and cash-crop production. Soil fertility and crop yields are continuously declining (Boahene *et al.*, 1998) and could cause a food crop production loss of at least $2.4billion to $5 billion to across the Congo Basin (Ernst *et al.*, 2010). Without an optimal fallow system, local people are experiencing poor yields per hectare regarding cash-cropping and crop production. Indeed, at least 75% cocoa and plantain yield observed are less than 0,338t/ha and 3.59t/ha respectively with an average of 0.236t/ha and 3,09t/ha. This average yield is below the average performance given limited farm means of production that is 0.5t/ha and 16.5 t/ha, respectively. The potential yield of Cocoa is 0.73t/ha and 1.22t/ha when cocoa plantations are associated with timber shade and leguminous tree species and when there is a good use of the litter fall resoectively. The maximum yield can reach 2.4t/ha (Somarriba et Beer, 1998, 2006). Regarding plantains, the potential yield can reach 30t/ha/year (MINCOMMERCE, 2010). The diminishing returns due to the unsustainable practices contribute to the perpetration of poverty (Alemagi *et al.*, 2014). Hence, the high level of forest dependence may not necessarily correspond to a high and sustainable potential to reduce poverty (Angelsen et Wunder, 2003). Rather, this may lead to over-exploitation of common access resources and constitute poverty trap when rural households face a large need of insurance (Delacote, 2007).

In light of the above considerations, analyzing the full set of potential drivers of households' deforestation, prioritizing or distinguishing among them in order to inform policy makers and facilitate appropriate political decision process to curb deforestation in the medium and long term perspectives is of crucial interest (Pfaff,

[2]The forest sector in Congo Basin Countries is divided into (i) 'Permanent Forest Estate', that includes logging concessions, ought to remain forest and mandated to maintain the biological diversity, and (ii) 'Non-Permanent Forest Estate', that can be turned to alternative use including sustainable agriculture.

1999; Tegegne *et al.*, 2016). Our paper contributes to the literature, and seeks to answer the following questions : How and how much do the different livelihoods strategies developed by households, given wildlife constrains such as human-wildlife conflict impact small-scale deforestation ?

The following sections develop the literature review and our contribution (section 2.2), Objectives and hypothesis (section 2.3), a simple microeconomic model (section 2.4). The spatial economic procedure in presented in section 2.5, the results in section (2.6) and discussion and conclusion in section (2.7).

2.2 Literature Review and contribution

2.2.1 Literature review

The substantial academic research on the causes of tropical deforestation includes (1) conceptual framework for analyzing deforestation, (2) macro-level empirical studies including regional and national levels, (3) micro-level empirical studies and (4) spatially explicit analyses.

2.2.1.1 Conceptual Framework related studies

The first analysis that combined the results of multiple studies to frame the causes of tropical deforestation was realized by Angelsen et Kaimowitz (1999). The authors have synthesized the results of more than 140 economic models using five types of variables[3] to build a helpful framework for both understanding deforestation processes and classifying modeling approaches. According to the authors, the agent or the source of deforestation (plantation companies, small farmers, etc.) has to be identified. Further, agents' decisions have to be considered, accounting for (1) their characteristics, including their preferences, their background (seniority of a households head), labour allocation as well as their initial resource and for (2) their decision parameters such as property regime, agricultural price, timber prices and

[3]The five types of variables used in the 140 models of deforestation are : (1) The magnitude and location of deforestation; (2) the agents of deforestation, namely, individuals, households, or companies involved in land use change and their characteristics; (3) the choice variables (decisions about land allocation that determine the overall level of deforestation for the particular agent or group of agents); (4) Agents' decision parameters and (5) macroeconomic variables and policy instruments affecting forest clearing indirectly through their influence on the decision parameters Angelsen et Kaimowitz (1999).

income. These variables represent immediate or proximate causes. Finally, underlying variables, i.e., broader forces like macroeconomic variables or policy instruments that influence the source or agents and indirectly drive deforestation have to be taken into account. Proximate drivers stand for human-induced factors that influence directly households' deforestation, while underlying driving forces are fundamental social processes, that underpin the proximate causes and either operate at the local level or have an indirect impact from the national level (Geist et Lambin, 2002; KissinGer et Herold, 2012). From their meta-analysis, Angelsen et Kaimowitz (1999) derived two categories of models. Microeconomic models should focus on immediate causes, while macroeconomic models tend to deal with underlying causes. The authors also suggest distinguishing between models based on perfect markets and models assuming imperfect markets.

Geist et Lambin (2002) have contributed to the building of this conceptual framework via a meta-analysis of 152 case studies taken from 95 articles published in 40 scientific journals. The authors' main contribution was the breakdown of numerous factors found in the existing literature into (1) three aggregate proximate causes that are agricultural expansion, wood extraction and expansion of infrastructure; into (2) five broad categories of underlying driving forces which are demographic, economic, technological, policy/institutional, cultural or socio-political factors; and a group of "other variables" associated with deforestation, comprising land characteristics, biophysical drivers and social trigger events (economic crises, war, etc.).

More recently, Combes *et al.* (2015) have contributed to the conceptual framework with a theoretical model that emphasize a substitution effect between seigniorage and deforestation income. This contribution complies with the framework presented above. Indeed, Combes *et al.* (2015) considered the triple Environment-Economic-Social crises, which Geist et Lambin (2002) refer to as social trigger event, and proposed a link or a trade-off between macroeconomic and environmental outcomes, using an explicit model. This contribution is valuable to the traditional framework developed by Angelsen et Kaimowitz (1999). It presents a very feasible transmission channel between broad underlying drivers and deforestation. For instance, international transfers, public debt and saving can be used by the government to optimize inter-temporal allocation of natural resources and spending (Combes *et al.*, 2015).

2.2.1.2 Macro-level empirical studies

A broad existing literature addresses causes of tropical deforestation at national, regional, and global scales using macro-level data in developing countries, considering many type of forests, macroeconomic variables, institutional and policy factors (Kaimowitz et Angelsen, 1998; Pfaff, 1999; Palo, 1999; Bhattarai et Hammig, 2001; Barbier et Burgess, 2001; Geist et Lambin, 2002; Nguyen Van et Azomahou, 2007; Culas, 2007; Damette et Delacote, 2012; Wolfersberger *et al.*, 2015; Tegegne *et al.*, 2016; Combes *et al.*, 2015). Major conclusions from a meta-analysis using results of 150 deforestation models by Kaimowitz et Angelsen (1998) in Brazil, Cameroon, Costa Rica, Indonesia, Mexico, Thailand, Ecuador, the Philippines and Tanzania are that deforestation tends to be greater when economic liberalization and adjustment policy reforms increases; when forested lands are more accessible; when agricultural and timber prices are higher; when rural wages are lower and there are more opportunities for long distance trade. Nguyen Van et Azomahou (2007) use a panel dataset of 59 developing countries over the 1972–1994 period to study the deforestation process. They found no evidence of an Environmental Kuznets Curve and they pointed out political institution failures as factor that can worsen the deforestation process in developing countries. More generally, the evidence supporting the existence of an EKC for deforestation is contrasted (Choumert *et al.*, 2013).

Hosonuma *et al.* (2012) derive deforestation and degradation drivers using empirical data synthesized from existing reports on national REDD+ readiness activities. They assessed the relative importance as well as the drivers of variability by continent reflecting approximately the period 2000–2010. They used the forest transition model, considering deforestation rate and remaining forest cover in 100 subtropical non-Annex I countries[4]. They found that, similarly to Asia, the importance of deforestation drivers in Africa varies with different forest transition phases and with different areas. The impact of commercial agriculture on deforestation rises until the late-transition phase and the relative importance of subsistence agriculture remains fairly stable throughout the different phases.

[4]Annex I countries parties to the Convention includes the OECD countries and economies in transition that accepted to returning individually or jointly to their 1990 levels of greenhouse gas emissions by the year 2000. The other countries are referred to as Non-Annex I countries.

2.2.1.3 Micro-level empirical studies relating to agent livelihoods decision

There is strong evidence that forests have an important role in insuring livelihood over time and in some cases, contribute to poverty alleviation (Sunderlin *et al.*, 2005). Yet, few studies have investigated the relation between agent livelihoods decision and tropical deforestation at household's level.

Babigumira *et al.* (2014) use the CIFOR-PEN dataset, comprising of 7172 households from 24 developing countries to analyze which household and contextual characteristics affect land use decision in the developing world. The authors consider the sustainable livelihoods framework and assess the role of various asset types on households' deforestation. The authors found out that 27% of rural household have cleared forest for agricultural based livelihoods. They also found out that asset poverty does not drive deforestation. Indeed, households with medium to high asset holdings and higher market orientation were more likely to clear forest than the poorest and market-isolated households. They found out that households that cleared forests were closer to the forest and came from villages with higher forest cover.

Relying on a rich panel dataset collected from the Tsimane' communities in Bolivia, Perge et McKay (2016) analyze the relationship between forest households' livelihoods strategies, and forest clearing, and the relationship of both to welfare. The authors identify four livelihoods strategies based on households' reported sources of cash earnings, namely, sale, wage, diversified and subsistence strategy. They find that forest clearing is positively linked to welfare especially for households whose income results from combining agricultural sales and wage activities compared to households adopting other strategies. Households with subsistence strategy are not able to accumulate assets in the long run. As one of the main conclusions, the authors state that households clear only small areas of forest with a positive effect on welfare, enabling accumulation of assets.

Pacheco (2009) define a typology of smallholders that accounts for both livelihoods, farming systems and wealth to analyze smallholders' deforestation in Uruará and Redenção in the Brazilian Amazon. The author use households survey data from 136 interviews in Uruará and 82 interviews in Redenção area, and find that cattle ranching is associated to greater impact than cash cropping or subsistence agriculture. Contrary to Perge et McKay (2016), a strong correlation between deforestation and the wealth of the farmers is found.

2.2.1.4 Spatially patterns studies

Spatially explicit econometric studies of drivers of deforestation have taken more importance in the last few years (Ferretti-Gallon and Busch, 2014). According to these studies, most deforestation tends to be located outside the reserve and mountainous area and deforestation occurred primarily within the more accessible Eastern counties and at areas near deforested areas. This illustrates the spread effect of deforestation in the Brazilian Amazon (Mertens *et al.*, 2002). In the same vein, Pfaff *et al.* (2007) find evidence of spatial spillovers from roads in the Brazilian Amazon's deforestation. Considering local administrative entity, Amin *et al.* (2014) found that deforestation activities of neighboring municipalities are correlated with some leakage. As a point of fact, protected areas may shift deforestation to neighboring municipalities.

Using a general spatial two stage least squares model to analyze the determinants of deforestation in 24 Sub-Saharan African countries during the period spanning 1990 to 2004, Boubacar (2012) found that deforestation in one country is positively correlated to deforestation in neighboring countries and that determinants of forest clearing are region specific.

2.2.2 Contribution

More often, data on tropical deforestation including household scale-level have been debatable and notoriously unreliable or non-available (Palo, 1999; Geist et Lambin, 2002). Furthermore, there is a very poor level of econometric studies on the drivers of deforestation in tropical Africa including Congo Basin countries (Gbetnkom, 2009). While, unlike Southeast Asia and the Amazon regions, where large-scale agricultural operations play an important role, most deforestation in the Congo basin can be attributed to small-scale farmers using extensive slash-and-burn techniques (Weise et Ngobo, 2004; Kotto-Same *et al.*, 2002). In the same vein, a meta-analysis by Ferretti-Gallon et Busch (2014) reveals a geographical lag of spatially explicit studies of tropical deforestation in peer-reviewed academic journals as regard to Africa from 1996-2013, underlined the availability of data as the main constraint.

In this context, our contribution is multiple:

- We assess the impact of livelihood choices on deforestation. This research is among the pioneering studies that investigate the factors that govern households' deforestation in the Congo basin using a household-level survey. Indeed, west

and central Africa account among regions that lag in econometric analysis of deforestation (Ferretti-Gallon et Busch, 2014; Geist et Lambin, 2002). At the same time, the factors affecting deforestation are more complex and vary significantly from one location or continent to another (Rudel et Roper, 1997; Murali et Hedge, 1997; VanWey *et al.*, 2005; Babigumira *et al.*, 2014).

- We refer to the standard protocol of analyzing deforestation. This is crucial as it allows for improved comparisons in future research (Geist et Lambin, 2002). Our research considers and tests the influence of (1) agents' decision parameters such as family income and factor constraints (2) agents' characteristics and (3) other contextual variables such as choice and biophysical variables on the agent' deforestation. Further, our research used a microeconomic model, therefore, we focus on immediate causes as suggested by (Angelsen et Kaimowitz, 1999). The figure 2.1 shows the adaptation of our research to the conceptual framework for analyzing households' deforestation.

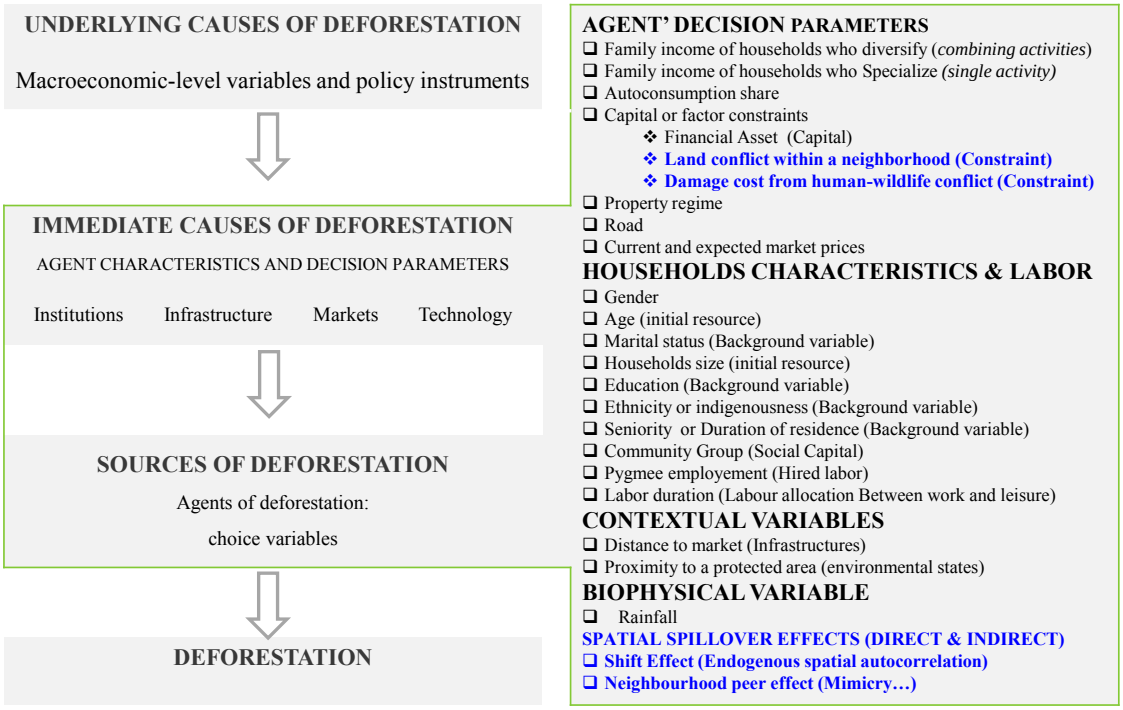
- We consider the landscape approach and test the impact of human wildlife conflicts on households' deforestation. In the same vein, we consider testing the impact of land conflict among households on households' deforestation.

- The influence of spatial spillovers is investigated. Beside direct effects on households' characteristics, we consider endogenous and exogenous interactions among households and test the possible resulting spillover effect on households' deforestation within their neighborhood.

2.3 Objective and Hypothesis

This paper investigates the factors that drive households' deforestation in the Tridom-TCL, with a particular interest in the impact of households' choice of livelihoods strategies. More precisely, we test the following hypothesis:

Decision variables influence deforestation. (1) The impact of family income on small-scale deforestation is closely related to the households' livelihoods strategies. This hypothesis will allow comparing the incremental change on households' deforestation resulting from a one-unit increase in income given their livelihoods portfolio and strategies. (2) Following Pfaff (1999); Fontes et Palmer (2016); Caldas *et al.*



Source: Authors, Adapted from Angelsen and Kaimowitz (1999). Elements in blue color represent our contribution to the framework.

Figure 2.1: Adaptation of deforestation framework to Tridom-TCL case study

(2007), distance to market influences deforestation. Distance to market is considered here as an indicator of transaction cost regarding land location. (3) Financial asset (Walker *et al.*, 2000, 2002) and factor constraints such as both Human-Human and Human-Wildlife conflicts drive households' deforestation. (4) Environmental state and policy, captured by the distance to the nearest protected area, rank among households' deforestation drivers. Due to their legal status, protected areas are supposed to be associated to lower deforestation (Pfaff *et al.*, 2015; Ferretti-Gallon et Busch, 2014). Yet they may also have an impact on surrounding deforestation, for instance through leakage (Amin *et al.*, 2014).

Households' characteristics influence deforestation. Gender, households' head age and education, marital status, the household's size, ethnicity as well as duration of residence (seniority) account for the drivers of small-scale deforestation.

Households' Choice variables influence deforestation. Following Pichón (1997); Walker *et al.* (2000, 2002), labour allocation between work and leisure and hired labour (especially Pygmies employment with very low cost in our case)

increases forest clearing. (2) Social capital, like belonging to a group of interest, has an impact on households' deforestation. (3) Finally, following Chowdhury (2006a,b) we test that biophysical variables namely, rainfall have a strong impact on small-scale deforestation.

Spatial patterns influence deforestation. This paper tests the presence of endogenous interaction of households' deforestation. Indeed, proximity among households in the Tridom-TCL implies the existence of cultural and social interaction that could yield spatial spillover effect leading to similarities in deforestation decision. Further, it was shown that, households' deforestation as a social and cultural phenomenon is likely to be characterized by spatial autocorrelation (Mertens *et al.*, 2002; Pfaff *et al.*, 2007; Boubacar, 2012; Amin *et al.*, 2014; Brueckner, 2003; Anselin, 2002). The observations we did during the 8 months fieldwork in Cameroon and Gabon reveal some competition about land holding among household heads. This observation calls for testing the existence of spatial effects within a household's neighborhood.

2.4 A simple microeconomic model of deforestation choices

Consider household i choosing his/her level of deforestation D_i to maximize its utility:

$$\max_{D_i} U_i(D_i, L_i, X_i, D_j) \tag{2.1}$$

L_i is the livelihoods strategy selected by the household, as defined in citeNgouhouoPoufoun2016lvlhd. 6 different household strategies are considered: agriculture (A), cash crop production (C), forest-based activities (F), and combinations of cash crops/forest-based (CF), agriculture/forest-based (AF) and agriculture/cash crops/forest-based (ACF); such that $L_i = [A, C, F, CF, AF, ACF]$.

X_i is a vector of household i socio-economic variables susceptible to influence deforestation. Household i's utility function may encompass income, but also other non-observable outcomes such as household's vulnerability. Thus, the household characteristics X_i may influence not only the household economic return, but also

other household matters of interest. Furthermore, we also consider that household i's utility may be influenced by its neighbors. D_j is the level of deforestation chosen by household i's neighbors, that is likely to influence its decision. This type of strategic interactions is close to the resource-flow model presented by Brueckner (2003) and Anselin (2002).

The first-order condition implicitly gives the optimal level of deforestation $D_i^*(L_i, X_i, D_j^*)$ for household i:

$$U'_{D_i} = \frac{\partial U_i(D_i^*, L_i, X_i, D_j^*)}{\partial D_i^*} = 0 \tag{2.2}$$

Optimal deforestation strongly depends on the livelihoods strategies chosen by the households:

$$D_i^*(L_i, X_i, D_j^*) \neq D_i^*(L'_i, X_i, D_j^*), \ \forall L_i \neq L'_i. \tag{2.3}$$

Moreover, one can then infer the impact of livelihoods strategies, other variables and neighbors deforestation on household i deforestation level:

$$\frac{\partial D_i^*(L_i, X_i, D_j^*)}{\partial X_i} = -\frac{\frac{\partial U'_{D_i}}{\partial X_i}}{\frac{\partial U'_{D_i}}{\partial D_i}} \tag{2.4}$$

$$\frac{\partial D_i^*(L_i, X_i, D_j^*)}{\partial D_j} = -\frac{\frac{\partial U'_{D_i}}{\partial D_j}}{\frac{\partial U'_{D_i}}{\partial D_i}} \tag{2.5}$$

In the next section, we will investigate the impact of livelihood choices on deforestation levels (sign of equation (2.3)), the impact of other control variables (sign of equation (2.4)) and the nature of spatial spillovers (sign of equation (2.5)).

2.5 Spatial Econometric Procedure

The common observation that individuals belonging to the same group tend to behave similarly can de explained by three hypotheses of the standard linear model (SLM) that are the endogenous effects, the exogenous effects, and the correlated effects (Manski, 1993). The endogenous and the exogenous effects express distinct ways that

persons might be influenced by their social environments. The first assumes that, all else equal, individual behavior (deforestation (D_i) tends to vary with the average behavior (deforestation of the group or neighbor (D_{-i})). The second effect assumes that individual behavior is in some way influenced by the characteristics of the group or neighbors (Z_{-i}). The correlated effects express nonsocial phenomena. According to these similarities in individuals' behavior may results from spatially dependent omitted variables, interaction among error terms (ϵ) or environmental similarities (Brueckner, 2003; Manski, 1993; Elhorst, 2014; Anselin, 1988b). In the following, we present a short description of various cross-sectional spatial econometric models (2.5.1). Then, we present the selection procedure we used (2.5.2).

2.5.1 Cross-sectional spatial econometric models

The matrix form of the generalized nested spatial model that accounts for all the three effects was defined by Manski (1993) in equations (2.6-2.7). This model is also called the Manski model.

$$D = \alpha * I_N + \rho WD + Z\beta + WZ\theta + \epsilon, \tag{2.6}$$

$$\epsilon = \lambda W\epsilon + \mu \tag{2.7}$$

.

In this expression, I_N is a n by n identity matrix. WD denotes the endogenous effects, representing the average deforestation of neighboring individuals (D_{-i}). The ρ parameter measures the strength of spatial dependence. W is a row-standardized weights matrix such that the elements (w_{ij}) in each row (i) sum to one and the diagonal elements set to zero, each element (w_{ij}) measures the intensity of interaction among household's (i) and its relevant neighbors (Anselin, 1995). WZ stands for the exogenous effects representing the average value of neighboring households' characteristics, scaled by the parameter θ. The parameter β captures the direct impact of independent variables. $W\epsilon$ denotes the interaction among the disturbance terms. the parameter λ measures the spatial autocorrelation intensity among error terms. After testing the equations (2.6-2.7), Manski (1993) found that data on equilibrium outcomes cannot distinguish both endogenous and exogenous interactions from contextual effects based on testing the model (2.6-2.7).

Further, LeSage (1997) suggested specifying a model that accounts for both endogenous and exogenous spatial effects among individuals. Equation (2.8) is the resulting model, called the Spatial Durbin Model (SDM) by Anselin (1988b). This model is equivalent to the component (2.6) of the Manski model, with $\lambda = 0$ in (2.7). Following (LeSage, 2008), The SDM will allow deforestation of each household to vary with respect to both own characteristics and the mean characteristics within his/her neighborhood.

$$D = \alpha * I_N + \rho W D + Z\beta + WZ\theta + \epsilon \tag{2.8}$$

A year later, Kelejian et Prucha (1998) suggested to include both endogenous interaction effects and correlated effects among the error terms. This model is equivalent to the Manski equation with $\theta = 0$ in the component (2.6). This model is called the Kelejian-Prucha Model or the Spatial Autoregressive model with Autoregressive disturbances (SARAR). This allows spatial autocorrelation in both non-observed pattern and households' deforestation, without spillover effects neither from the neighborhood characteristics, nor from own characteristics on neighboring households.

$$D = \alpha * I_N + \rho W D + Z\beta + \epsilon \tag{2.9}$$

$$\epsilon = \lambda W \epsilon + \mu \tag{2.10}$$

.

The Spatial Autoregressive Model (SAR) was proposed by Anselin (1988b) to test only the endogenous interaction, using the lag value of the dependent variable. The SAR model allows only spatial autocorrelation of households' deforestation, without spillover effects neither from the neighborhood, nor from own behavior on neighboring households.

$$D = \alpha * I_N + \rho W D + Z\beta + \epsilon \tag{2.11}$$

Among other models, (1) the Spatial Error Model (SEM) was developed by Anselin (1988b) to account only for the correlated effects. This assumes that $\rho = 0$ in the SDM model. (2) The Spatial Durbin Error Model (SDEM) includes spatial lags of independents varables ($\theta \neq 0$) and the spatially lagged error term ($\lambda \neq 0$) in equation (2.6-2.7). (3) The Spatial Lag of the explanatory variable (SLX), ($\rho = 0$), ($\theta \neq 0$) and ($\lambda = 0$) in equation (2.6-2.7)

2.5.2 Selection procedure

The consideration of spatial effects in econometric models require some specific processes to avoid model misspecification (Le Gallo, 2002).

The usual standard approach is to start with a specific SLM. Further, test if the error terms and/or the dependent variable are spatially correlated, to specify the spatial model that is consistent with the data generation process. This is called the specific-to-general approach. The second approach is to start with the Mansky model and test progressively the existence of various spatial effects (Elhorst, 2014). In this study, we started with the standard approach that is most common in spatial analyses, following Anselin (1988a). After estimating a SLM, we first tested for the existence of spatial autocorrelation using the Moran i statistic on the residual of the linear model. Further, we proceeded to the Lagrange Multiplier test that helps to find the type of spatial effects that fit with our data generation process. Tables 2.2 and **??** in the subsection 2.6.2 display our procedure of model specification.

An issue that arises in applied econometrics is the need to compare models (LeSage, 2008). Indeed, a universal criticism of spatial regression models is the sensitivity of the estimates and inferences to the form of spatial weight matrix (LeSage et Pace, 2014). After specifying our econometric model, we use four types of weight matrix namely, the Gabriel graph weight matrix, the five nearest neighbors (5NN), the ten nearest neighbors (10NN) and the distance based weight matrix to account for this criticism. These weight matrices are presented in detail in Ngouhouo Poufoun et Delacote (2016).

2.6 Results

2.6.1 Variables and Descriptive statistics

Dependent variable : our measure of deforestation followed two steps. We first asked the households to fill the information about their land-holding in a table. After that, we randomly chose one plot among the total plots declared by the household to visit. The visited plot was tracked using a Global Positioning System (GPS) to have the real area. A total of 3338 plots of land were declared by overall sample that is on average 3.2 plots held by each household. A total of 526 plots were tracked with a GPS. The data declared were adjusted using the tracked data to obtain the value used in this study. On average, household heads declared clearing 4.75 ha of forest. We found after statistical adjustment that the average land clearing of each household stands at 4.41 ha.

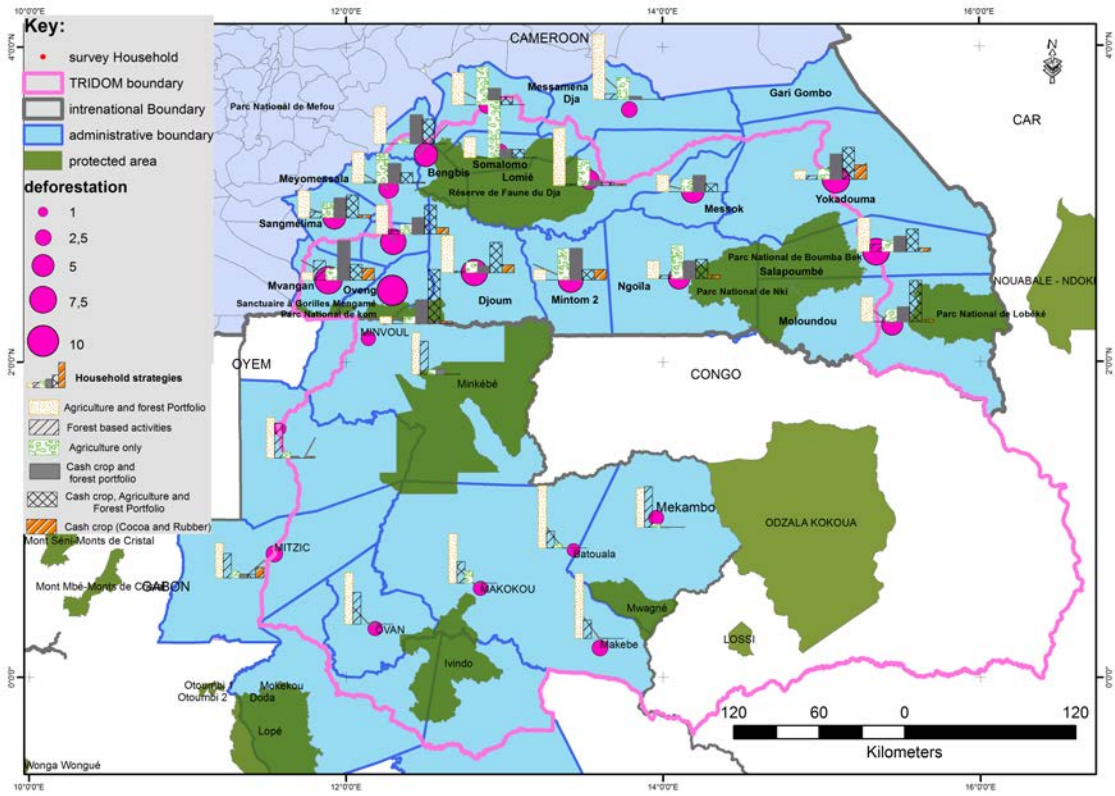


Figure 2.2: Livelihoods and mean deforestation in the landscape

Independent variables : we distinguish our independent variables in three categories.

First, we consider the household income, depending on the livelihoods strategy chosen. In our case study, like many contexts in rural areas of developing countries, access to land can be considered open. Figure (2.2) above displays the distribution of mean deforestation and livelihoods in the Tridom-TCL.

Second, diverse households' characteristics can have a part in explaining deforestation. We consider here several potential constraints to deforestation. Credit constraints are approached through credit and money transfer received by the household. Finally, land-use conflict is a proxy for constraints on land access, while the damage costs from wildlife conflicts represent environmental damages.

Third we consider a set of contextual variables, such as distance to markets, as a proxy for transaction costs. Proximity to protected areas represents constraints brought by environmental policies. Table 2.1 displays the variables' definition and descriptive statistics.

Table 2.1: Variables and descriptive statistics (N=986 households)

Variable	Definition of variables	Mean	Std. Dev.
AGENT'S DECISION PARAMETERS			
Income of households adopting diversification livelihoods strategies (FCFA10^3)			
FamilyIncome_*ACF_households*	Income of households mixing Agriculture &Cashcrop & Forest	38.96	117.06
FamilyIncome_*AF_households*	Income of households mixing Agriculture & Forest	54.97	126.6
FamilyIncome_*CF_CashcropForest*	Income of households mixing Cashcrop & Forest	21.28	73.34
Income of households adopting specialisation livelihoods strategies (FCFA10^3)			
FamilyIncome_*F_Forestbased*	Income of households specializing in Forest-based activities	70.18	372.79
FamilyIncome_*A_Agriculture*	Income of households specializing in Agricultural	12.39	121.41
FamilyIncome_*C_Cashcrop*	Income of households specializing in Cashcrop	8.85	67.93
Other decision variables			
Autocons_Share (% of total value)	Autoconsumption share in the total income	0.26	0.19
Capital & factor constraints			
Finance_asset	Credit and money transfer (CFAF/month)	8.67	33.55
Human_Wildlife (FCFA10^3)	Damage cost of wildlife conflict (CFA/month)	0.62	1.45
Landconflict Dummy (1=yes)	Land use conflict, Dummy (1=yes)	0.18	0.38
HOUSEHOLDS CHARACTERISTICS			
Gender	Gender, Dummy (1=Male)	0.77	0.42
Age	Household head age (continuous, in years)	48.44	14.61
Ages_thr	Age centered and squared	213.34	246.72
Marit_single	Matrimonial status, Dummy (1=Maried)	0.7	0.46
Hsize	Household size (continuous)	6.5	4.01
Schoolcycl_2	Education level, Dummy (1=secondary school)	0.56	0.5
Autochbaka	Indegenouesness, Dummy (1=Pygmy. 0=Bantou)	0.05	0.22
Seniority	Seniority in the village (continuous, in years)	27.01	20.71
CommunityGroup	Community Interest Companies, Dummy (1=yes)	0.28	0.45
Pygmy_employmt	Pygmies employment (continuous)	1.87	2.96
Labourduration	Working hour per day	5.49	4.39
CONTEXTUAL VARIABLES			
Country	Country, Dummy (1=Cameroon, 0=Gabon)	0.73	0.44
Distmarket	Distance to market (in Km)	65.06	58.69
Distance to P. Area	Distance to the nearest Protected Area (in Km)	29.3	22.58
Biophysical factor			
Rainfall	The *per annum* amount of rain that falls (mm)	1638.30	113.66

2.6.2 Spatial dependence diagnostic

Table 2.2 below displays the Moran coefficient index computed after running the SLM. This statistic tests the existence of the spatial autocorrelation. Except for the Gabriel Graph weight structure, the index value is positive and statistically greater than 0. It appears a positive spatial clustering of deforestation among nearby households in the Tridom-TCL.

The Lagrange multiplier test presented in table 2.3 is used to diagnose the type of spatial dependence that governs our data generation process among the endogenous effects, i.e. spatial lag of the dependent variable ($\rho \neq 0$) and the correlated effects or the spatial autocorrelation of the disturbance term ($\lambda \neq 0$). This test suggests rejecting all the specifications that allow spatial autocorrelation in the disturbance term. Therefore, we avoid estimating the SARAR, the SEM and the generalized nested Manski spatial model. In the following, we estimate the SAR as it fits with our data generation process. We avoid displaying the results of the SDM as it yielded counter-intuitive findings.

Overall, following the findings in tables 2.2 and 2.3, we cannot reject our hypothesis of a spatial effects, giving rise to a presumption of the existence of a positive relation between households' deforestation and the average deforestation of neighboring households. In section 2.6.3 below will confirm or reject this presumption via the ρ parameter and present the drivers of households' deforestation.

Table 2.2: Spatial autocorrelation test

	Global Moran I				Moran I test under randomisation			
	Moran I	E(I)	z(I)	**P-value**	Moran I	E(I)	z(I)	**P-value**
gabhsld.w	0.0171	-0.0032	0.7060	**0.2401**	0.1191	-0.0010	4.2133	**0.0000**
3NN weight matrix	0.0377	-0.0032	1.7138	**0.0433**	0.1461	-0.0010	6.2109	**0.0000**
4NN weight matrix	0.0339	-0.0032	1.7903	**0.0367**	0.1396	-0.0010	6.8335	**0.0000**
5NN weight matrix	0.0336	-0.0032	1.9876	**0.0234**	0.1301	-0.0010	7.1017	**0.0000**
10NN weight matrix	0.0363	-0.0030	2.9635	**0.0015**	0.1352	-0.0010	10.2690	**0.0000**
17NN weight matrix	0.0217	-0.0028	2.4270	**0.0076**	0.1218	-0.0010	12.0470	**0.0000**
Distance based weight matrix	0.0171	-0.0025	3.1368	**0.0009**	0.0993	-0.0010	15.4710	**0.0000**

Table 2.3: Lagrange Multiplier Diagnostic of Spatial dependence

	LM Test for Spatial Error Components				LM Test for Spatial lag model				
	Ordinary LMerr		**Robust LMerr** ($\rho = 0$)		Ordinary LMlag		**Robust LMlag** ($\lambda = 0$)		
	Stat.	P-value	Stat.	P-value	Stat.	P-value	Stat.	P-value	
Gabhsldweight matrix	0.3512	0.5535	0.1233	**0.7254**	0.6565	0.4178	0.4286	**0.5127**	
3NN weight matrix	2.4699	0.1160	0.5971	**0.4397**	4.4385	0.0351	2.5657	**0.0992**	*
4NN weight matrix	2.6354	0.1045	0.6091	**0.4351**	4.9138	0.0266	2.8875	**0.0893**	*
5NN weight matrix	3.2194	0.0728	0.1058	**0.7449**	4.9313	0.0264	1.8178	**0.0976**	*
10NN weight matrix	7.2122	0.0072	0.8022	**0.3704**	13.0090	0.0003	6.5990	**0.0102**	**
17NN weight matrix	4.3451	0.0371	2.0311	**0.1541**	12.2670	0.0005	9.9533	**0.0016**	***
Distance based weight matrix	6.4858	0.0109	0.0442	**0.8335**	12.0590	0.0005	5.6177	**0.0178**	**

2.6.3 What are the immediate causes of households' deforestation in the Tridom-TCL?

2.6.3.1 Robustness check and spatial dependence

Table 2.4 displays the estimates' results based on the SLM and four variants of SAR model considering four different types of weight matrix. This result considers only the factors that significantly drive households' deforestation. The table (B.2.1) in appendix display the results from the model with overall variables presented in the subsection 2.6.1 above. Insignificant variables were removed progressively until we got the reduced set of significant variables. The post estimation test (Akaike Information Criterion (AIC), Wald and LR tests) confirm the reduced model as best-suited compared to the full model.

The SAR models show a significant spatial dependence between deforestation of each household and the average deforestation of neighboring households. This suggests some similarities in the deforestation decision of households located nearby. The expected deforestation of each household in the Tridom-TCL is determined by both own characteristics and a linear combination of neighboring households' deforestation scaled by ρ. The SLM estimates have larger size compare to the SAR models considering all types of weight matrice. It attributes the variabilities in households' deforestation only to the independent variables. Also, the SAR model suggests that the variability of deforestation across households is partially explained by neighbors' deforestation behaviour. Further, the spatial lag of households' deforestation is treated as an endogenous variable and the error term is influence by the same process. As a result, although the Q-Q plot in the figure (B.1.1) in appendix reveals normal distribution of households' deforestation, the SLM is biased and yields inconsistent estimates due to simultaneity bias. In these conditions, the SAR is

a proper specification to account for this endogeneity (Anselin, 2001). Following Anselin (1988b, 2001) our spatial lag model of deforestation was estimated using the maximum likelihood technique.

As shown in table 2.4, the strength of spatial dependence (ρ) varies along with the type of the weight matrix. The scale of the ρ parameter varies increasingly from 0.027 for the the Gabriel graph weight matrix to 0.235 for the distance-based weight matrix. It equals 0.089 for the 5NN and 0.179 for the 10NN weight matrices. Further, the estimates vary decreasingly from the from the Gabriel graph matrix to the distance-based matrix. The warning in LeSage et Pace (2014) regarding the sensitivity of the estimates and inferences to the type of matrix is confirmed. Among these four candidate models, the 10NN base model, displayed in the third column with bold characters, performs better as it minimizes the information loss. This model has the maximum log likelihood with the minimum Akaike Information Criterion (AIC) compared to others. The goodness-of-fit test confirms that the SAR model based on the 10NN weight matrix is the best to fit the households' deforestation. Indeed, combining the Wald test (W), the the Log-likelihood Ratio test (LR) and the Lagrange Multiplier test (LM) as suggested by Anselin (1988b), we found that the inequality $W \geq LR \geq LM$ is verified only for the 10NN based model that is $(W = 10.399) \geq (LR = 10.16) \geq (LM = 1.014)$. In the following, estimates from the SAR model based on 10NN weight matrix are used to derive the drivers of households' deforestation.

The β coefficient of the SAR model cannot be interpreted as partial derivatives of households' deforestation in the Tridom-TCL with respect to a one-unit change of various independent variables as in conventional linear regression model (Pace et LeSage, 2006). The subsection 2.6.3.2 below presents the impact of the various independent variables on the households' deforestation.

2.6.3.2 Direct, Indirect and Total effects

Table 2.5 displays the factors that proximately drive households' deforestation in the Tridom-TCL. These factors are regrouped into (1) Livelihoods Strategies; (2) households characteristics and (3) contextual variables. Variables with insignificant coefficients are displayed in the full model in table (B.2.1) in appendix.

Table 2.4: Spatial Autoregressive Model

	SLM			GabGraph			5NN Weight matrix			**10NN Weight Matrix**			Distance based		
	Coef.	SD		Coef.	SD		Coef.	SD		**Coef.**	**SD**		Coef.	SD	
(Intercept)	-3.5941	1.1117	***	-1.1331	0.7166		-1.2545	0.7185	*	**-1.4842**	**0.7173**	**	-1.7664	0.7390	**
AGENT'S DECISION PARAMETERS															
Income of households adopting diversification livelihoods strategies (FCFA10^3)															
FamilyIncome_*ACF_households*	0.0109	0.0013	***	0.0108	0.0013	***	0.0106	0.0013	***	**0.0102**	**0.0013**	***	0.0102	0.0013	***
FamilyIncome_*AF_households*	0.0026	0.0012	**	0.0026	0.0012	**	0.0025	0.0011	**	**0.0025**	**0.0011**	**	0.0025	0.0011	**
FamilyIncome_*CF_CashcropForest*	0.0120	0.0021	***	0.0119	0.0020	***	0.0116	0.0020	***	**0.0112**	**0.0020**	***	0.0113	0.0020	***
Income of households adopting specialisation livelihoods strategies (FCFA10^3)															
FamilyIncome_*A_Agriculture*	0.0029	0.0012	**	0.0029	0.0012	**	0.0029	0.0012	**	**0.0029**	**0.0012**	**	0.0028	0.0012	**
FamilyIncome_*C_Cashcrop*	0.0186	0.0021	***	0.0185	0.0021	***	0.0183	0.0021	***	**0.0180**	**0.0021**	***	0.0179	0.0021	***
Autocons_Share (% of total value)	-2.1269	0.7737	***	-2.1210	0.7667	***	-2.1518	0.7649	***	**-2.0922**	**0.7620**	***	-2.1346	0.7633	***
Capital & factor constraints															
Finance_asset (FCFA10^3)	0.0106	0.0043	**	0.0106	0.0042	**	0.0104	0.0042	**	**0.0102**	**0.0042**	**	0.0099	0.0042	**
Human_Wildlife (FCFA10^3)	-0.2135	0.0979	**	-0.2125	0.0970	**	-0.2143	0.0968	**	**-0.2179**	**0.0965**	**	-0.2183	0.0966	**
HOUSEHOLDS CHARACTERISTICS															
Gender (1=Male)	0.6200	0.3450	*	0.6127	0.3419	*	0.5928	0.3411	*	**0.5816**	**0.3398**	*	0.6210	0.3404	*
Age (continuous. in years)	0.0293	0.0115	**	0.0293	0.0114	**	0.0291	0.0114	**	**0.0301**	**0.0113**	***	0.0303	0.0114	***
Ages_thr	-0.0013	0.0006	**	-0.0013	0.0006	**	-0.0013	0.0006	**	**-0.0013**	**0.0006**	**	-0.0013	0.0006	**
Hsize (continuous)	0.1692	0.0379	***	0.1677	0.0376	***	0.1669	0.0375	***	**0.1650**	**0.0374**	***	0.1675	0.0374	***
Seniority (continuous. in years)	0.0401	0.0080	***	0.0402	0.0079	***	0.0404	0.0079	***	**0.0399**	**0.0078**	***	0.0390	0.0079	***
CommunityGroup Dummy (1=yes)	0.5566	0.3263	*	0.5605	0.3233	*	0.5777	0.3226	*	**0.5718**	**0.3214**	*	0.5922	0.3220	*
Pygmy_employmt (coutinuous)	0.1428	0.0507	***	0.1462	0.0503	**	0.1522	0.0502	***	**0.1584**	**0.0500**	***	0.1539	0.0501	***
CONTEXTUAL VARIABLE															
Country (1=Cameroun. 0=Gabon)	1.3424	0.3556	***	1.2738	0.3617	***	1.0840	0.3722	***	**0.8565**	**0.3826**	**	0.8475	0.4080	**
R-squared:	0.32														
F-statistic: (16; 969)	28.38	*													
Rho (ρ)				0.0274			0.0892	**		**0.1799**	***		0.2354	***	
Log Likelihood				-2856			-2855			**-2852**			-2853		
ML residual σ				4.39			4.38			4.36			4.3667		
AIC Criterion	5750			5751			5748			**5742**			5744		
Wald Statistic				0.737			3.996	**		**10.399**	***		7.848	***	
LR test value				0.694			4.207			**10.165**			8.010		
LM for Residual autocorrelation				0.122			0.262			**1.014**			0.128		
Observations	986			986			986			986			986		

*, ** and *** = significance level at 1% 5% 10% respectively

Livelihoods Strategies: The direct effects for household income are all positive and significant regardless of the livelihoods strategy, except for the income of households who practice forest-based activities.

Diversification strategies and specialization strategies have comparable impacts on deforestation. Strategies that encompass cash crops production have the highest impact. On the other hand, family income of households specializing in forest-based activities unsurprisingly do not tend to impact deforestation. Further, the indirect effects of these incomes are positive and significant except for households who adopt a diversified portfolio comprised of agriculture and forest-based activities. More precisely:

- **ACF**: A one-unit increase in the monthly income of a household's head, who diversifies choosing agriculture, cash-crop and forest-based activities (ACF), leads to increasing own deforestation by 0.0102 ha; with a positive spillover effect of 0.0023 ha within his/her neighborhood. The resulting total effect is 0.0125 ha. Translating into dollars, using the 2014 exchange rate [5], this approximately equates to an incremental increase of own deforestation by 4.9

[5] In 2014, year of the field work, $\$ \; CFAF1 = \$0,0021$)

ha with a spillover effect of 1.1 ha within the neighborhood, resulting from *per annum* $1000 increase in the household income. That is a total effect of 6ha.

- **CF**: Likewise, a one-unit increase in the monthly income, of a household's head who chooses cash crop and forest (CF), leads to increasing own deforestation by 0.0113 ha; with a positive spillover effect of 0.0025 ha within his/her neighborhood. This approximately equates to an incremental increase of own deforestation by 5.4 ha with a spillover effect of 1.2 ha within the neighborhood, resulting from *per annum* $1000 increase in the household income. The total effect is of 6.6 ha.

- **AF**: A one-unit increase in the monthly income, of a household's head choosing agriculture and forest, leads to increasing own deforestation by 0.0025 ha; This approximately equates to an incremental increase of own deforestation by 1.2 ha resulting from *per annum* $1000 increase in the household income. Households' heads choosing (AF) portfolio do not exert any significant spillover effect within their neighborhood.

- **A**: The direct effect of increasing of households specializing in agriculture (A) is a significant increase by 0.0030 ha of own deforestation. The resulting significant and positive spillover effect within the neighborhood is 0.0007 ha. The resulting total effect is 0.0037 ha. This approximately equates to an incremental increase of own deforestation by 1.43 ha with a spillover effect of 0.33 ha within the neighborhood, resulting from *per annum* $1000 increase in the household income. That is a total effect of 1.76 ha.

- **C**: The incremental change of deforestation resulting from a one-unit increase in the monthly income of households choosing cash crop (C) is an increase of 0.0180 ha. This leads to increasing deforestation of households sharing the same neighborhood by 0.0040 ha. The resulting total effect is 0.022 ha. This approximately equates to an incremental increase of own deforestation by 8.6 ha with a spillover effect of 1.9 ha within the neighborhood, resulting from *per annum* $1000 increase in the household income. The total effect is of 10.5 ha.

As regard the capital and factor constraint decision's variables, financial asset as well as "the damage cost from human-elephants conflict have both significant direct and indirect effects (table 2.5). Yet,the existence of land conflicts among households (Human-Human conflict) were insignificant (see table (B.2.1) in appendix).

An additional unit of loan contracted (or transfer received) by a household's head leads to a marginal increase of own deforestation of 0.0102 ha with a positive spillover effect within his/her neighborhood of 0.0043 ha. That is a total effect of 0.0145 ha. This equates to an increase of own deforestation by 6.9 ha with a spillover effect of 2.04 ha within the neighborhood, resulting from *per annum* $1000 increase in the financial asset. That is a total effect of 8.94 ha. This indicates that increasing money transfer in favor of households living in the landscape may foster engagement in forest clearing by households.

Unlike the financial asset, monthly cost of crops damage by elephants exert a negative and significant direct and indirect effect on the households' deforestation. Indeed, additional unit of damage cost reduces both own and neighboring deforestation by 0.217 ha and 0.048 ha. The resulting total effect is 0.265 ha. This approximately equates to an incremental decrease of 103 ha and 22.8 ha respectively, resulting from *per annum* $1000 increase in damage cost. This result translates into two complementary effects. Firstly, a business discouragement effect that could lead to the abandonment of spaces nearby the promenade area of elephants; on the other hand, it may cause a switch from activities relating to land use to forest extraction activities that seem least risky with a possibility of increasing forest degradation.

The existence of land conflict among households (Human-Human conflict) were insignificant (see table (B.2.1) in appendix). The third result gives the insight that there is little constraint on land access in our case study: deforestation and agricultural expansion is not impacted by neighbor conflicts.

Households characteristics: Among the socioeconomic variables, education, the marital status and the ethnicity do not influence households' deforestation as shown in table (B.2.1) in appendix. Those with significant effects include gender, age, households' size and the residence duration or seniority.

Table 2.5 shows that men are associated with 0.58 ha more deforestation than women without spillover effects within the neighborhood.

Deforestation increases slowly and significantly with the household's head age with some threshold effect. For every year they get older, deforestation increases by 0.03 ha, with a negligible spillover effect. Larger household's size induces more deforestation. Indeed, an additional member in a family increases own deforestation by 0.16 ha with a spillover effect of 0.034 ha. As pointed out by Kaimowitz et

Angelsen (1998), the residence duration is positively associated to forest clearing with the same level as age.

When it comes to labour, it is interesting to note that Pygmy employment is related to larger deforestation, while household labour duration has no influence (see table (B.2.1 in appendix). Thus both types of labour do not seem to be substitutes for households' labour. Pygmy labour appears to be more land-intensive practices, while household labour seems not to be related to land-use choices, i.e. more related to labour-intensive practices.

Contextual variables: Among contextual variables presented in table 2.1, "distance to market", "distance to the nearest protected area" and the first result suggest that distance to markets has no direct effect on deforestation. However, as shown by citeNgouhouoPoufoun2016lvlhd, distance to markets influences the livelihoods strategies: thus the effect of distance apparently passes through the livelihoods strategies transmission channel. The second result indicates that public policies such as protected areas do not bring constraints on land use decision. Moreover, we do not find evidence of leakage between protected areas and neighboring households.

Finally, both the direct and the indirect effects of country are positive and significant. Indeed, households living in Cameroon are associated with 0.85 ha more deforestation compare to those living in Gabon, with a spillover effect of 0.178 ha on proximate households in Gabon. This result suggests paying additional attention in the Cameroonian segment of the landscape.

2.7 Discussion and conclusion

The aim of this study is to better understand how livelihoods strategies have an impact on deforestation. To that matter, this paper is a natural extension of citeNgouhouoPoufoun2016lvlhd, which determines the variables influencing livelihoods strategies. We also develop a spatial approach in order to take into account spatial interactions between agents. Our analysis relies on an original household survey collected in the Tridom-TCL.

Our results are multiple. First, when it comes to livelihoods, diversification and specialization strategies roughly seem to have the same impacts. Yet, we show that strategies incorporating agricultural activities tend to have an impact on deforestation.

Table 2.5: Directs, Indirects and Total Effects

	Coeff.	Direct Effects			Indirect effects			Total effects		
		Mean	SD		Mean	SD		Mean	SD	
AGENT'S DECISION PARAMETERS										
Income of households adopting diversification livelihoods strategies (FCFA10^3)										
FamilyIncome_*ACF_households*	0.0102	0.0102	0.0012	***	0.0023	0.0009	***	0.0125	0.0017	***
FamilyIncome_*AF_households*	0.0025	0.0025	0.0012	**	0.0006	0.0003		0.0030	0.0014	**
FamilyIncome_*CF_CashcropForest*	0.0112	0.0113	0.0020	***	0.0025	0.0010	**	0.0138	0.0025	***
Income of households adopting specialisation livelihoods strategies (FCFA10^3)										
FamilyIncome_*A_Agriculture*	0.0029	0.0030	0.0012	**	0.0007	0.0004	*	0.0036	0.0015	**
FamilyIncome_*C_Cashcrop*	0.0180	0.0180	0.0021	***	0.0040	0.0016	***	0.0220	0.0029	***
Autocons_Share (% of total value)	-2.0922	-2.1099	0.7635	***	-0.4726	0.2496	*	-2.5825	0.9487	***
Capital & factor constraints										
Finance_asset (FCFA10^3)	0.0102	0.0102	0.0043	**	0.0023	0.0013	*	0.0125	0.0053	**
Human_Wildlife (FCFA10^3)	-0.2179	-0.2172	0.0975	**	-0.0488	0.0297	*	-0.2660	0.1213	**
HOUSEHOLDS CHARACTERISTICS										
Gender (1=Male)	0.5816	0.5802	0.3326	*	0.1300	0.0944		0.7102	0.4122	*
Age (continuous, in years)	0.0301	0.0301	0.0113	***	0.0067	0.0037	*	0.0368	0.0140	***
Ages_thr	-0.0013	-0.0013	0.0006	**	-0.0003	0.0002		-0.0017	0.0008	**
Hsize (continuous)	0.1650	0.1649	0.0369	***	0.0369	0.0164	**	0.2018	0.0475	***
Seniority (continuous, in years)	0.0399	0.0403	0.0080	***	0.0090	0.0039	**	0.0494	0.0105	***
CommunityGroup Dummy (1=yes)	0.5718	0.5729	0.3161	*	0.1281	0.0896		0.7010	0.3914	*
Pygmy_employement (coutinuous)	0.1584	0.1592	0.0495	***	0.0356	0.0177	**	0.1948	0.0622	***
CONTEXTUAL VARIABLE										
Country (1=Cameroun. 0=Gabon)	0.8565	0.8515	0.3778	**	0.1786	0.0921	*	1.0300	0.4406	**

*, ** and *** = significance level at 1% 5% 10% respectively

The corollary to this result is that only agents specializing in forest-based activities do not influence deforestation. More precisely, households integrating cash-crops in their activity portfolio are those getting the largest impact on deforestation. Further, spillover effects from strategies with cash-crop (C, CF, ACF) have almost the same scale than the direct effect of the remaining strategies (AF, A). Cash-crop as a specialization strategy has the highest influence on forest cover compared to the other strategies, with a spillover effect that is almost twice as large as the direct effect caused by households mixing agriculture and forest. These results bring the insight that, if development leads to households switching from small-scale agriculture to cash-cropping as a main activity, this would result to a major increase in deforestation. As an example, one extra dollar earned in cash-crops appears to have about a 7-times larger effect on deforestation than an extra dollar in agriculture. In the same vein, we show that the share of auto-consumption is negatively related to deforestation. Here again, if economic development brings a better market access and lower auto-consumption shares, this may positively influence deforestation.

Second, we show that land conflicts and distance to protected areas do not seem to influence deforestation. This result brings the insight that competing land-uses is not really a matter of constraints for households, nor does it represent a source of leakage. In contrast, land-wildlife conflicts do seem to have a negative impact on deforestation. Therefore, if policies are set with the aim to protect wildlife in rural

areas and decrease human-wildlife interactions at the same time (Ngouhouo Poufoun *et al.*, 2016), it is a crucial matter to monitor and to involve local populations in order to avoid a bump up in deforestation.

Third, our paper underlines the importance of assessing deforestation factors in a spatial context, using a landscape approach. Indeed, spatial spillovers tend to be of large magnitude: indirect effects may reach up to 20% of the direct effects. This result is important, as it shows that micro-economic analysis of deforestation factors should take into account those spatial interactions, in order to have an accurate understanding of the mechanisms in place. This statement also holds for the choice of livelihoods strategies (Ngouhouo Poufoun et Delacote, 2016).

Fourth, labour allocation is important. While the household labour duration does not seem to impact deforestation, employing Pygmy labour tend to increase it. Therefore, both types of labour cannot be considered as substitutes, especially when it comes to land use. Household labour appears to be allocated to labour-intensive activities, while Pygmy labour seems to be allocated to activities requiring more land and thus more deforestation. If we consider a Chayanovian approach (Kaimowitz et Angelsen, 1998), it seems that the trade-off between household labour and leisure does not influence deforestation.

Overall, our paper brings some reflexion on how development may influence deforestation in such a landscape. Three transmission channels are to be distinguished: an *income channel*, an *activity portfolio channel* and a *market integration channel*. First, economic development comes with larger income. We show that, except for households specializing in forest-based activities, an increase in income is related to more deforestation. Second, the portfolio of activities is likely to change with economic development, with an increased importance of cash-cropping. This would also result in larger deforestation rates. Finally, when households have a better access to markets, they tend to decrease their share of auto-consumption, which can also have an tendency to increase deforestation. It is important for development projects and policies to take those three channels into account, when dealing with possible environmental adverse effects.

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Chapter 3

The Value of Endangered Forest Elephants to Local Communities in a Transboundary Conservation Landscape

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Sommaire

Abstract

This paper seeks to determine and characterize social and cultural preferences for the conservation of endangered forest elephants (EFEs) in the Congo Basin's Tridom Landscape. Using unique data from a stratified, random, face-to-face survey with 1,035 households in 108 villages in 2014, we combine double-bounded dichotomous choice with open-ended elicitation formats to assess the willingness-to-pay (WTP) for EFE conservation. We find that local households are willing to pay CFA 1,139.4 (€1.74) per month to prevent EFE extinction. This totals CFA 753.9 million (€1.15 million) per year for all inhabitants. Indigenousness positively influences the WTP for EFE conservation. Spatial data suggest that local communities prefer that elephants remain far from their crops. The existence of human-elephant conflicts has a neutral effect on preferences for EFE conservation. Therefore, our study suggests that local communities would engage in biodiversity preservation when the public benefits of conservation are accompanied by private benefits, such as human-elephant conflict avoidance.

Keyword: Forest Elephant Extinction, Indigenous People, Contingent Valuation, WTP, Interval Regression Model, Double-Hurdle Model.

JEL Classification : Q 57, 29, C24

3.1 Introduction

Forest elephant (*Loxodonta africana cyclotis*)[1] poaching in tropical Africa is a major threat to the dynamics of this iconic species. In 2011, the Congo Basin's forest elephant population was less than 10% of its potential size and occupied less than 25% of its potential range (Maisels *et al.*, 2013; Blake *et al.*, 2007; Martin et Stiles, 2000). The Tri-national Dja-Odzala-Minkebe (Tridom) cross-border landscape, spanning Cameroon, Congo (R), and Gabon, is considered to have ecological and biodiversity uniqueness, and hosts the most important population of forest elephants in the world, with the highest density in the Minkébé National Park (MNP). The MNP lost more than 11,000 individuals between 2004 and 2012, representing more than 50% of the 2004 elephant population (Maisels *et al.*, 2013). Despite the ivory trade ban by CITES[2] to protect the African elephant (Van Kooten, 2005), the current growing demand for ivory for jewellery, leisure and Asian medicine as well as the increasing deforestation and land pressure are the main drivers of the elephant population's devastating decline. It is evident that the elephant is much appreciated for these material and provisioning services. However, elephants also contribute to the maintenance of ecological equilibrium and to the provision of social and cultural services.

The forest elephant can be considered a flagship species, as its protection implies the protection of other species in the same ecosystem. Indeed, the elephant disseminates the seeds of important tropical fleshy fruit trees over long distances and contributes to the regeneration of these tree species throughout the Congo Basin (Blake *et al.*, 2009; Wang, 2008; Beaune *et al.*, 2013). For instance, *Baillonella toxisperma* (moabi), a traditional multi-use species among Bantu and Baka villagers in the Tridom region is now an endangered species because of its high commercial value in the wood market. Moabi contributes significantly to balanced diets among forest people. Indeed, its fruits and nuts are eaten raw and its oil is used in cooking, disease treatment and cosmetics. By disseminating its seeds, the elephant contributes to the restoration of the forest; therefore, it indirectly contributes to carbon storage.

[1] There are two elephant subspecies, the forest elephant and the savannah elephant. This paper focuses on the forest elephant.

[2] CITES stands for Convention on International Trade in Endangered Species of Wild Fauna and Flora Signed in Washington, D.C., on 3 March 1973

Hence, elephant conservation is consistent with the REDD+ mechanism [3], which has emerged as an important framework for forest conservation. Forest elephants help improve the forest habitat and thus restore the ecological services provided by the forest (i.e., they regulate the ecosystem).

Moreover, forest elephant populations are crucial to the cultural identity of the indigenous Baka ethnic group. Their main rituals occur after an elephant hunt, and the most important are the *"yeli"* and the *"jengi"* ceremonies. *"Yeli"* is the female ritual, and *"Jengi"* is the male ritual (Kent, 1996). The traditional elephant hunt is also the most important spiritual and religious event for this population. The hunt brings together dispersed groups, all of which have specific responsibilities (e.g., the vital contribution of women to the mystical preparations for a safe hunt). Only the oldest Baka are permitted to kill elephants, and they undergo rigorous preparation, in which they learn from experienced hunters over many years before obtaining permission to kill elephants. Once killed, the elephant is celebrated for many days and nights in a complex series of ritual feasts and celebrations until all the meat has been consumed (Lewis, 2002). Therefore, elephants participate in maintaining the spiritual enrichment, cultural identity and knowledge of the Baka community. This cultural service implies that elephant extinction entails an opportunity cost in terms of the loss of cultural values (Garrod et Willis, 1999). *Figure 3.1* provides a synoptic description of the ecosystem services and the total economic value of the elephant in the Tridom landscape. Considering the importance of forest elephants to ecological, cultural and socio-economic equilibria, possible crop damage (human-elephant conflicts) notwithstanding, endangered forest elephant (EFE) extinction would severely and directly affect local and indigenous welfare. Considering the interdependence of the elephant, *Baillonella toxisperma* and rural communities as described above, "nature too would seem to lose" (Tisdell, 1990, pp. 83). This irreplaceable loss to Tridom society makes the EFE a priority in biodiversity conservation decisions. In addition, the social value of biodiversity is unknown, and thus, the potential impact of this loss in biodiversity on social wellbeing is uncertain (Turpie, 2003). An assessment of the economic

[3]This emerging policy aims to Reduce Emissions from Deforestation and Forest Degradation (REDD+). It aims to create financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. REDD+ goes beyond deforestation and forest degradation and includes the role of conservation, the sustainable management of forests and improvement of forest carbon stocks.

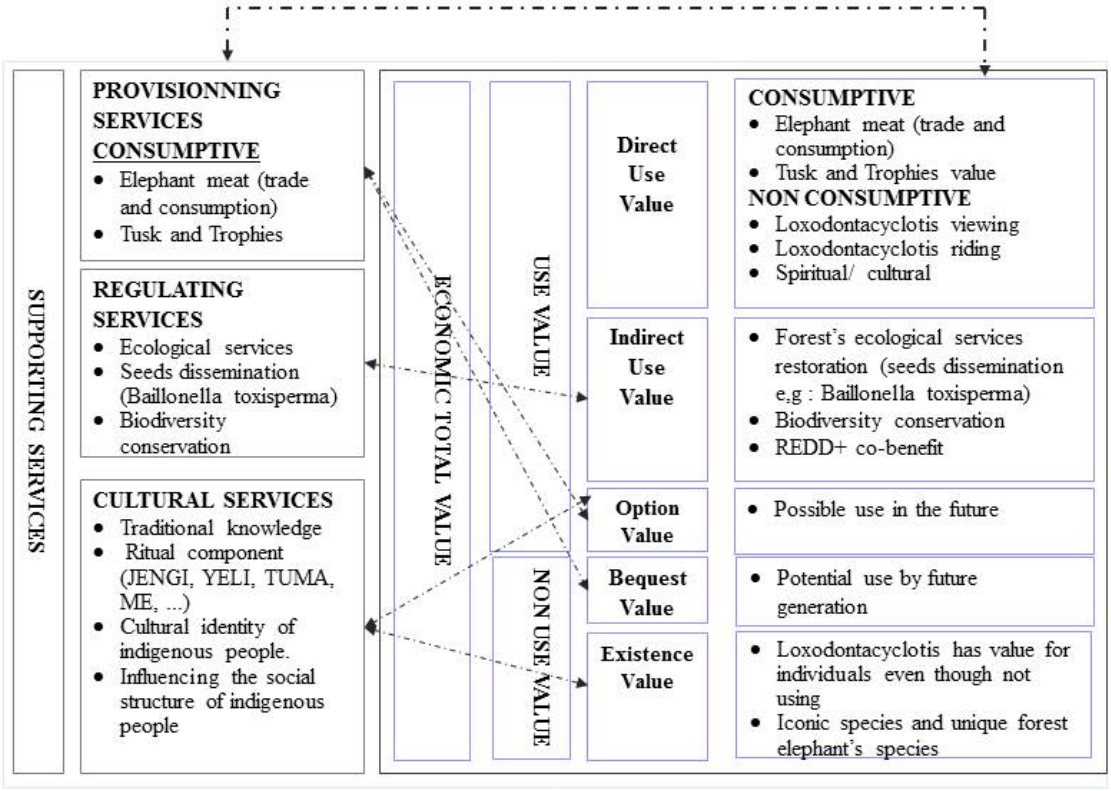

Figure 3.1: Ecosystem Services and Total Economic Value (TEV) of Forest Elephants (Adapted from Brahic et Terreaux (2009); MEA (2005)).

value of the ecosystem services that the elephants provide for local communities will yield important information for policy makers and conservation managers. The findings may also increase awareness of the importance of biodiversity conservation. Therefore, the key question addressed in this paper is the following: ***What are local households willing to pay to prevent the elephant's extinction***?

A large body of research has contributed to enriching the literature on the economics of endangered species conservation (Bishop, 1978; Barbier *et al.*, 2013; Kremer et Morcom, 2000; Tisdell *et al.*, 2002; Bulte et Kooten, 2002). However, only a few studies have assessed the indirect use value, bequest value and existence value of the elephant (Bandara et Tisdell, 2005, 2003a,b), even though this iconic species plays important roles in socio-cultural and ecological integrity (Lewis, 2002; Blake *et al.*, 2009).

Bandara et Tisdell (2001) used data from a face-to-face contingent valuation (CV) study of a sample of 300 urban residents in Colombo (Sri Lanka) to assess their willingness to pay (WTP) for elephant conservation. Their assessment differentiated between the values reported by users and non-users for the Asian elephant. Respondents who had used elephant facilities at least once were willing to pay Rs. 137.38 (€2.05), while non-users were willing to pay Rs. 82.96 (€1.24) for elephant conservation, yielding an average of Rs. 110.17 (€1.65) per month. The results reveal that urban residents are willing to pay for elephant conservation because they want to secure the existence of the elephant (non-use value) and because the presence of elephants has a use value, i.e., importance for recreation and tourism. The results also indicated that the probability of a positive WTP is significantly and positively influenced by pro-conservation attitudes and higher incomes (Bandara et Tisdell, 2004). The study found that the total WTP is sufficient to compensate for the value of annual crop damage.

While a small number of studies have investigated farmers' valuations of the use value (Smith et Sullivan, 2014), as well as the option value and non-use value, of Asian savannah elephants (Vredin, 1997; Bandara et Tisdell, 2003a,b, 2004), no research has addressed the value of EFEs to local and indigenous communities. Our first contribution is thus to measure the value of EFEs to local and indigenous communities in Central Africa to contribute to the growing literature on CV implementation in developing countries. Additionally, this paper considers the relations between

landscape factors, such as the distance between the household and the nearest concentration of elephants (i.e., protected areas), the elephant population density in the protected area and the households' land ownership, and the WTP. Furthermore, our methodological contribution involves combining closed-ended and open-ended (OE) elicitation formats to target robust WTP value. This analysis is facilitated by the collection of a novel, unexploited dataset obtained through face-to-face interviews with 1,035 households geo-localized by GPS.

The purpose of this study is to calculate local and indigenous households' WTP for EFE conservation and to analyse the factors that influence its value. We test four hypotheses. First, the extinction of the forest elephant may lead to a significant net loss in household welfare. Second, WTP for elephant conservation varies with the distance between the household and the nearest protected area. The effect of this distance may be positive or negative. Indeed, following the distance decay hypothesis, WTP declines as the distance between the respondent location and the site providing environmental services increases (Bateman *et al.*, 2006; Loomis *et al.*, 2000; Schaafsma *et al.*, 2013). However, the distance to the protected area may also be an indicator of elephant scarcity. Therefore, if we assume decreasing marginal utility of forest elephant presence, household heads living close to a protected area with higher elephant density would be likely to express lower marginal WTP for elephant conservation. Third, WTP is significantly influenced by the indigenous status of households, as cultural services such as traditions and religious practices depend on the elephant's existence. Knowledge of spatial and ethnic differences in WTP may be used to design spatially explicit and culturally adapted conservation policies. Fourth, the presence of human-elephant conflicts is expected to reduce WTP for elephant conservation.

The following sections present the case study of the Congo Basin Tridom landscape's EFEs (section 3.2), the methodology (section 3.3), the results (section 3.4) and the discussion and conclusion (section 3.5).

3.2 Case Study: The Tridom Landscape's EFEs in the Congo Basin

The Tridom is a cross-border conservation landscape covering a geographical area of 191,541 km^2, representing 7.5% of the total area of tropical forests in the

Congo Basin of Central Africa. The Tridom was created in 2005 by an agreement among the Cameroon, Gabon and Congo governments, as one of the twelve Congo Basin Forest Partnership (CBFP) priority landscapes. The agreement targets the promotion of long-term biodiversity and protected areas' system conservation, the rational use of natural resources and sustainable development, including poverty reduction. It encompasses 10 protected areas representing 37,498 km^2. Five of these areas are located in the Cameroonian segment (BoumbaBek, Kom, Mengame, Nki and Dja Biosphere Reserve), three in the Gabonese segment (Minkébé, Mwagne and Ivindo National Parks) and two in the Congolese segment (Odzala and Lossi National Parks). Between protected areas is a liveable inter-zone totaling 40,000 km^2, with the remaining area being non-livable. The Tridom landscape includes rich and diversified flora and fauna and is abundant in highly commercially valuable timber species. In addition to elephants, this landscape has a relatively high density of large mammals, such as buffaloes, bongos, giant pangolins and gorillas. The range of human population density is 1-7.9 inhabitants/km^2 and is increasing as a result of resource exploitation (Ngoufo *et al.*, 2012). The Tridom inter-zone is home to numerous economic activities, including forest management. Aproximately 78% of the indigenous and local communities rely on small-scale farming (40.9%), cash-cropping (19.6%), hunting-gathering bushmeat and non-timber forest products (14.8%), and Traditional gold-mining (3%) as their predominant livelihood with full-time employment. Among these activities, cash-cropping and small-scale farming constitute the main sources of income in the region.

Data were collected from a representative face-to-face survey of a random, stratified sample of 1,035 households (from a total of approximately 65,140 households in the study area). Because of administrative constraints and limited field work funding, our survey was conducted in the Cameroon and Gabon segments but not in Congo (*figure 3.2*). These segments are inhabited by more than 43 tribes, which are dominated by the Bantu, although the minority indigenous Baka tribe is also present (table C.2.1 in appendix). Random sampling of the households in the villages was based on the inhabitants' registers held by the village chiefs. The survey was administrated for 8 months between December 2013 and July 2014 in 108 villages representing all 26 administrative units of the Cameroonian and Gabonese part of the landscape (table C.2.2 in appendix). The visited villages are spread over nearly 27,000 km^2, which represents two-thirds of the landscape's liveable inter-zone. Each household was geo-localized using a GPS. Interviews lasted between 1 and 3 hours. In addition, evening

visits to various surveyed households were conducted to measure daily production. The field work was supervised by the first author. Ten master's degree students were selected after five training seminars to participate as surveyors. Each village provided us with at least two local translators in case the household heads could not communicate in French.

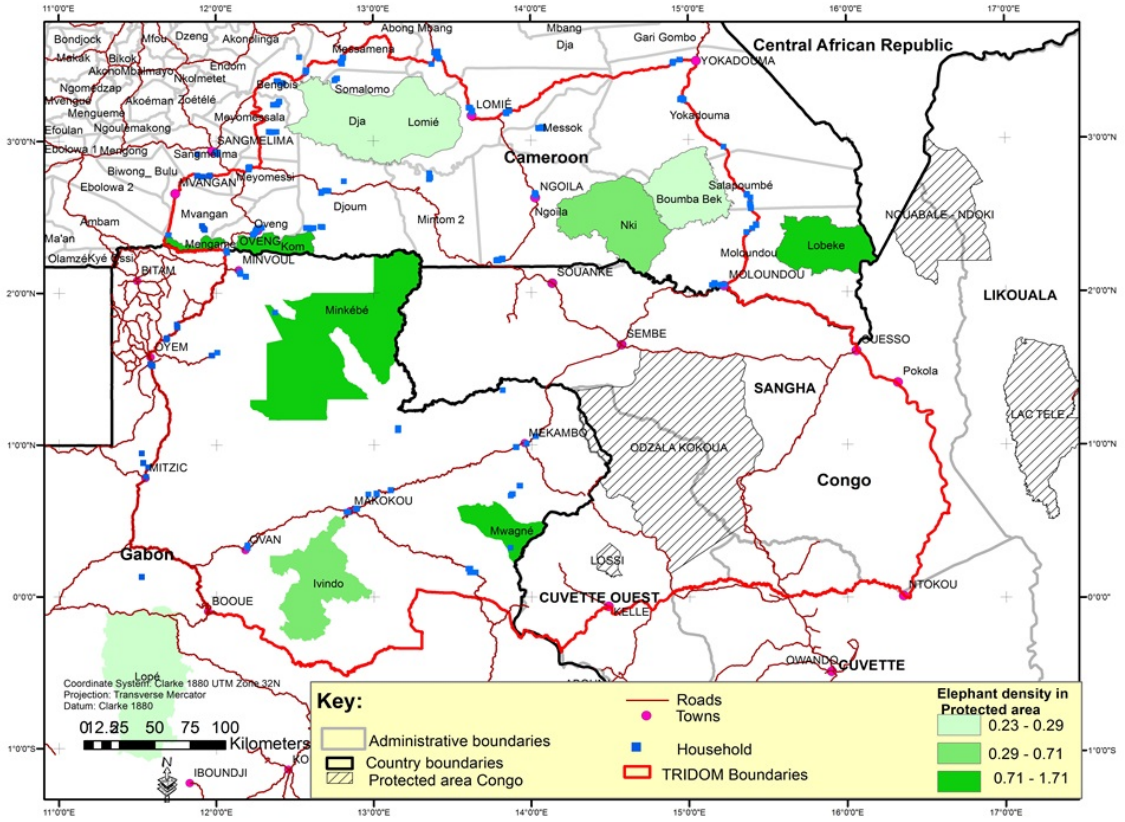

Figure 3.2: The Study Area.

3.3 Methodology: Combining Open-Ended and Closed-Ended CV Methods

3.3.1 Overview of CV methods

Major differences between CV approaches include open-ended (OE) and closed-ended formats, or discrete-choice contingent valuation (DCCV)(Cameron et James, 1987). In the OE format, respondents are asked to specify their WTP, while in the

close-ended format, respondents are asked to indicate whether they would pay a specified amount (Kealy et Turner, 1993). Regardless of the level of information that respondents receive, the predicted WTP may be unstable with respect to the elicitation format (Brown *et al.*, 1996). Indeed, the DCCV and OE mechanisms may yield significantly different preferences for public goods because of the varying incentives for strategic behaviour (Kealy et Turner, 1993). We use both mechanisms to approximate the true WTP. The DCCV approaches include single-, double-, or multiple-bounded dichotomous-choice approaches (Hanemann, 1985; Carson, 1985; Hanemann et Kanninen, 1999). In the double-bounded dichotomous choice (DBDC) approach, the respondents, having been asked a DCCV question, are asked a second DCCV question that depends on the answer to the first.

We first apply the DBDC model proposed by Hanemann (1985) and Carson (1985). The advantage of DBDC over the single-bounded format is that we obtain more information from the respondents. The former is therefore asymptotically more efficient than the single-bounded method developed by Bishop et Heberlein (1979); Hanemann *et al.* (1991); Alberini (1995); Haab et McConnell (2002). However, DBDC is more complicated to implement and requires more advanced econometric approaches to analyse the data. Furthermore, the initial bid may provide an anchor for the uncertain respondent, implying a bias in the response to the second question. For example the respondent may believe that the first bid may represent the "true" value of amenity valuated and may consider this information when responding to the second question (Hanemann *et al.*, 1991; Herriges et Shogren, 1996). However, a good starting point has the benefit of preparing and encouraging respondents to reveal their maximum WTP (Brouwer et Martin-Ortega, 2012; Bateman *et al.*, 2008; Frew, 2010a; Fischhoff et Furby, 1988).

Our methodological approach is to combine the DBDC format and the OE format. Once the starting points are well defined, the use of DBDC in first stage is expected to provide the best basis for an OE question. In fact, stand-alone OE questions often suffer from a high share of protesters as the respondents have difficulties when they are not accustomed to valuing a service or good (Zeiler et Plott, 2004; Bateman *et al.*, 2011; Brouwer et Martin-Ortega, 2012). According to the discovered preference hypothesis, executing DBDC yields repetition and experience and therefore facilitates convergence towards stable and theoretically consistent preferences (Zeiler et Plott, 2004; Bateman *et al.*, 2008). Hence, following Bateman *et al.* (2008), the DBDC

format may be considered a learning design that may help to reduce the preference anomalies that occur under the OE format as well as the non-response rate and the number of protesters. Asking an OE question after the DBDC provides more information when the respondent answered either 'yes' to both amounts or 'no' to both amounts (Mahieu *et al.*, 2012b). Indeed,the WTP stated by these respondents is unbounded when only the DBDC format is used.

3.3.2 Survey design

CV questions were included in a questionnaire addressing the characteristics, behaviours and motivations of the households. The CV first described the socio-economic and ecological attributes of the elephant, as well as the potential change in socio-cultural services associated with possible extinction given that forest elephants are currently present only in the Congo Basin. The respondents were asked to state their preferences for the entire bundle of services provided by forest elephants because addressing services separately leads to double counting. For instance, existence value will ensure bequest value, as well as option value (Loomis et Larson, 1994; Bandara et Tisdell, 2003a). Next, we proposed the following hypothetical scenario, given that we are valuing a non-market good without an implicit market. "*Considering the trend towards the extinction of forest elephants, if action is not taken quickly, this multi-use, iconic species will disappear in the next few years. To stop this tendency towards extinction and make the species more abundant, the Tridom Regional Project Management Unit may develop a 10-year elephant conservation programme that aims to seize weapons currently used by poachers and to effectively fight cross-border poaching by (1) creating joint checkpoints on the landscape scale and (2) recruiting more young people from villages and involving them in a communication network to improve anti-poaching control strategies and prevent human-elephant conflicts*". Then, each respondent was asked whether *he would be willing to contribute to the programme by paying some monthly amount if the Regional Management Unit were to demand financial support from all the inhabitants of the village.*

The payment vehicle presented was the direct cash payment of secure funds that would be held by the Tridom programme. This means of payment is the most familiar, credible and feasible based on the economic situation in the landscape. To

minimize "yea-saying" and "nay-saying" bias[4] as well as the starting point bias, (1) we asked each respondent to consider his monthly income, his sources of income, and his usual monthly expenditures, and (2) we asked each respondent to be realistic, in ensuring that he could actually pay the stated monthly amount for the next 10 years before answering. Furthermore, the respondents were randomly assigned to one of six starting bids developed and validated during two pretest steps with 40 households in four villages (Meyomessi, Oveng, Kongo and Mbieleme) of two subdivisions of the study area using an OE elicitation format (Boyle et Bishop, 1988). A lower bid was presented to those who gave a negative answer to the starting bid, and a higher bid was presented to those who gave a positive answer. The bid card structure is presented in the figure (C.1.1 in appendix). After the double-bounded elicitation format was used, the respondents were assigned an OE question asking the maximum amount they would be willing to pay for forest elephant conservation. Finally, we ask follow-up questions to examine the reasons for zero observations to be able to identify protest bidders in the database before model estimation (Arrow *et al.*, 1993).

3.3.3 Theoretical model specification

Household preferences for forest elephant conservation in the Tridom can be described by a random utility model as developed by McFadden (1973) and formalized by Manski (1977) and Hanemann *et al.* (1991). The indirect utility function is given by the following:

$$U_{ij} = V_{ij}(Y_i - a, E(a), X_i) + \varepsilon_{ij} \tag{3.1}$$

In equation (3.1), $j = 1 \wedge a > 0$ if household i is willing to pay an amount a, or $j = 0 \wedge a = 0$ otherwise. Y_i is the household head's income, V_{ij} is the deterministic component of the utility function measuring the indirect utility to respondent i in the state j, and X_i is vector of socio-economic and geographical characteristics influencing households preferences, ε_{ij} is the unobserved random component of the utility function. This function is supposed to be increasing and concave in available income Y_i as well as in the level of elephant protection $E(a)$. The household head i

[4]Yea-sayers and nay-sayers are respondents who try to please or to counter, respectively, the interviewer without considering the specific amount they are asked about (Carson et Hamenann, 2005; Frew, 2010b).

will then be willing to pay if the following holds:

$$U_{i1} > U_{i0}, \Longleftrightarrow (V_{i1}(Y_i - a, E(a), X_i) + \varepsilon_{i1}) > (V_{i0}(Y_i - 0, E(0), X_i) + \varepsilon_{i0}) \quad (3.2)$$

A household would be willing to contribute to EFE conservation if doing so provides greater utility than not paying. Therefore, the maximum WTP_i of household head i can be expressed in equation (3.4):

$$(V_{i1}(Y_i - WTP_i, E(WTP_i), X_i) + \varepsilon_{i1}) = (V_{i0}(Y_i - 0, E(0), X_i) + \varepsilon_{i0}) > 0 \quad (3.3)$$
$$(3.4)$$

3.3.4 Econometric model specification

Following Cameron (1988), we model the random WTP generated by closed-ended and OE question formats using the following formulation:

$$WTP_i(X_i, \mu_i) = X_i'\beta + \mu_i \quad (3.5)$$

In equation (3.5), WTP_i represents the WTP vector of the i^{th} respondent, X_i is a vector of explanatory variables, β is a parameter vector, and μ_i a normally distributed error term.
In the following, we specify four econometric models, using both the DBDC and the OE elicitation procedures described above. These models represent different assumptions about the reasons for respondents of not giving a positive bid. Our sample included a significant number of zero-bidders. Furthermore, as explained below, the different model assumptions concerns also how we combine information from the closed-ended and OE elicitation formats. The first two models are variants of the interval regression model (IRM) initially proposed by Hanemann *et al.* (1991) to analyse DBDC data. The other two models are corner solution models, i.e., a Tobit model and Cragg's truncated normal double-hurdle model (DHM).

3.3.4.1 Interval regression models

First, we estimate a standard interval regression model (IRM) based on the data obtained from the DBDC elicitation format. We estimate the model with and

without zero-bid protesters. In our questionnaire, zero-bid protesters are identified as zero bidders who may have a true positive WTP but stated zero WTP in the OE question. Strazzera *et al.* (2003); Jorgensen et Syme (2000) and Halstead *et al.* (1992) recommend excluding them from the analysis only if they are similar to other respondents. Indeed, socio-demographic characteristics do not differ significantly between zero-bid protesters and non-protesters (see *Table 3.2*). By excluding zero-bid protesters, we assume that they have similar preferences, on average, as non-protesters.

In the standard application of IRMs (DBDC), a respondent who refuses to pay the lowest bid ("no/no" respondents) is left-censored at the lowest bid. If the respondent accepts both bids, the true WTP is right-censored at the upper bid.

The IRM is adapted to account for point data. Applying OE responses in cases in which the respondents reply "no/no" or "yes/yes" under a DBDC format helps significantly reduce the share of unbounded intervals. Our hypothesis is that combining these two datasets increases statistical efficiency (Mahieu *et al.*, 2012a; Haab et McConnell, 2002).

Furthermore, we use follow-up questions to identify respondents who may have a negative WTP in the proposed conservation scenario. It is assumed that respondents may have a negative WTP if they answer zero WTP for the OE question and reply to a follow-up question that elephants are considered a cost[5]. We estimate the modified interval regression model (IRM1) assuming that respondents who consider elephants a cost after facing a human-elephant conflict and who answer zero WTP in the OE question may effectively have a negative WTP. This approach involves left-censoring at zero. The remaining respondents answering zero in the OE format are considered true zero bidders and are integrated as point data. These respondents' main motives for zero WTP include *"I cannot afford to pay for elephant conservation", "I do not receive any benefit from elephants", and "I do not see any problem if they disappear"*. The second estimation of the modified IRM left-censors household heads who expressed a possible loss in utility from the presence of elephants and who do not necessarily face human-elephant conflicts. This IRM has expected negative preferences (IRM2).

The standard IRM or DBDC model described above yields four possible interval outcomes with respect to the "yes/yes", "yes/no", "no/yes" and "no/no" answers.

[5]The motives offered by these respondents include "elephants are a cost for me because they destroy my crops".

The added value of the modified IRM is that, in addition to the output formats of the DBDC, it accounts for point data. Hence, *Table 3.1* presents various possible specifications of the dependent variable.

Table 3.1: Various specifications of the dependent variable

	Data	First Bid (FB)	Secondary Bid (SB)	OE
"no/no" and WTP ≥ 0	a_i^{OE}	a_{ij}^s	a_{ij}^l	$a_i^{OE} \geq 0$
"no/no" and WTP < 0[1]	$[-\infty, 0[$	a_{ij}^s	a_{ij}^l	0
"yes/yes"	a_i^{OE}	a_{ij}^s	a_{ij}^u	$a_i^{OE} \geq a_{ij}^u$
Interval "no/yes"	$[a_{ij}^l, a_{ij}^s[$	a_{ij}^s	a_{ij}^l	$a_i^l \leq a_{ij}^{OE} \leq a_{ij}^s$
Interval "yes/no"	$[a_{ij}^s, a_{ij}^u[$	a_{ij}^s	a_{ij}^u	$a_i^s \leq a_{ij}^{OE} \leq a_{ij}^u$

[1]These are "no/no" respondents who respond 0 to the OE and who faced or expect to face crop damage caused by elephants.

Here, a_{ij}^s, a_{ij}^l and a_{ij}^u represent the starting point, the lower bid and the upper bid, respectively, of the j^{th} random bid card assigned to the i^{th} household. According to *Table 3.1*, the probability that the i^{th} household is willing to pay an unobserved amount within one of these intervals is given by the following:

$$\begin{aligned} P^{lc} &= P\left(\mu_i < 0 - X_i'\beta\right) \\ &= \Psi\left(\frac{0 - X_i'\beta}{\sigma}\right) = \Psi\left(\frac{-X_i'\beta}{\sigma}\right) \end{aligned} \tag{3.6}$$

$$\begin{aligned} P^{id} &= P\left(FB_i \leq X_i'\beta + \mu_i < SB_i\right) \\ &= \Psi\left(\frac{SB_i - X_i'\beta}{\sigma}\right) - \Psi\left(\frac{FB_i - X_i'\beta}{\sigma}\right) \end{aligned} \tag{3.7}$$

where $\Psi(*)$ is the cumulative normal distribution function. Equation (3.6) represents the left-censored (lc) data, that is, zero bidders who face or expect to face crop damage caused by elephants. Equation (3.7) represents the interval data (id), that is, the no/yes and yes/no respondents in the DBDC format. In this equation, FB_i is the first bid or starting point a_{ij}^s, and SB_i is the secondary bid, with a_{ij}^l or a_{ij}^u as

the value for the "no/yes" or "yes/no" respondents, respectively

Stewart (1983) suggests using the maximum likelihood technique when estimating the IRM. Hence, following Wooldridge (2012), the log-likelihood function can be expressed as follows:

$$\begin{aligned}\ln(L(\beta)) = &\sum_{i=1}^{N} b_i^{lc} \ln\left[\Psi\left(\frac{-X_i'\beta}{\sigma}\right)\right] \\ &+ \sum_{i=1}^{N} b_i^{id} \ln\left[\Psi\left(\frac{SB_i - X_i'\beta}{\sigma}\right) - \Psi\left(\frac{FB_i - X_i'\beta}{\sigma}\right)\right] \\ &+ \sum_{i=1}^{N} \frac{1}{2} b_i^{OE}\left[\left(\frac{a_i^{OE} - X_i'\beta}{\sigma} + \ln 2\pi\sigma^2\right)\right]\end{aligned} \tag{3.8}$$

The first element of equation (3.8) accounts for left-censoring at zero observations. The second element accounts for interval data ("no/yes" and "yes/no"). The last element accounts for "no/no" or "yes/yes" respondents who are willing to pay an amount $a_i^{OE} \geq 0$. In equation (3.8), b_i^{lc}, b_i^{id} and b_i^{OE} are dummy variables indicating the type of interval to which a houshold relates.

3.3.4.2 Corner solution models

A total of 358 households replied "no/no" in the DBDC and gave zero as an answer to the OE question; thus, there remains a non-trivial proportion of the population that did not state positive preferences for forest elephant conservation. These zeros may represent true zeros when the respondent does not obtain any utility from the proposed conservation scenario or cannot afford to pay for the conservation programme. A stated zero WTP can also be given if respondents have a negative WTP but are asked to only state a positive WTP. Alternatively, respondents may obtain positive (or negative) utility from elephant conservation but refuse to reveal their preferences, e.g., because they may find it difficult to put a value on such an asset (Mitchell et Carson, 1993). If some household heads stating a zero WTP in fact have a negative WTP for conservation, then the full possible range of respondents' preferences for elephant conservation is not observed. In this case, the dependent variable is a corner solution outcome (Wooldridge, 2010; Cameron et Trivedi, 2005). Econometric models that can cope with corner solution outcomes include Type I Tobit models (Tobin, 1958), Heckman selection or incidental truncation models

(Heckman, 1979) and Cragg DHMs (Cragg, 1971).

Given the high number of zero bidders we apply a Tobit model and a DHM model that allows us to investigate the reasons for not participating (giving a positive bid). In the Tobit model, the likelihood of participation and the intensity of participation (in elephant conservation) are determined in the same way using the same covariates. This assumption is not generally reasonable (Katchova et Miranda, 2004). For example, in our case, households living very far from a protected area with high elephant density may be less likely to participate in elephant conservation and those that do participate may pay larger amounts because they are often close to urban areas. Furthermore, Tobit models do not remain consistent under heteroscedasticity (Brooks, 2014; Amemiya, 1984). DHMs provide the option of separating the parameterization of both decisions under a conditional independence assumption for drivers of participation and intensity (Burke, 2009; Solomon et Bekele, 2014; Wooldridge, 2010). Cragg's DHM allows heteroscedasticity in the second hurdle without conceding model misspecification in the first hurdle (Burke, 2009).
The paper considers and compares traditional Tobit models and Cragg's DHMs. As the Tobit model is nested within Cragg's alternative, the following specifies only Cragg's model. The first hurdle, or participation decision d_i, and the second hurdle, explaining the intensity of participation (Y_{2i}), are defined as follows:

Participation equation:

$$Y_{1i}^{*} = X_{1i}\alpha + \varepsilon_i \tag{3.9}$$

Threshold participation equation:

$$d_i = \begin{cases} 1 & \text{if } Y_{1i}^{*}>0 \\ 0 & \text{otherwise} \end{cases} \tag{3.10}$$

Observed contribution intensity:

$$Y_{2i}^{*} = X_{2i}\gamma + \mu_i \tag{3.11}$$

Threshold contribution intensity:

$$Y_{2i} = \begin{cases} Y_{2i}^{*} & \text{if } Y_{2i}^{*}>0 \\ 0 & \text{otherwise} \end{cases} \tag{3.12}$$

In equations (3.9), (3.10), (3.11) and (3.12), Y_{1i}^{*} and Y_{2i}^{*} are latent variables. Here, d_i equals 1 if the household participates in EFE conservation and 0 otherwise, X_{1i} is a vector of socio-demographic and geographical covariates, α a vector of coefficients, and ε_i is the *iid* error term. Y_{2i}^{*} is the household's latent contribution to EFE conservation, X_{2i} is the vector of socio-demographic and geographical covariates that drives the intensity of payment, γ is the vector of coefficients, and μ_i is an *iid* error term. Following Moffatt (2005), the DHM log-likelihood function is specified as follows:

$$\begin{aligned} \ln(L) = & \sum_{Y_{2i}=0} \ln\left[1 - \psi\left(X_{1i}\alpha\right)\Psi\left(\frac{X_{2i}\gamma}{\sigma_i}\right)\right] \\ & + \sum_{Y_{2i}>0} \ln\left[\frac{1}{\sigma_i}\psi\left(\frac{Y_{2i} - X_{2i}\gamma}{\sigma_i}\right)\Psi\left(\frac{X_{1i}\alpha}{\sigma_i}\right)\right] \end{aligned} \tag{3.13}$$

In equation (3.13), $\psi(*)$ and $\Psi(*)$ are the probability density functions and cumulative normal distribution functions, respectively. The first element represents the non-participants, while the second represents the summation over observed positive contributions to EFE conservation. The expression σ_i is the standard error or the value of σ for each observation. If $\frac{\alpha}{\sigma_i} = \gamma$ and $X_{1i} = X_{2i}$, then the Tobit model and the truncated DHM are mathematically identical. For detailed presentations of both models, see Cragg (1971) and Wooldridge (2010).
Following Burke (2009), this paper considers three values of interest to characterize the households' likelihood and intensity of participation in EFE conservation. The first is the partial effects of the covariates on the probability of participation, and the second and third are the partial effects of the covariates on the conditional and unconditional expected preferences derived using the maximum likelihood outcome obtained from the truncated DHM.

Partial effects of the covariates j on the probability of participation:

$$\frac{\partial P\left(Y_1^{*} > 0 \mid X_1\right)}{\partial X_{1j}} = \alpha_j \psi\left(X_1\alpha\right) \tag{3.14}$$

Partial effects of the covariates on the conditional expected preferences:

$$\frac{\partial E\left(Y_2 \mid Y_{2i} > 0, X_{2i}\right)}{\partial X_{1j}} = \gamma_j\left[1 - \lambda\left(\frac{X_2\gamma}{\sigma_i}\right)\left(\frac{X_2\gamma}{\sigma_i} + \lambda\left(\frac{X_2\gamma}{\sigma_i}\right)\right)\right] \tag{3.15}$$

Partial effects of the covariates on the unconditional expected preferences:

$$\begin{aligned}\frac{\partial E\left(Y_2 \mid X_1, X_2\right)}{\partial X_{1j}} &= \alpha_j \psi\left(X_1\alpha\right)\left\{X_2\gamma + \sigma\lambda\left(\frac{X_2\gamma}{\sigma_i}\right)\right\} \\ &+ \Psi\left(X_1\alpha\right) * \gamma_j\left[1 - \lambda\left(\frac{X_2\gamma}{\sigma_i}\right)\left(\frac{X_2\gamma}{\sigma_i} + \lambda\left(\frac{X_2\gamma}{\sigma_i}\right)\right)\right]\end{aligned} \tag{3.16}$$

In equations (3.14) and (3.16), α_j is an element of α that appears as the coefficient on X_1. In equations (3.15) and (3.16), γ_j is an element of γ that appears as the coefficient on X_2; $\lambda = \psi\left(X_1\alpha\right)/\Psi\left(X_1\alpha\right)$ is the inverse Mills ratio.
We also considered a Heckman selection model allowing for dependence in the error terms of the participation and contribution equations (Martínez-Espiñeira, 2006). However, our tests indicated no significant dependence, and the results of the Heckman selection model are not presented.

3.4 Results

3.4.1 Variable Descriptions and Descriptive Statistics

Table 3.2 describes the independent variables used in the various econometric models, as well as the descriptive statistics. Of the 1,035 household heads surveyed, 99 (9.6%) were excluded as protesters, leaving a sample of 936 of non-protesters. The Baka indigenous group, an ethnic minority group, represented 5% of the households. Their traditional way of life is closely linked to the elephant's existence. The main activity or type of land use may also influence a household's preferences for forest elephant conservation. Of the 936 respondents, 19% produce cash crops (e.g., cocoa) as their main use of land, while 41% are small-scale farmers producing crops for subsistence and small-scale trading. Only 3% of households use forest land for traditional gold mining. Using the forest for hunting and gathering was reported by 15% of the sample, while 3% work in biodiversity conservation organizations, forest administration, or forest concession management. Among the remaining respondents, 9% work for other administrations, and 10% engage in animal husbandry, work in fisheries, or engage in trade.
Experiencing conflicts with elephants may have a negative impact on households welfare and thus on households preferences for EFE conservation. Indeed, conflicts have been reported by 259 households (28%), with approximately CFA 28,140 or

€43 of damages reported per household. This cost is rigorously calculated, as it is typically registered by households that faced conflict in obtening compensation from decentralized administrations. To date, no household has received compensation.

Table 3.2: Descriptive statistics

Variable	Description of household head characteristics	Without protesters (n=936)	Protest bidders (n=99)	Overall obs. (n=1,035)	Comparison test
		Mean (Std)	Mean (Std)	Mean(Std)	Chi 2 (1) <3.84 [t-test (5%, 1,033)] <1.96
GENDER	1 if male, 0 otherwise	0.76 (0.42)	0.77 (0.42)	0.76 (0.42)	0.007
AGE	age in years	48.29 (14.68)	50.79 (13.52)	48.53 (14.59)	[-14.07]
HSIZE	household size	6.43 (4.05)	7.02 (3.90)	6.49 (4.04)	[-0.0194]
EDUCATION LEVEL	1 if at least secondary school, 0 otherwise	0.55 (0.50)	0.68 (0.47)	0.56 (0.50)	6.21
MONTHLY EXP	monthly expense	46,604 (59,463)	59,792 (68,242)	47,865 (60,446)	[-2.40E+19]
INDIGENOUSNESS	1 if indigenous BAKA (Pygmies), 0 otherwise	0.05 (0.22)	0.03 (0.17)	0.05 (0.21)	0.77
SMALL FARMER	1 if small scale farmer, 0 otherwise	0.41 (0.49)	0.42 (0.50)	0.41 (0.49)	0.09
TRAD GOLD MINER	1 if traditional gold miner, 0 otherwise	0.03 (0.16)	0.00 (0.00)	0.03 (0.16)	2.82
HUNTER GATHERER	1 if hunter-gatherer, 0 otherwise	0.15 (0.36)	0.09 (0.29)	0.15 (0.36)	2.81
FMU OR FOREST AD	1 if works in the forest administration or a FMU	0.03 (0.18)	0.02 (0.14)	0.03 (0.18)	0.48
OTHER ADMIN	1 if works in other administration	0.09 (0.28)	0.10 (0.30)	0.09 (0.29)	0.16
HUM/ELEPH CONFLICT	1 if human-elephant conflict, 0 otherwise	0.28 (0.45)	0.23 (0.42)	0.27 (0.45)	0.88
LAND HOLDINGS	land area (ha) ownership	4.32 (5.32)	5.36 (4.32)	4.42 (5.24)	[-0.09.73]
DIST_NAREA	distance to the nearest protected area (km)	28.98 (22.26)	27.60 (22.14)	49.06 (493.20)	[40.17]
ELEPHANT DENSITY	elephant density of the nearest protected area	0.94 (0.84)	0.83 (0.72)	0.93 (0.83)	[0.01.51]

Variables such as land holdings, distance between the respondent and the nearest protected area and proximity to a protected area with relatively high elephant density may also influence the preferences of the respondents for elephant conservation. The first two of these variables were determined using a GPS and the ArcMap software. Indeed, land holdings refer to the area of land holdings of a household head. This variable was generated using GPS tracking to capture the exact area. Approximately 70% of the households own between 0.1 and 5 ha, 8% do not have access to land, 29% own between 5 and 15 ha, and 3% own between 15 and 25 ha. A few household heads own between 25 and 57 ha of land. With regard to proximity to a protected area (with relatively high elephant density), the elephant density of the various protected areas is considered a continuous variable (this variable was determined using the UICN elephant database).

Table 3.3 provides the distribution of the 936 answers to the DBDC questions, excluding identified protest bidders. As expected, the frequency of "yes" and "yes/yes" respondents decreases with the starting bid. On average, 56% responded "no/no". The WTP reported by 18.4% of the remaining respondents was in the interval between the lower bid and the starting bid (6.5%) or between the starting bid and the upper bid (11.9%). Approximately 25.4% were willing to pay more than the higher bid. *Table 3.4* shows the outcome summary with respect to the various econometric models estimated. The DBDC model without protesters left-censors all "no/no" observations, that is, 56.2% of the sample; it considers 43.8% of positive

Table 3.3: Answers to bids

Bid cards $a^s/a^l/a^{u1}$	Bid card Statistics		Yes to a^s	No to a^s	Answers to bids		Perc. (%)	
	Freq.	Perc.			YY	NY	YY	NY
					YN	NN	YN	NN
1,000/500/1,500	191	20%	46%	54%	56	15	5.98	1.60
					31	89	3.31	9.51
1,500/1,000/2,000	161	17%	47%	53%	53	5	5.66	0.53
					22	81	2.35	8.65
2,000/1,500/2,500	148	16%	34%	66%	33	14	3.53	1.50
					18	83	1.92	8.87
2,500/1,000/3,000	163	17%	33%	67%	40	5	4.27	0.53
					13	105	1.39	11.22
3,000/1,500/3,500	115	12%	38%	70%	31	10	3.31	1.07
					3	71	0.32	7.59
3,500/2,000/4,000	158	17%	31%	56%	25	12	2.67	1.28
					24	77	2.56	10.36
Total	936	100%			238	61	25.43	6.52
					111	526	11.86	56.20

[1] a^s = Starting bid; a^l = Lower bid; a^u=Upper bid

preferences. The OE format assigned to the respondent after the DBDC yielded 578 positive stated WTP values, that is, for 61.75% of the respondents. As a corollary, the level of information obtained about forest community preferences improved considerably in two ways. Among the household heads responding "no/no" to the

Table 3.4: Dataset description (percentages)

	DBDC standard IRM		Tobit	Double-hurdle model		IRM + point data	
	Total (1,035)	Without protesters (936)		First hurdle	Second hurdle	IRM 1	IRM 2
Left-censored data	60.4	56.2	38.20	-	0.00	2.90	11.10
Right-censored data	23	25.4	0.00	-	0.00	0.00	0.00
Interval data	16.6	18.4	0.00	-	0.00	18.20	18.20
Point data	0	0.00	61.80	100	61.80	79.00	70.70
Truncated at zero	-	-	0.00	-	38.20	-	-
Total	100	100	100	100	100	100	100

DBDC question, that is, 56.2% of the sample surveyed, 18% stated a positive WTP in response to the OE question, and 25.4% were willing to pay more than the higher bid. The follow-up questions revealed that 104 households reported a zero WTP because they considered elephants to be a cost for them. Of these, 27 households had experienced crop damage from elephants.

3.4.2 Econometric results

3.4.2.1 Predicted WTP for EFE conservation and extrapolation

Table 3.5 presents the factors influencing households' WTP, as well as the estimated WTP. We display the results from the diverse models described in the previous section in order to underline how estimated WTP are influenced by the chosen models. Overall, we see that the estimated WTP is sensitive to the estimation techniques and assumptions about protesters and zero bidders. Indeed, the first two columns display the results based on the standard DBDC model with and without the zero-bid protesters. As expected, the predicted WTP is higher when zero-bid protesters are removed. Indeed, the remaining respondents are assumed to be representative of the population, as they have nearly the same characteristics as the zero-bid protesters. The removal of protesters leads to an increase in the monthly predicted WTP from CFA 368.84 (€0.56) to CFA 742.92 (€1.13) per household.

The DHM model resulted in an unconditional expected WTP for EFE conservation of CFA 1,326.87 (€2.02). As expected the conditional expected WTP, based on the respondent having a positive WTP, was significant higher CFA 2,081.84 (€3.17) because of the non-trivial share of respondents who did not state positive preferences for forest elephant conservation. IRM1 produced a monthly predicted WTP of CFA 1,245.66 (€1.89). This model left-censors only the 27 households that experienced both human-elephant conflicts and crop damage. IRM2 left-censors the 104 households that experienced elephant-related costs as well as those citing potential elephants-related cost as the reason for a zero bid. This model generated a predicted WTP of CFA 1,138.17 (€1.74) or CFA 13,658 (€20.82) annually per household.

To estimate the expected aggregate WTP for elephant conservation by the population living in both the Cameroonian and Gabonese segments of the Tridom landscape, the simple transferring point estimate is used as the sampling of respondents was random and representative. This method produces a robust aggregate with less bias than a benefits function transfer approach (Bandara et Tisdell, 2004; Loomis *et al.*, 2000; Brouwer et Spaninks, 1999). The aggregate population size in both segments of the Tridom is 418,855 inhabitants (Bucrep, 2010; Gabon, 2010). Considering the mean household size of the sample (6.43), the number of households is approximately 65,140. The monthly WTP of the overall population is CFA 74.14 million (€113,000) or CFA 889.7 million (€1.36 million) annually. Given the current 2.4% population growth rate (World Bank) and a 3% discount rate, the local and indigenous Tridom households have a net present value of CFA 8.67 billion (€13.2

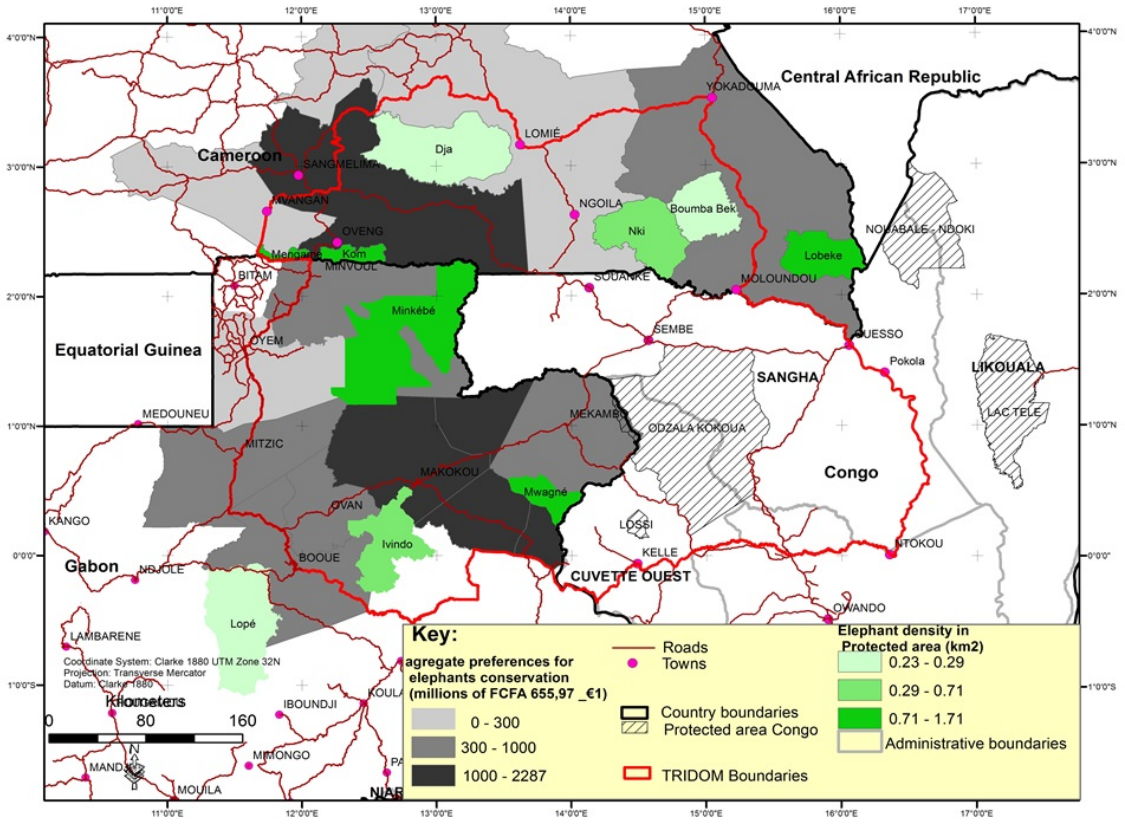

Figure 3.3: Aggregate WTP ($*10^6 CFA$) by division and elephant densities in protected areas.

million) for the proposed 10-year elephant conservation programme. According to the high population density, as shown in *figure 3.3*, the Haut-Nyong, the Dja et Lobo and the Boumba et Ngoko in Cameroon expressed the greatest aggregate WTP for elephant conservation at CFA 2,380 million, CFA 2,287 million and CFA 1,139 million, respectively (figure C.1.2 in appendix). Among the Gabonese subdivisions, the Ivindo, Woleu and Haut-Ntem expressed the greatest WTP at CFA 769 million, CFA 528 million and CFA 380 million, respectively.

3.4.2.2 Drivers of participation, intensity of participation and the impact of covariate change

The drivers of households' participation decisions and their intensity of participation are analysed using the Tobit model and DHM. Applying a log-likelihood test, we test if the more general DHM can be reduced to a Tobit model. See, for example, Katchova

et Miranda (2004). The calculated $L_{statistic}$ given by $-2*(DHMLL–TobitLL)$, which equals 178, is greater than $\chi^2(13)$ at the 5% critical value (27.69). This outcome shows that the data do not support the more restricted Tobit model. Indeed, participation in and the size of the contribution to elephant conservation cannot be examined using one-step parameterization. In addition, these decisions are not explained by the same covariates. The household heads' activities influence the participation decision, but not the intensity of participation. These variables are removed from the second hurdle, as the restricted model provides a smaller Akaike Information Criterion value compared with the value obtained from the model including all covariates.

Table 3.5: Coefficient estimates

Predictors	CLOSE-ENDED MODELS		OPEN-ENDED – CORNER SOLUTION MODELS				COMBINING DBDC and OE	
	DBDC Overall sample	DBDC without protesters	Tobit model	Heteroscedastic double-hurdle estimates			IRM 1 + effective negative utility	IRM 2 + potential negative utility
				1^{st} hurdle	2^{nd} hurdle	Het.		
	Coef. (Std)	Coef. (Std)	Coef. (Std)	Coef. (Std)	Coef. (Std)	Coef. (Std)	Coef. (Std)	Coef. (Std)
AGE	-28.476***	-24.444***	-22.153***	-0.008**	16.136	-20.297**	-13.373***	-15.855***
	(8.938)	(8.537)	(7.482)	(0.003)	(15.671)	(8.669)	(4.786)	(5.325)
EDUCATION LEVEL	814.450***	966.276***	639.181***	0.296***	2,204.333***	-678.365***	337.981***	405.907***
	(261.024)	(251.769)	(197.365)	(0.092)	(643.792)	(247.065)	(117.385)	(130.888)
MONTHLY EXP	0.007***	0.009***	0.00784***	6.00E-07	-0.005	0.022***	0.007***	0.006***
	(0.002)	(0.002)	(0.002)	(8.00E-07)	(0.011)	(0.005)	(0.001)	(0.001)
INDIGENOUSNESS	1,678.716***	1,684.426***	881.164**	0.417**	2,802.750***	-1,002.568***	580.169***	629.073***
	(536.186)	(512.805)	(347.409)	(0.210)	(666.533)	(283.159)	(209.415)	(225.923)
SMALL FARMER	66.121	53.891	181.726	0.126	-	-	53.789	84.957
	(289.733)	(281.481)	(218.536)	(0.103)			(142.599)	(152.844)
TRAD GOLD MINER	2,516.476***	1,993.225***	1,776.781**	0.660**	-	-	1,310.554**	1,385.737**
	(774.178)	(722.910)	(686.945)	(0.305)			(595.34)	(611.959)
HUNTER GATHERER	497.433	419.813	406.523	0.195	-	-	209.180	224.920
	(388.632)	(373.119)	(280.632)	(0.141)			(177.173)	(191.492)
FMU OR FOREST AD	1,880.433	1,665.085***	1,408.703***	0.962***	-	-	767.973**	849.319**
	(665.502)**	(639.716)	(456.845)	(0.304)			(378.348)	(381.100)
OTHER ADMIN	1,102.013	1,012.012**	868.687**	0.418**	-	-	472.233*	514.322*
	(450.792)	(440.923)	(355.409)	(0.177)			(274.521)	(291.193)
LAND HOLDINGS	469.118*	569.682**	589.087***	0.177*	-8,663.312	2,960.953*	350.103***	360.581**
	(264.529)	(257.990)	(211.915)	(0.096)	(7,696.3)	(1,642.55)	(133.111)	(143.537)
HUM-ELEPH CONFLICT	-43.790	-61.491	48.305	-0.013	-1,394.463	905.122**	-131.466	0.664
	(267.087)	(257.591)	(202.818)	(0.098)	(1,231.3)	(452.839)	(138.767)	(139.280)
DISTANCE*DENSITY	2.152	0.942	-0.763	-0.001	7.398**	0.315	-0.342	-0.588
	(2.509)	(2.421)	(1.911)	(0.001)	(2.890)	(2.409)	(1.153)	(1.279)
INTERCEPT	334.306	391.343	336.557	0.298	-1,956.741	2,553.671***	1,132.088***	1,054.191***
	(561.368)	(535.129)	(393.581)	(0.196)	(1,203.5)	(582.020)	(286.764)	(301.033)
/lnsigma	-	-	-	-	-	-	7.518***	7.580***
							(0.133)	(0.131)
SIGMA								
_CONS	3,017.586	2,814.215	2,582.161	-	-	-	1,841.317	1,959.043
	(198.43)	(183.290)	(314.105)				(244.970)	(257.955)
Number of obs	1,035	936	936	936	578		936	936
Left-censured	625	526	358	-	-		27	104
Uncensored	-	-	578	-	578		739	662
Right-censored	238	238	0	-	-		0	0
Interval Data	172	172	-	-	-		170	170
Wald chi2(13)	73.92	81.09		55.39			89.12	84.67
F(13, 923)	-	-	6.2	-			-	-
Prob >chi2	0.000	0.000	0.000	0.000			0.000	0.000
Pseudo R2	-	-	0.0092	-			-	-
Log-likelihood	-1,070.67	-1,012.31	-5,624.67	-5,535.857			-7,008.259	-6,439.55
Unconditional WTP	368.84	742.92	1,326.873				1,245.66	1,138.17
Conditional WTP			2,081.839					

Legend: * p<0.1; ** P<0.05; *** P<0.01

Drivers of participation and intensity

The coefficients of the first hurdle in the fourth column of *Table 3.5* indicate that the likelihood of participating in the elephant conservation programme is negatively influenced by age and positively influenced by education level; indigenousness; specific activities, such as traditional gold mining or having a job in a forest management unit, forest administration or other administration unit; and the land holdings of the household heads.
Some of the covariates have conflicting effects on both the decision to participate (first hurdle) and the intensity of participation (second hurdle). This also motivates the choice of the double parameterization technique under the DHM. Indeed, as a household head grows older, he is less likely to participate in the elephant conservation programme, yet the age variable does not influence the intensity of participation.
The higher the household head's education level is, the more likely he is to participate (and participate more intensively) in EFE conservation. The positive influence of education suggests positive feedback between better education and environmental awareness. This result suggests positive environmental benefits that arise from addressing education improvement and facilitating access to higher education in developing regions.
The effect of working in a forest management unit or a forest conservation NGO is positive, which implies a virtuous circle of environmental preservation: increasing the importance of forest protection also increases household awareness of biodiversity protection.

The impact of changes in covariate drivers of participation and intensity

The impact of a change in a covariate on the decision to participate is measured using the marginal effects based on the first hurdle equation. See the first column of *Table 3.6*. The conditional and unconditional average partial effects on the intensity of participation are derived from the second hurdle; see the second and third columns, respectively, of *Table 3.6*.

Indeed, a one-unit increase in the age of the household head will lead to an approximate decrease of 0.3 percentage points in the probability of programme participation.

Table 3.6: Conditional and Unconditional Partial Effects (CFA)

Predictors	Partial effect on prob(participation)	Conditional average partial effect on E(WTP)	Unconditional average partial effect on E(WTP)
AGE	-0.003	4.648	-3.036
EDUCATION LEVEL	0.107	635.031	615.652
MONTHLY EXP	2.29E-07	-0.001	0.0004
INDIGENOUSNESS	0.151	807.42	813.368
SMALL FARMER	0.046		-1,431.913
TRAD GOLD MINER	0.239		-260.821
HUNTER GATHERER	0.071		0.491
FMU OR FOREST AD	0.348		93.277
OTHER ADMIN	0.152		487.291
LAND HOLDINGS	0.064	-2,495.752	143.959
HUM-ELEPH CONFLICT	-0.005	-401.721	709.561
DISTANCE*DENSITY	-4.14E-04	2.131	308.764
INVERSE MILLS RATIO		1.344	

Given the unconditional average partial effect in the third column simultaneously with the first two columns of *Table 3.6*, it appears that the overall effect of being one year older is a decrease of CFA 3.04, as the negative effect on participation dominates the positive conditional average partial effect.

When a household head reaches secondary school, the probability of participation increases by 10.7 percentage points. This would lead to an average partial increase in the expected payment for EFE conservation of CFA 635 (€0.968) given the participation of the household head. The unconditional expected contribution to EFE conservation increases by CFA 615.6 (€0.939) compared with a contribution of a household head who has not enrolled in secondary school.

The likelihood of participating in such a programme would increase by 15.1, 23.9, 34.8 or 15.2 percentage points if the household head is a Baka pygmy, traditional gold miner, forest administration or other administration worker, respectively.

Conditional on agreeing to participate, an indigenous household head would pay an additional CFA 807.4 (€1.23). Not conditional on the agreement to participate, when the household head is an indigenous Baka, WTP increases by CFA 813.4 (€1.24) compared with the WTP of the rest of the population. Finally, household heads would pay an additional CFA 2.13 (€0.003) for an additional elephant per hectare in protected areas that are far from their crops.

3.5 Discussion and Conclusion

The aim of our paper is to determine local households WTP for forest elephant conservation. Our methodological contribution consists of combining OE and closed-ended CV methods. The above estimates provide four major outcomes with respect to the hypotheses. The extinction of *Loxodonta cyclotis* may lead to a significant net loss in household welfare. In fact, the predicted monthly WTP by household head is CFA 1,138.17 (€1.74). This value is close to the results found by Bandara et Tisdell (2005). Indeed, they found that respondents in general were willing to pay Rs. 110.17 (€1.65) per month for elephant conservation. The corresponding annual social value that we found is CFA 889.7 million (€1.36 million), and the net present value over 10 years is CFA 8.67billion (€13.2 million). By comparison, despite the expected annual budget of €1.5 million for the Tridom landscape biodiversity conservation project, the completed budget was €0.905 million on average per year between 2007 and 2011 (Baastel, 2012; Undp, 2013)[6]. This conservation project concerns slightly more than 9,000 species, including flagship species, such as buffaloes, gorillas, chimpanzees, bongos, otters, Nile crocodiles, giant hornbills, and giant pangolins in all Tridom segments, including Congo. As a matter of comparison, the estimated social value of improving conservation management for local people only, in the Cameroon and Gabon part of the Tridom of one species, the forest elephant, represents 150% of the total biodiversity conservation effective cost. This suggest that the programme is under-funded relative to the social benefits of biodiversity conservation.

The variable resulting from crossing distance and the protected area's elephant density does not influence the households' participation decision (i.e the first hurdle in the *Table 3.5* parameterization, the likelihood of participation in EFE conservation). However, household heads who live far from a protected area with high elephant density are willing to pay larger amounts to avoid EFE extinction. The positive sign of this variable tells us that local communities prefer elephants, albeit they prefer them far from their crops. Referring to the second hypothesis, distance as an indicator of scarcity is supported rather than the distance decay assumption. The Tridom Regional Management Unit should promote elephant mobility corridors, and these corridors should be located far from local and indigenous peoples' areas of

[6]The total project disbursements amounted to $6.03 million between 2008 and 2012, including $4.08 million between 2008 and 2011 and $1.95 million in 2012, yielding an annual disbursement of $1.2 million. Given the exchange rate prevailing in 2014(reference date for the social value), this amount is equivalent to €0.905 million.

interest in forests.

As expected in the third hypothesis, indigenousness (i.e., being a Baka pygmy) has a positive and significant influence on household preferences, while the distribution of the mean WTP does not seem to be conditional on ethnicity among the remaining Bantou ethnic groups (figure C.1.3 in appendix). Baka pygmies are likely to pay larger amounts. This information is important, as elephant extinction would severely threaten the spiritual enrichment, cultural identity and way of life of the Baka ethnic minority group.

Furthermore, contrary to the fourth hypothesis, the estimates show that the existence of human-elephant conflicts influences neither the household decision to participate nor the intensity of its preferences. Additionally, households with more access to land are more likely to contribute to the conservation programme. Theoretically, households with more access to land are more likely to face human-elephant conflicts, but the impact of such conflicts is likely to represent a smaller share of their income. Overall, the second effect seems to dominate the first. The relevance of these results is that local and indigenous people feel that their concerns about offsetting human-elephant conflicts are adequately addressed by the hypothetical scenario. This result makes the implementation of the proposed hypothetical scenario very important, as it simultaneously (1) insures the preservation of a public good (EFE) and its ecosystem services and (2) improves private benefits by preventing human-elephant conflicts. Therefore, our study suggests that local communities may be willing to engage in biodiversity preservation when the public benefits of conservation are accompanied by private benefits and when it prevents human-elephant conflicts.

EFE conservation decisions by policy makers should reflect a range of considerations, such as socio-economic and cultural issues, zero-conflict-oriented elephant habitats and optimal harvest rules with less poaching. However, our results cannot disentangle the WTP for EFE conservation from the WTP associated with avoiding human-elephant conflicts. Nevertheless, even if the policy does not succeed in preventing human-elephant conflicts, local demand for elephant conservation is likely to remain non-negligible. Indeed, considering the CFA 28,140 (€43) annual mean damage incurred by 27.7% of the sampled households, the net benefit for the overall

population in both the Tridom segments is CFA 3.73 billion (€5.68 millions). This finding suggests that the present benefits of the 10-year hypothetical scenario would be greater than the present value of crop damage caused by elephants. This result suggests that, conditional on the implementation of the hypothetical scenario, EFE conservation is socially beneficial. It may also indicate tolerance by farmers for the presence of EFE in their agricultural fields. Indeed, the underlying assumption of this result is that the 10-year hypothetical elephant conservation programme is effective in terms of both reducing poaching and preventing human-elephant conflicts, thus offsetting the damage faced by local people. A critical issue here is thus the ability of policy makers to cope with objectives that may be partially conflicting. Overlapping maps of social value with elephant density and human-elephant conflicts represent one way to proceed.

Biodiversity conservation solutions generally involve optimizing trade-off between land use activities and the natural habitat of fauna. Therefore, the issues of where habitat is needed and how it should be managed are at the core of the problem (O'Laughlin, 1998). The Tridom regional manager should proceed with the integration of elephant and large mammals in the national and international mobility corridor (see figure 3.4) in landscape land use planning. To enhance zero-conflict-oriented elephant habitats, corridors should be consistently placed relative to high elephant-concentration zones without crossing into zones with denser human populations. In (Figure 3.5), we propose to set some glades in protected area on the side of highly prevalent human-elephant conflict zones. We also propose an additional segment of the international corridor starting from the Ivondo National Park to Odzala Kokoua National Park via Mwagna National Park with some glades favoring elephant mobility within the natural habitat and far from communities.

The Tridom manager should devote additional effort to reducing poaching. The international standard for management of protected areas is "one eco-guard for 5,000 ha" (IUCN et UNESCO, 2006), while the ratio in the Tridom protected areas is one agent per 6,000 ha to 9,000 ha[7]. There is a need for recruiting and training 18 additional guards on average per protected area for a total of 160 guards, and providing them with convenient equipment and setting up surveillance infrastructure. Considering the average monthly wages (including bonus) of €100, this additional

[7]approximation from Rapac (2014)

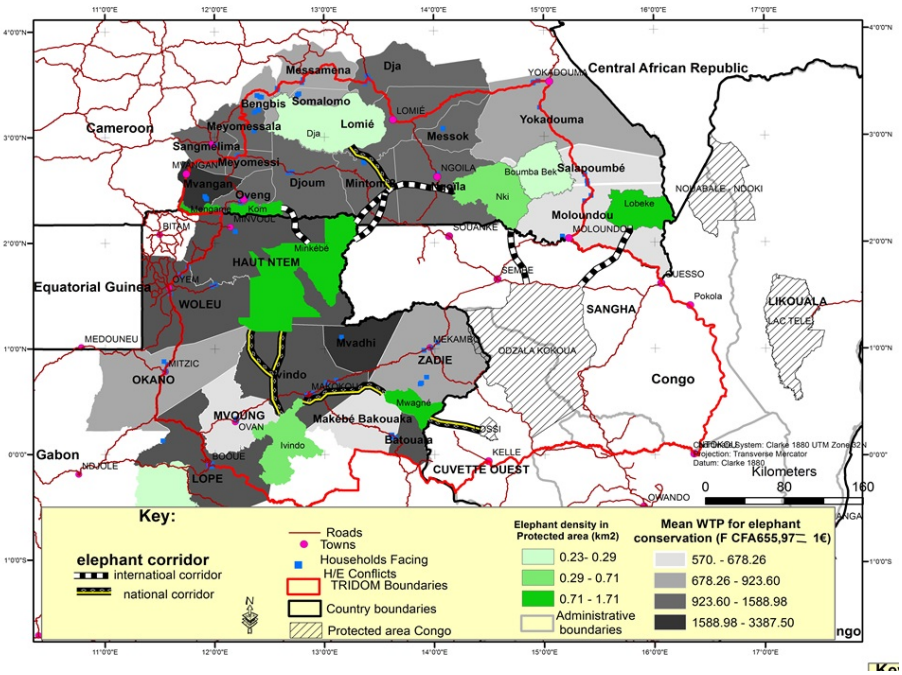

Figure 3.4: WTP, Human-elephant conflicts and corridor projects.

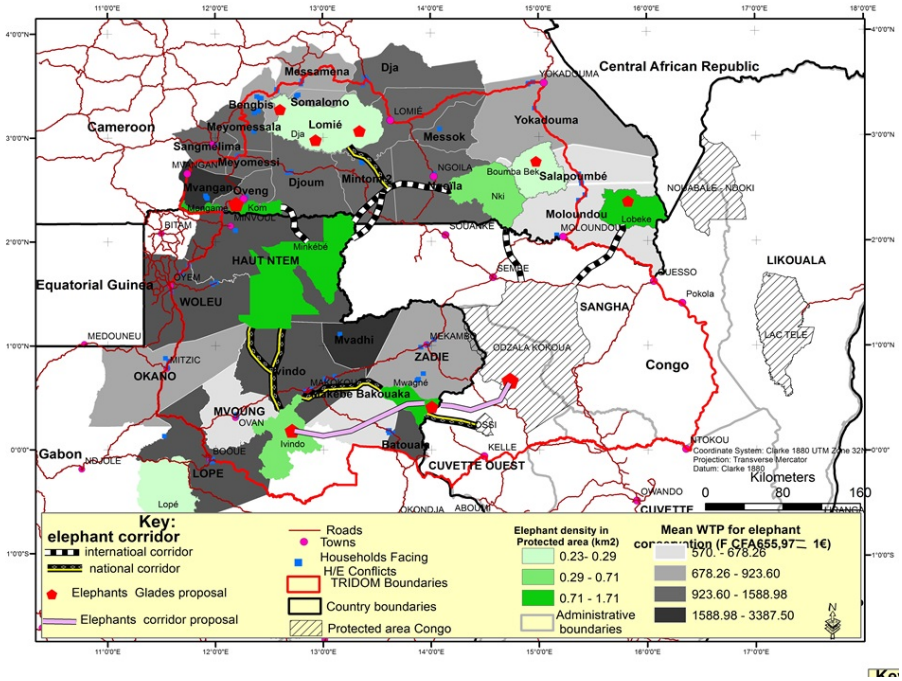

Figure 3.5: Glades proposition and elephants' mobility corridor modification proposition

effort equates to €1.64 million over the next 10 years and represents 12.4% of the social value. This additional staff would be employed to (1) create additional checkpoints in intensive poaching areas, such as Bengbis, Somalomo, Mouloundou, Ngoyla Mintom,

Ouésso and Ntam-Carrefour, and (2) create vehicle and foot transboundary patrols to strengthen cross-border cooperation for anti-poaching surveillance. As introduced in the hypothetical scenario, recruiting young people from the villages and involving them in anti-poaching communication networks remain feasible actions for improving EFE management, as they are low-cost actions relative to the social value of EFE (4%). Our results can also serve as the basis for determining optimal harvest rules for forest elephants while accounting for the social value of EFE in the social planner maximization programme. This important issue requires future research.

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General Conclusion

3.6 General Conclusion

What drives livelihoods strategies of rural households of developing regions? How do those strategies influence land-use choices and the willingness of local population to protect endangered species? The ambition of this thesis is to bring some elements of response on those important research questions.

Our work uses a unique households survey that we conducted for several months, interviewing more than 1000 households in the Dja-Odzala Minkebe Tri-national Transboundary Conservation Landscape (Tridom-TCL).. The database encompasses information on livelihoods strategies, income, and other socio-economic characteristics. It also bring information on the households past deforestation behavior. Finally, it has the unique advantage to present data from a choice experiment of protected forest elephant. In other word, the survey we collected presents the rare advantage to provide information on the links between livelihoods, deforestation and preference for biodiversity conservation.

Our contribution is multiple. First, we make a downstream assessment of the choice of livelihoods strategies and their impact on deforestation. Further, we analyze how households are influenced in their perception of wildlife conservation. Our study makes a strong emphasis on the need to analyze those choices taking into account spatial interactions. Indeed, we show that spatial spillovers may represent a strong part of the total effect of the investigated variables.

First, when it comes to livelihoods, we show that the autochthonous status has a strong influence on the choice of forest-based specialized strategies. We also find evidence that financial assets bring incentive for households to specialize in their main activity. It means that when households are less credit constraint, they tend to specialize, which can be good in terms of income and well-being, but this may be at the expense of larger deforestation. We finally show that people using forest-products

harvesting tend to deforest less, which let think that increasing the value of NTFP can be a way to protect tropical forests.

Second, we find indeed that households specializing in forest-based activities are the only ones not impacting deforestation. For all the other livelihoods strategies, an increase in family income leads to higher deforestation. This is especially true for strategies that include cash-cropping. Also, households with larger share of auto-consumption tend tu deforest less. Thus, when considering development in its whole process, increase of income, the rise of cash-cropping as an important activity, and market integration, appears to be three potentiel factors of deforestation.

Third, rural households appear to have significant willingness to pay for the protection and conservation of forest elephant in their neighborhood. Yet, this WTP is conditional on the fact that human-wildlife conflicts are avoided. However, in chapter 2, we find evidence that smaller damage costs are related to higher deforestation. Therefore, when implementing some conservation policy with the view to reduce conflicts between wildlife and rural households, it is very important to monitor land-use change and to let those households participate to the project in order to avoid a bump up in deforestation.

Overall, we find that livelihoods strategies are determined by autochtonous status, financial assets (money transfer and access to loan), distance to market and larger crop looses resulting from human-wildlife conflicts. Further, we show that livelihoods strategies are important for deforestation. Therefore, the commitments to reducing small-scale deforestation may be favored by a good consideration of factors that drive households' livelihoods strategies. We find out that spatial issues seems to be important. Proximity among households yields spatial shift effects and spatial spillover effects that are likely to amplify small-scale deforestation.

We also argue that, cross-cutting solutions towards a sustainable landscape considering these three side issues involve optimizing trade-off between households' livelihoods strategies, forest and the natural habitats of fauna. Therefore, the issues of community land security, of where natural habitat is needed and of how it should be managed are at the core of the problem. For example, decision-makers should proceed with the integration of large mammals mobility corridors far away from the community settlements in order to enhance zero-conflict-oriented elephant habitats; corridors should be consistently placed relatively to high elephant-concentration zones without crossing into zones with denser human populations.

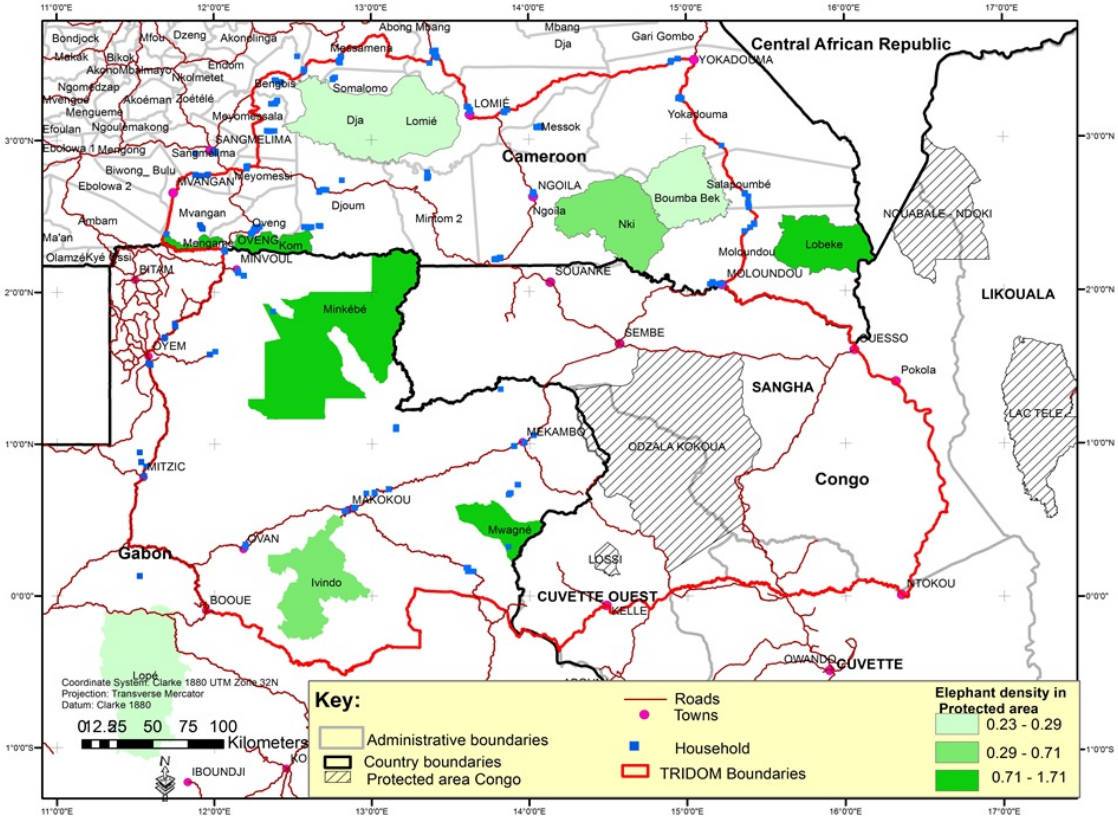
Many more work can be done using our household survey. For instance, risk preferences of households have been collected. It would be of great interest to get a better knowledge of the factors influencing rural households? behavior toward risk, and how their risk preferences relate to the use of natural resources is a key research question. The objective of such research is precisely to bring new evidence on (1) the factors explaining the rural households? attitude towards risk, (2) the impact of this attitude on land-use change and deforestation and on (3) preferences for multiple ecosystem services.

Appendix A

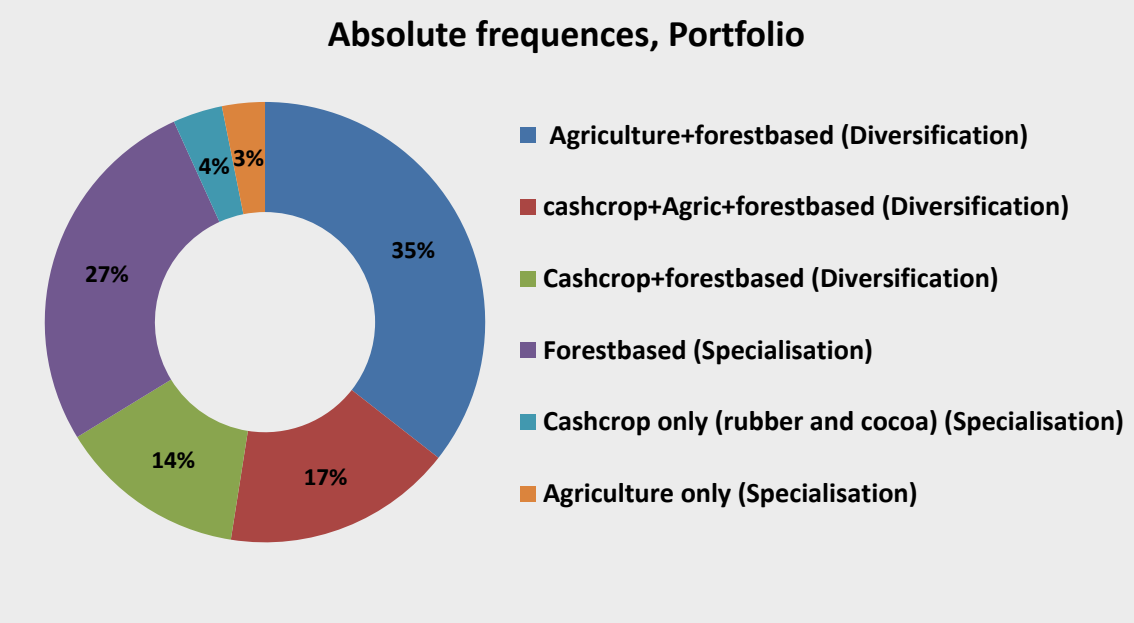
Appendix of chapter 1

A.1 Figures

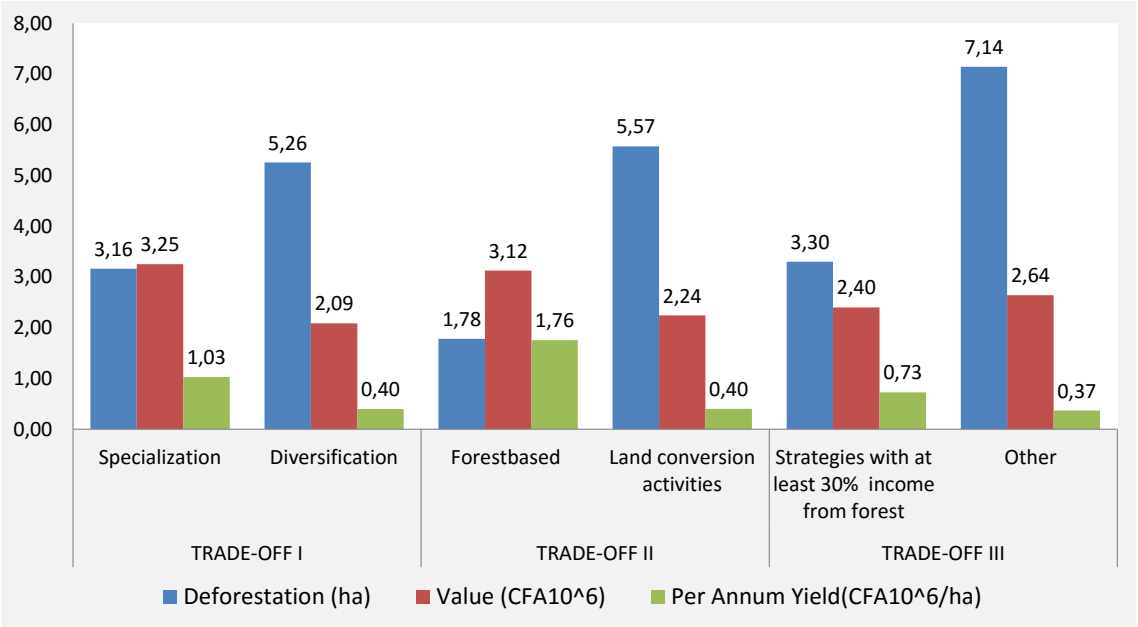
A.1.1 Study Area and Location of households surveyed



A.1.2 Absolute Frequencies of Households Strategies



A.1.3 Trade-offs in livelihoods, Deforestation and Per Annum Yiels/ha



A.2 Tables

A.2.1 Measurement of NTFP in the forest-based strategy

Scientific name	Vernacular name	Measure unit	Measure Conversion	Season (Months per year)	Conversion 12 pails
Ricinodendron Heudelotti	Ndjassang	5-liter pail	1 pail=7,5kg	2	1 bag=90kg
Gnetum africanum	Okok	packs	1 pack=2,5kg	12	
Irvingia Gabonensis	Peke/Ndo'o	5-liter pail	1 pail =4kg	2 - 3	1 bag=48kg
Elaeis guinensis	palm nuts	5-liter pail	1 =7,5kg	12	1 bag=90kg
Fungi	Edible mushroom	5-liter pail	1 pail=2,5kg	5	
Coula edulis	Noisettes	5-liter pail	1 pail = 6kg	2 - 3	1 bag=72kg
Garcinia kola	Bita Kola	5-liter pail	1 pail =7,5kg	3	1 bag=90kg
Cola acuminata	Cola spp	5-liter pail	1 pail = 10kg	3	1 bag= 120kg
Monodora myristica	Pepe/ndind	5-liter pail	1 pail = 5kg	3	1 bag=60kg
Pausinystalia johimbe, garcinia klaineana,	Bark	5kg	5kg	12	
Dacryodes edulis	Safout	5-liter pail	1 pail = 7,5kg	3	1 bag=90kg
Calameae	Rattan	bundle	KG		
Piper nigrum	sap	5-liter pail	1 pail = 6kg	12	1 bag=72kg
Raphia farinifera	Raphia	bundle			
Diospyros nigra	black fruits	5-liter pail	1 pail = 7,5kg	12	bag=90kg
Fagus	Fuelwood	bundle	1 bundle=25kg	12	
	Matango	liter		12	
Baillonella Toxisperme	Adjap moabi	liter			
Morinda	Ndong-Tondo	5-liter pail	1pail = 6kg	12	1 bag=72kg
Afrostyrax lepidophyllus.	Nguimba sihé	5-liter pail	1 pail = 5kg	3	1 bag=60kg

A.2.2 Descriptive statistique among various trade-off

PART I	Specification (n=333)				Diversification (n=654)			
	Mean	St Dv	Min	Max	Mean	St Dv	Min	Max
Country(1=Cameroon)	0.62	0.48	0	1	0.78	0.41	0	1
Age(continious)	47.81	15.42	16	90	48.77	14.18	17	90
Gender(1=Male)	0.75	0.43	0	1	0.78	0.42	0	1
Marit_single(1=Maried)	0.66	0.47	0	1	0.73	0.45	0	1
Hsize(continious)	5.27	3.65	0	20	7.12	4.04	0	19
CommunityGroup(1=yes)	0.22	0.42	0	1	0.31	0.46	0	1
Seniority(years in the vlge)	24.08	21.22	0	86	28.5	20.3	0	90
Autochbaka(1=pygmy)	0.08	0.26	0	1	0.04	0.19	0	1
Schoolcycl(1=2ndschool)	0.52	0.5	0	1	0.58	0.49	0	1
Landconflict.(1=yes)	0.17	0.37	0	1	0.18	0.38	0	1
Human_Wildlife(Damage cost)	0.76	1.56	0	8.33	0.55	1.39	0	8.33
Distance(in km)	30.67	23	0	94.54	28.6	22.34	0	94.55
Distance to Market (in km)	64.84	58.23	0	224.12	65.47	59.65	0	224.01
Finance_asset(CFAF/month)	11.67	52.34	0	750	7.12	17.28	0	170.83
PART II	Forest-based act. (n=266)				Land-Conversion (n=721)			
	Mean	St Dv	Min	Max	Mean	St Dv	Min	Max
Country(1=Cameroon)	0.6	0.49	0	1	0.78	0.42	0	1
Age(continious)	46.61	15.57	16	90	49.12	14.19	17	90
Gender(1=Male)	0.74	0.44	0	1	0.78	0.42	0	1
Marit_single(1=Maried)	0.62	0.49	0	1	0.74	0.44	0	1
Hsize(continious)	4.94	3.26	0	18	7.07	4.11	0	20
CommunityGroup(1=yes)	0.21	0.41	0	1	0.3	0.46	0	1
Seniority(years in the vlge)	22.76	20.71	0	86	28.58	20.5	0	90
Autochbaka(1=pygmy)	0.09	0.29	0	1	0.03	0.18	0	1
Schoolcycl(1=2ndschool)	0.49	0.5	0	1	0.58	0.49	0	1
Landconflict.(1=yes)	0.17	0.38	0	1	0.18	0.38	0	1
Human_Wildlife(Damage cost)	0.83	1.63	0	8.33	0.54	1.37	0	8.33
Distance(in km)	28.89	22.02	0	94.4	29.45	22.79	0	94.55
Distance to Market (in km)	63.55	57.73	0	224.12	69.13	61.14	0	224.01
Finance_asset(CFAF/month)	9.4	49.91	0	750	8.39	24.97	0	425
PART III	Strategies + Forest (n=666)				Other strategies (n=321)			
	Mean	St Dv	Min	Max	Mean	St Dv	Min	Max
Country(1=Cameroon)	0.69	0.46	0	1	0.81	0.39	0	1
Age(continious)	48.01	14.86	16	90	49.34	14.07	17	81
Gender(1=Male)	0.76	0.43	0	1	0.78	0.41	0	1
Marit_single(1=Maried)	0.66	0.47	0	1	0.79	0.4	0	1
Hsize(continious)	6.13	3.85	0	19	7.25	4.23	0	20
CommunityGroup(1=yes)	0.26	0.44	0	1	0.33	0.47	0	1
Seniority(years in the vlge)	26.2	20.75	0	90	28.7	20.57	0	80
Autochbaka(1=pygmy)	0.06	0.25	0	1	0.02	0.15	0	1
Schoolcycl(1=2ndschool)	0.53	0.5	0	1	0.63	0.48	0	1
Landconflict.(1=yes)	0.17	0.37	0	1	0.19	0.39	0	1
Human_Wildlife(Damage cost)	0.71	1.55	0	8.33	0.43	1.19	0	6.67
Distance(in km)	27.85	21.45	0	94.49	32.3	24.52	1.52	94.55
Distance to Market (in km)	58.65	56.81	0	224	68.14	59.36	0	224.12
Finance_asset(CFAF/month)	7.4	34.07	0	750	11.27	32.3	0	425

A.2.3 Standard Probit VS SAR-Probit

	Standard Probit Model			*SAR-Probit Model*				
	Estimates		Marginal effect	*Estimates*		*Direct effects*	*Indirect effects*	*Total effects*
Country	-0.4210	***	-0.1418	*-0.2464*	**	*-0.0813*	*-0.0465*	*-0.1278*
Age	0.0025		0.0008	*0.0038*		*0.0013*	*0.0008*	*0.002*
Gender	0.0180		0.0061	*0.0258*		*0.0085*	*0.0046*	*0.0132*
Marit_single	0.0604		0.0203	*0.0640*		*0.0212*	*0.0133*	*0.0345*
Hsize	-0.0596	***	-0.0201	*-0.0584*	***	*-0.0193*	*-0.0116*	*-0.0309*
Pygmee_employt	0.0098		0.0033	*0.0095*		*0.0032*	*0.002*	*0.0051*
CommunityGroup	-0.1440		-0.0485	*-0.1531*		*-0.0507*	*-0.0306*	*-0.0813*
Seniority	-0.0058	**	-0.0019	*-0.0056*	**	*-0.0018*	*-0.0011*	*-0.0029*
Autochbaka	0.4056	**	0.1366	*0.4552*	**	*0.1508*	*0.0915*	*0.2423*
Schoolcycl	-0.1045		-0.0352	*-0.0857*		*-0.0283*	*-0.0164*	*-0.0447*
Landconflict.	0.0733		0.0247	*0.0631*		*0.021*	*0.0128*	*0.0338*
Human_Wildlife	0.0476		0.0160	*0.0497*	*	*0.0165*	*0.0098*	*0.0263*
Distance	0.0032	*	0.0011	*0.0023*		*0.0008*	*0.0004*	*0.0012*
Distmarket	0.0016	**	0.0005	*0.0010*		*0.0003*	*0.0002*	*0.0005*
Finance_asset	0.0030	*	0.0010	*0.0036*	**	*0.0012*	*0.0007*	*0.0019*
ρ	-			*0.3620*	**			

A.2.4 results' accuracy with the weight matrix type

	Specialisation vs Diversification				
	Gabgrah	3NN	5NN	10NN	Distance
ρ	0.0501	0.2322***	0.2974***	0.3682***	0.3616**
AIC Criterion	1200.15	1194.85	1194.12	1190.58	1199.26
logLik.sarprobit	-584.07	-581.42	-581.06	-579.29	-583.63

A.2.5 Variance Inflation Factor

Variable	VIF	1/VIF
Age	1.56	0.64
Country	1.51	0.66
Seniority	1.40	0.71
Marit_single	1.30	0.77
Distmarket	1.26	0.79
Schoolcycl	1.22	0.82
Pygmee_employment	1.13	0.88
Autochbaka	1.13	0.89
Distance to nearest Protected Area	1.12	0.89
Hsize	1.09	0.92
Gender	1.09	0.92
CommunityGroup	1.08	0.93
Landconflict	1.05	0.95
Financial Asset	1.05	0.96
Human_Wildlife ConflictDamage cost	1.04	0.96
Mean VIF	1.20	

A.2.6 Correlation matrix among quantitative variables

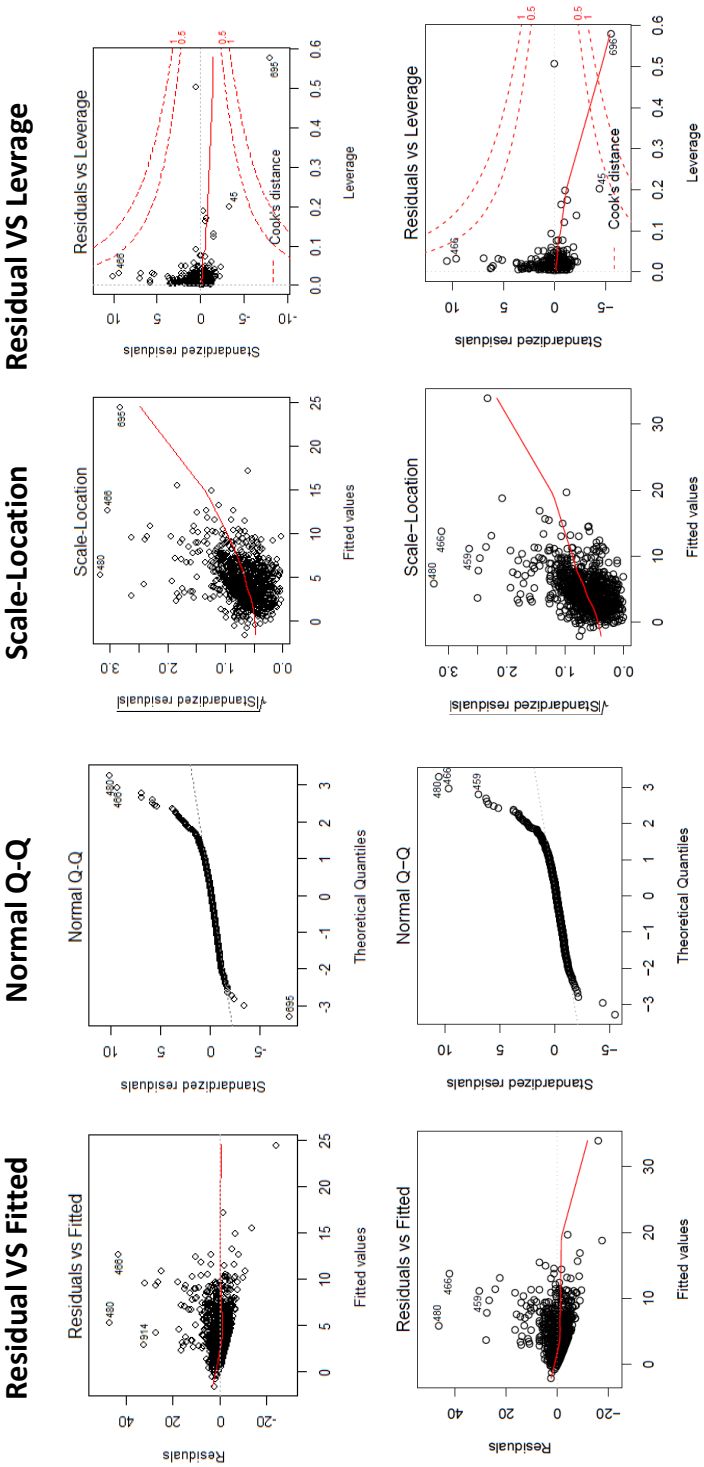
		v2	v7	v8	v11	v12	v13	v14	v15
Age	v2	1,00							
Hsize	v7	0,03	1,00						
Pygmee_employment	v8	-0,12	0,18	1,00					
Human-Wildlife ConflictDamage cost	v11	-0,03	-0,07	-0,03	1,00				
Seniority	v12	0,47	0,10	-0,01	-0,02	1,00			
Distance to nearest Protected Area	v13	0,10	-0,02	-0,03	0,00	-0,03	1,00		
Distmarket	v14	-0,13	-0,04	0,09	0,01	-0,02	-0,29	1,00	
Financial Asset	v15	0,03	0,03	0,00	-0,02	-0,10	0,06	-0,09	1,00

Appendix B

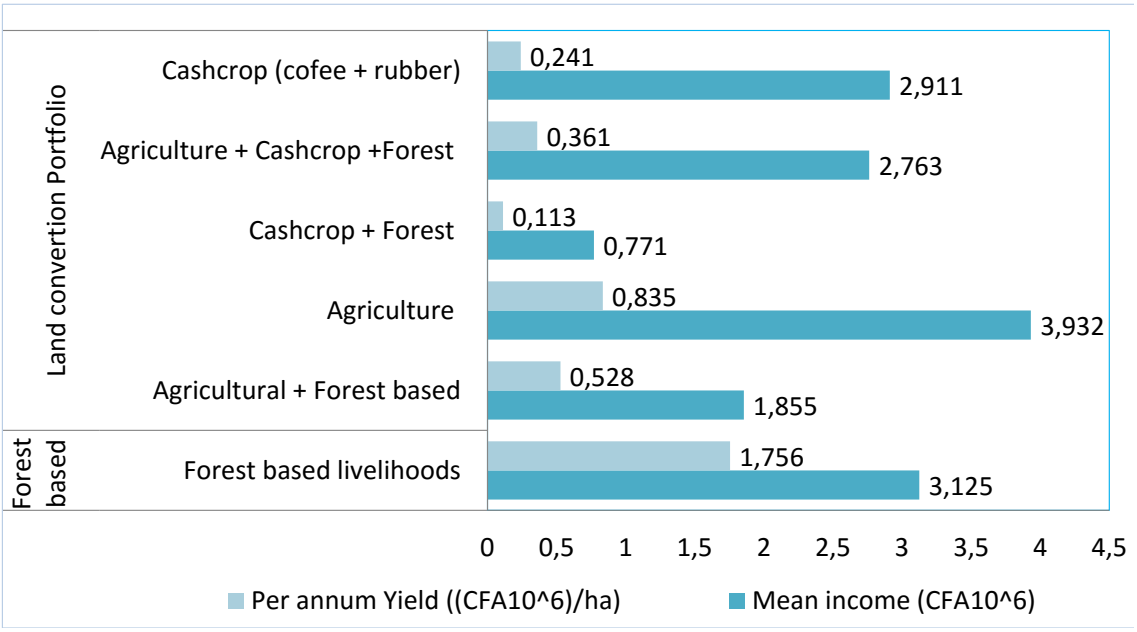
Appendix of chapter 2

B.1 Figures

B.1.1 Diagnostic Plots for Regression Analysis



B.1.2 Livelohoods Strategies and Per Annum Yiels/ha



B.2 Tables

B.2.1 Full Spatial Autoregressive Model

	SPATIAL AUTOREGRESSIVE FULL MODEL				
	Coef.	SD	z value		Pr(>|z|)
(Intercept)	-4,1857	2,2804	-1,8355	0,0664	*
AGENT'S DECISION PARAMETERS					
Income of households adopting diversification livelihoods' strategies (FCFA10^3)					
FamilyIncome_*ACF_households*	0,0101	0,0013	7,905	0	***
FamilyIncome_*AF_households*	0,0024	0,0012	2,0399	0,0414	**
FamilyIncome_*CF_CashcropForest*	0,0109	0,0021	5,326	0	***
Income of households adopting specialisation livelihoods' strategies (FCFA10^3)					
FamilyIncome_*F_Forestbased*	-0,0002	0,0004	-0,4287	0,6682	
FamilyIncome_*A_Agriculture*	0,0026	0,0012	2,2638	0,0236	**
FamilyIncome_*C_Cashcrop*	0,0178	0,0021	8,3798	0	***
Other decision variables					
Autocons_Share (% of total value)	-2,2003	0,7772	-2,8308	0,0046	***
Capital & factor constraints					
Finance_asset (FCFA10^3)	0,0089	0,0043	2,0988	0,0358	**
Landconflict Dummy (1=yes)	0,33	0,3763	0,8771	0,3804	
Human_Wildlife (FCFA10^3)	-0,2033	0,0978	-2,0785	0,0377	**
HOUSEHOLDS CHARACTERISTICS					
Gender (1=Male)	0,6824	0,3508	1,9451	0,0518	*
Age (continuous. in years)	0,0208	0,0121	1,7115	0,087	*
Ages_thr	-0,0014	0,0006	-2,2333	0,0255	**
Marit_single (1=Maried)	0,42	0,3485	1,2051	0,2282	
Hsize (continuous)	0,1582	0,0376	4,2037	0	***
Schoolcycl_2 (1=secondary school)	-0,1703	0,314	-0,5423	0,5876	
Autochbaka (1=Pygmy. 0=Bantou)	-0,5574	0,6761	-0,8244	0,4097	
Seniority (continuous. in years)	0,0391	0,008	4,859	0	***
CommunityGroup Dummy (1=yes)	0,524	0,3235	1,62	0,1052	
Pygmy_employement (coutinuous)	0,1518	0,0504	3,0118	0,0026	***
Labourduration	-0,0483	0,0319	-1,5107	0,1309	
CONTEXTUAL VARIABLES					
Country (1=Cameroun. 0=Gabon)	0,8112	0,4593	1,7661	0,0774	*
Distmarket Km	-0,0037	0,0029	-1,2952	0,1952	
Distance to P. Area (Km)	0,0006	0,0066	0,0903	0,928	
Biophysical factor					
Rainfall	0,0014	0,0014	0,9974	0,3186	
Rho (ρ)	0.1947	**			
Log Likelihood	-2849				
ML residual σ	4.350				
AIC Criterion	5754				
Wald Statistic	4.8115	**			
Observations	986				
residual autocorrelation	0.0728				

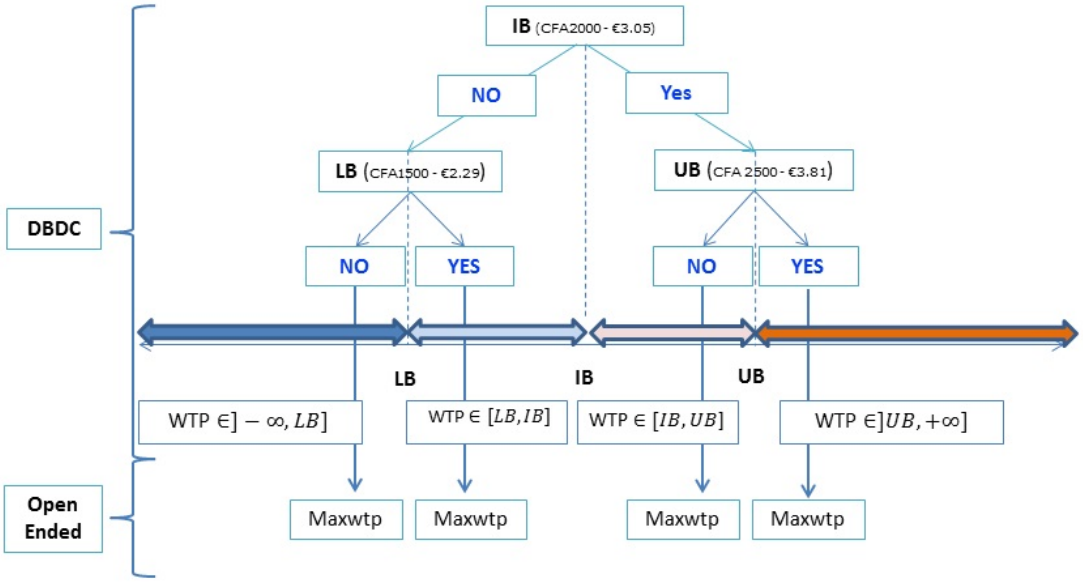
*, ** and *** = significance level at 1% 5% 10% respectively

Appendix C

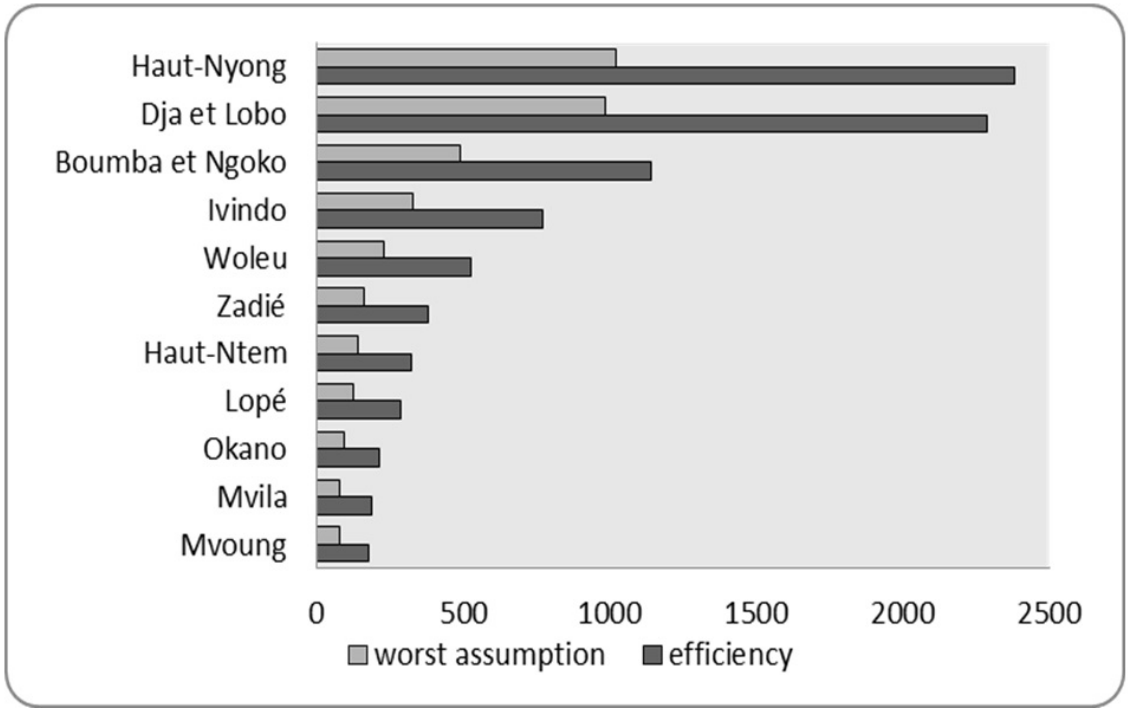
Appendix of chapter 3

C.1 Figures

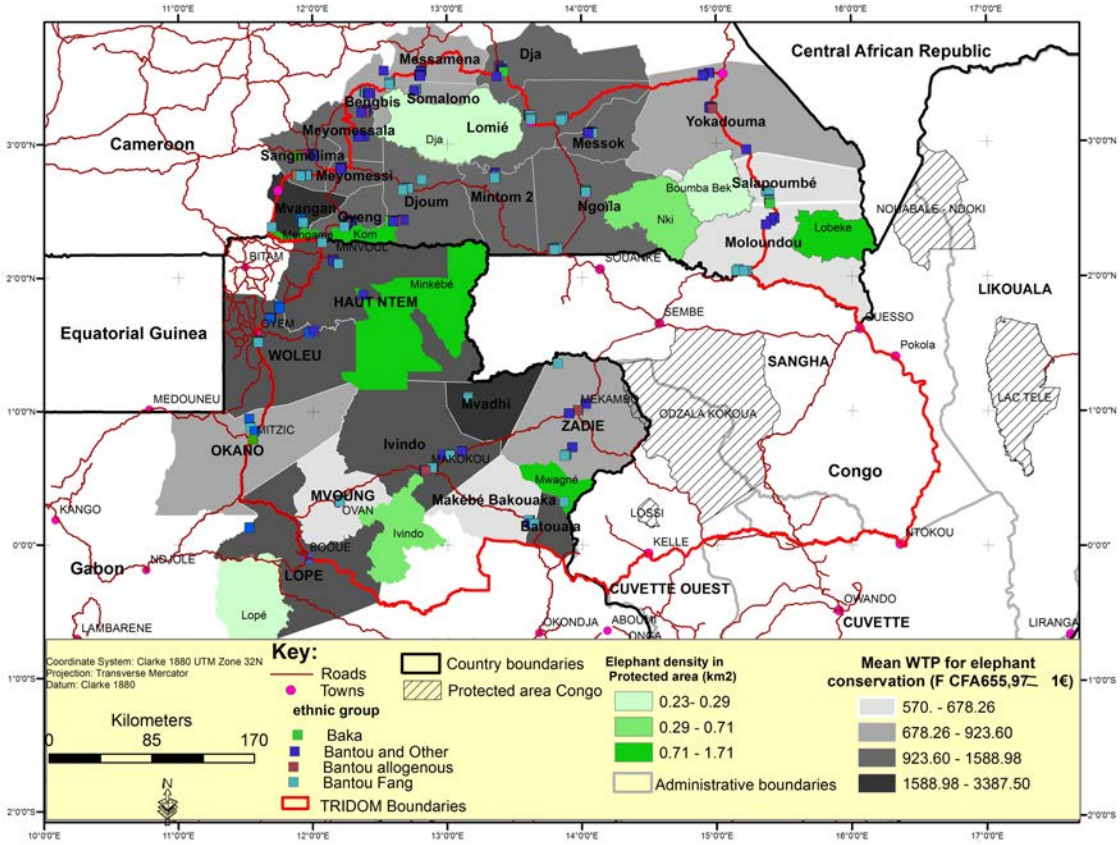
C.1.1 Bid structure



C.1.2 Aggregate WTP for elephant conservation of the local Tridom population (10^6* CFA).



C.1.3 Mean willingness to pay per subdivision and ethnic distribution(CFA).



C.2 Tables

C.2.1 Ethnic Representativeness (without protesters)

	Freq.	Perc.	Cum.
Baka	47	5.02	5.02
Fang-Beti-Bulu	369	39.42	44.44
Bangando	34	3.63	48.08
Kota et Bakota	64	6.84	54.91
Mahongwe	40	4.27	59.19
Kounabembe	20	2.14	61.32
Mvong Mvong et Mpumpong	22	2.35	63.68
Djem	65	6.94	70.62
Badjoue	66	7.05	77.67
Migration, Yambassa, Bamoun...	59	6.30	83.97
Nzime	61	6.52	90.49
Other ethnic groups (20)	89	9.51	100.0
Total	936	100.00	

C.2.2 Spatial Representativeness

	Division	Subdivision	Freq.	Perc.	Cum.
CAMEROONIAN SEGMENT					
South	DJA ET LOBO	Sangmelima	47	5.02	5.02
		Meyomessala	53	5.66	10.68
		Bengbis	22	2.35	13.03
		Meyomessi	27	2.88	15.91
		Djoum	48	5.13	21.04
		Oveng	33	3.53	24.57
		Mintom	17	1.82	26.39
	MVILLA	Mvangan	20	2.14	28.53
Est	HAUT NYONG	Ngoyla	58	6.2	34.73
		Lomie	52	5.56	40.29
		Messamena	32	3.42	43.71
		Somalomo	43	4.59	48.3
		Dja	32	3.42	51.72
		Messock	43	4.59	56.31
	BOUMBA ET NGOKO	Mouloundou	46	4.91	61.22
		Yokadouma	50	5.34	66.56
		Salapoumbe	25	2.67	69.23
GABONESE SEGMENT					
Ogooue Ivondo	IVINDO	Makokou	29	3.1	72.33
		Batouala	20	2.14	74.47
		Mvadhi	14	1.5	75.97
		Makebe Bakouaka	20	2.14	78.11
	LA ZADIE	Mekambo	42	4.49	82.6
	LA LOPE	Booue	30	3.21	85.81
	LA MVOUNG	Ovan	19	2.03	87.84
Woleu Ntem	HAUT-NTEM	Minvoul	35	3.74	91.58
	WOLEU	Oyem	56	5.98	97.56
	OKANO	Mitzic	23	2.46	100
	Total		936	100	

Appendix D

Questionnaire

426

(V)

C

UNIVERSITE DE YAOUNDE
UNIVERSITE DE LORRAINE

ENQUETE SUR L'ANALYSE SOCIOECONOMIQUE ET ECOLOGIQUE DES AFFECTATIONS ET DES UTILISATIONS DES TERRES FORESTIERES DANS LE COMPLEXE TRANSFRONTALIER DU TRINATIONAL DU DJA-ODZALA-MINKEBE (TRIDOM)- BASSIN DU CONGO

QUESTIONNAIRE - MENAGES

Madame, Mademoiselle, Monsieur, Bonjour / Bonsoir

Je me nomme DGOLONG Daniel, Je participe à une enquête sur ***l'Analyse Socioéconomique et Ecologique des Utilisations des terres forestières dans le Complexe Tridom.*** Les réponses fournies sont strictement confidentielles et seront analysées pour la rédaction d'une thèse de doctorat. Cette thèse a pour but de réfléchir sur un schéma d'aménagement optimal qui intègre à la fois les préoccupations sociales, économiques et celles de conservation de la biodiversité à l'échelle du paysage Tridom.

Je vous prie de bien vouloir m'accorder un peu de votre précieux temps pour répondre à quelques questions.

En vous assurant de la confidentialité de vos réponses, nous vous remercions d'avance pour votre accord.

LOCALISATION DE L'ENQUETE

Enquêté :.....M.....Tel.....

Heure de début :..8h35..... Heure de fin :.....11h..... Durée :..2h25....

Localisation de l'Enquêté

Pays	Pays d'origine	Région/province d'origine[1]	Région/ Province[1]	Département[2]	Arrondissement/**Commune**[3]	Canton	Village
01 : Cameroun	01		03	04	14	Nzimé	Mbang Mbang
02 : Gabon							
03 : Congo							

Coordonnées GPS du ménage

Code	signification	X	Y	Z	observations
Menagn°.....	Coordonnées ménage	33N0397814	0340233	640	
HVCtomb.....	Sépulcre	33N0397828	0340255	645	
Vivrmenn°.....	Agriculture vivrière	33N0397356	0339963	608	
Cacmenn°.....	Cacaoyère/caféière				
Conflit.....	Zone de conflit				
Vpalmen°	Zone vin de palm				

[1] Codes Régions :
Cameroun : 01= Adamaoua, 02=Centre, 03=Est, 04=Extrême Nord, 05=Littoral, 06=Nord, 07=Nord Ouest, 08=Ouest, 09=Sud, 10=Sud Ouest
Gabon : 01= Estuaire, 02=Haut-Ogooué, 03=Moyen-Ogooué, 04=Ngounie, 05=Nyanga, 06=Ogooué-Ivondo, 07=Ogooué-Lolo, 08=Ogooué-Maritime, 09=Woleu-Ntem
Congo : 01= Bouenza, 02=Cuvette, 03= Cuvette-Ouest, 04= Kouilou, 05= Lékoumou, 06= Likouala, 07= Niari, 08= Plateaux, 09= Pool, 10= Sangha 11 = Brazzaville, 12= Pointe-Noire
[2] Codes Départements
01=Mvilla, 02=Dja et Lobo, 03=Boumba et Ngoko, 04=haut nyong
[3] Codes Arrondissements
01=Sangmelima, 02=Meyomessala, 03=Bengbis, 04=Meyomessi, 05 =Djoum, 06=Oveng, 07= Mintom, 08= Mvangan, 09=Ngoyla, 10=Lomié, 11=Dja, 12=Messamena, 13=Somalomo, 14= Messock, 15= Gari gombo, 16=Mouloundou, 17=Yokadouma, 18= Salapoumbé,

PARTIEI : LES DETERMINANTS DES CHOIX D'UTILISATIONS DES SOLS / CONVERSION DES SOLS

	I.1. Caractéristiques socioéconomiques du ménage		Aller à
q.1	Répondant : qu'elle est votre position dans le ménage ? 01= Chef de ménage/ 02.= Epoux (se) / 03= Enfant / 04= Autre (à préciser).....	⌊_⌋⌊_⌋	
q.2	Quel est votre sexe : 01= Masculin / 02 = Féminin.....	⌊_⌋⌊_⌋	
q.3	Quel est l'âge du chef de ménage ? ...64 ans.....	⌊_⌋⌊_⌋	
q.4	Quelle est votre langue maternelle ? : 01= Beti/Boulou/Fang , 02=Yambassa =, 03= bamiliké, 04=Bamoun, 05= anglophone, 06= Nzimé/ Dzimon, 07= Baka, 08= Maka, 09= haoussa, 10=Gbanzili, 11= Ndjèm, 12=Bikélé, 13=Boman, 14=Essel, 15=, 16= Medjime, 17=Konabembé, 18=Mbimon, 19=Bangatou, 20=Mombo 21= Kikongo, 22=Ubangui, 23= Omvang/Bobilis/Bamvelé, 24= Badjoué, 25=lingala, **26= Haoussa, 27=Tikar, 28**=autre	⌊_⌋⌊_⌋	
q.5	Quelle est votre religion : 01= Protestante 02= Catholique 03=Pentecôtiste 04=Témoins de Jéhovah ; 05=Adventiste 06 =Musulman 07=Animiste **08=Batiste ; 09**=Autre (à préciser)	⌊_⌋⌊_⌋	
q.6	Où réside le chef du ménage auquel vous appartenez ? 01= Au village ; 02 = en ville (préciser)	⌊_⌋⌊_⌋	
q.7	Quel est votre statut matrimonial : 01= Marié(e) monogame; 02= Marié(e) polygame (nombre de femmes....); 03= Célibataire; 04 =Veuf/Veuve; 05=Divorcé(e)	⌊_⌋⌊_⌋	
q.8	Vivez-vous en couple ? 00=non, 01= oui	⌊_⌋⌊_⌋	
q.9	Combien de personnes vivent dans votre ménage ? 3	⌊_⌋⌊_⌋	
q.10	Combien de vos enfants non mariés vivent en dehors du village ? 0		
q.11	Durant les dix dernières années, combien avez-vous eu de : 01 = décès (...0.1...), 02=naissance (...02..), 03=départ (...0.1...), 04=arrivée (...01...), 05=autres.....		
q.12	Avez-vous été scolarisé? 01 = Oui / 00= Non,.....	⌊_⌋⌊_⌋	Si 00, aller à Q15
q.13	Quel est votre dernier cycle fréquenté ? 01= primaire/ 02= secondaire/ 03= supérieur	⌊_⌋⌊_⌋	
q.14	Quel est votre dernier diplôme obtenu ? 00=aucun, 01=CEP 02=BEPC/CAP, 03=Probatoire, 04=BAC, 05=Licence et plus	⌊_⌋⌊_⌋	
q.15	êtes-vous salarié? 01 = Oui ; 00= Non,.....	⌊_⌋⌊_⌋	Si 00, allez à Q20
q.16	Dans quelle entreprise travaillez-vous? 01=concession forestière; 02=concession minière; 03=agriculture industrielle; 04=Administration forestière; 05= Secteur publique Hors Administration forestière; 06=pour le compte d'un ménage, 07=Elevage, 08=Commerce, 09 artisan, 10=chômeur, 11=conducteur/transporteur, 12=Autre (préciser).....		
q.17	Quelle est votre catégorie socioprofessionnelle? 01=Manœuvre, 02=Ouvrier, 03=Ouvrier qualifié, 04=Agent de maîtrise 05=Cadre 06=Cadre Supérieur 07=retraité	⌊_⌋⌊_⌋	
q.18	Dans quel intervalle se situe votre salaire (allocation retraite) mensuel en CFA? 00= moins de 15000, 02= entre 15000 et 30000, 03 = entre 30001 et 50000, 04 = entre 50001 et 100000, 05 = entre 100000 et 150 000, 06 = entre 150 001 et 250000, 07=entre 250001 et 350 000, 08= plus de 350001	⌊_⌋⌊_⌋	
q.19	Etes-vous affilié à la Caisse Nationale de Prévoyance Sociale ? 00= Non/ 01 = Oui/ 02=Je ne sais pas		
q.20	Quelle est votre activité principale? 00 = Aucune, 01 = Cacao culture, 02 = Agriculture vivrière, 03 = cueillette/PFNL , 04= élevage, 05 = Pêche, 06 = orpaillage traditionnelle, **07 = Chasse**, 08 = Employé Foresterie Communautaire, 09 = Employé concession forestière, 10 = Employé concession minière, 11 = administration forestière, 12 = Autre admin, 13 = transporteur, 14 = restauration, 15= Commerçant, 16= Essarteur-chasseur, 17= Essarteur-cultivateur, **18= Employé Foresterie communale, 19= autre (préciser) .....**	⌊_⌋⌊_⌋	
q.21	Combien d'heures travaillez-vous par jour dans le cadre de votre activité principale ? 8 h.	⌊_⌋⌊_⌋	
q.22	Quelle est votre activité Secondaire (plusieurs réponses sont possibles)? 00 = Aucune, 01 = Cacao culture, 02 = Agriculture vivrière, 03= Chasse-cueillette/PFNL , 04= élevage, 05 = Pêche, 06 = orpaillage traditionnelle, 07 = Employé Foresterie communale, 08 = Employé Foresterie Communautaire, 09 = Employé concession forestière, 10 = Employé concession minière, 11 = administration forestière, 12 = Autre admin, 13 = transporteur, 14 = restauration, 15= Commerçant, 16= Essarteur-chasseur, 17= Essarteur-cultivateur, 18=Viticulture, 19=Pisciculture, 20==autre (préciser) .....,	⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋ ⌊_⌋⌊_⌋	
q.23	Combien d'heures travaillez-vous par semaine dans le cadre de votre activité secondaire ? 8 h.		
q.24	Combien de personnes extérieures à votre ménage recrutez-vous en moyenne par an pour vous assister dans vos activités (agricoles, chasse, ...)? 00=aucune ; 01= ...3.	⌊_⌋⌊_⌋	Si 00, allez à Q26

q.25	Quel est l'équivalent monétaire la rémunération de cette main d'œuvre par mois?....333.....		
q.26	Combien dépensez-vous en moyenne par mois pour vous nourrir, vous vêtir, vous loger, vous éclairer?.....150m f.....		
q.27	Approximativement à combien était le revenu total de tous les membres de votre ménage le mois dernier (CFA) 00= moins de 15000, 02= entre 15000 et 30000, 03 = entre 30001 et 50000, 04 = entre 50001 et 100000, 05 = entre 100000 et 150 000, 06 = entre 150 001 et 250000, 07=entre 250001 et 350 000, 08= plus de 350001	⌊_⌊_⌋	
q.28	êtes-vous satisfait de votre niveau de vie? 01= Pas du tout 02 = Pas très satisfait 03= Assez satisfait 04= Très satisfait	⌊_⌊_⌋	
q.29	avez-vous un compte d'épargne ? 01=ui, 00=non	⌊_⌊_⌋	
q.30	Où est-il logé? 01=dans une Micro finance, 02=dans une Banque, 03=tontine/**association**, 04= autre...famille restée	⌊_⌊_⌋	
q.31	Quel montant avez-vous emprunté l'année dernière pour financer votre activité? 00=aucune, 01=……..		Si 00, allez à Q34
q.32	Auprès de qui effectuez-vous vos prêts d'argent? 01= Micro finance, 02=Banque, 03=tontine, **04 = Ami/famille, 05=un particulier, 06=autre**……	⌊_⌊_⌋	
q.33	Avez-vous toujours procédé au remboursement des sommes prêtées dans les délais? **01=Oui, 00=non**	⌊_⌊_⌋	
q.34	Durant l'année 2013, avez-vous reçu un transfert d'argent d'un ami ou d'un membre de votre famille résidant hors de votre village? 01= Oui ; 00= Non,……	⌊_⌊_⌋	Si 00, allez à Q36
q.35	Combien avez-vous reçue durant les 12 derniers mois?.....5 Mm f.....		
q.36	Vous arrive-t-il d'expédier de l'argent à un membre de votre famille ou à un ami? 01 = Oui ; 00= Non,……	⌊_⌊_⌋	Si 00, allez à Q38
q.37	En 2013 quelle somme d'argent avez-vous en tout expédié ?.....150Mf.....		
	I.2. Autochtonie et appartenance tribale		
q.38	Est-ce que vos parents ont vécu dans ce village ? 01 = Oui ; 00= Non,……	⌊_⌊_⌋	
q.39	Depuis combien d'années êtes-vous installés dans ce village ?.....13 ans.....	⌊_⌊_⌋	
q.40	Etes-vous autochtones de ce village ? 01 = Oui ; 00= Non,……	⌊_⌊_⌋	
q.41	Quel est votre groupe ethnique? 01= Baka 02= Mbenzele/Benjelle 03= Babinga 04= Fang-Béti-Bolou -**Ewondo**, 05= Maka, 06 = Bangando, 07 = Zaman, 08=Kota, 09=Makina, 10=Mahongwe, 11= Bakoya , 12=Bangombe, 13=Bibayack, 14=Mboman, 15=Mbimo ; 16=Kako, 17=Kounabembe, 18=Mvong Mvong, 19=Djem, 20=Badjoué, 21=Medjime, 22=yambassa, 23= Dzimon, 24=Essel, 25=Bikélé, 26=Bangato, **27=Fong, 28= Haoussa ; 29= Tikar, 30**=autre, préciser ..08...Ngimé	⌊_⌊_⌋	
q.42	Quel est le groupe ethnique de votre conjoint? 01= Baka 02= Mbenzele/Benjelle 03= Babinga 04= Fang-Béti- Bolou -**Ewondo**, 05= Maka, 06 = Bangando, 07 = Zaman, 08=Kota, 09=Makina, 10=Mahongwe, 11= Bakoya , 12=Bangombe, 13=Bibayack, 14=Mboman, 15=Mbimo ; 16=Kako, 17=Kounabembe, 18=Mvong Mvong, 19=Djem, 20=Badjoué, 21=Medjime, 22=yambassa, 23= Dzimon, 24=Essel, 25=Bikélé, 26=Bangato, **27=Fong, 28= Haoussa ; 29= Tikar, 30**=autre..08...Ngimé	⌊_⌊_⌋	
q.43	Quel est le nombre de Baka qui travaille pour votre compte ? 00=aucun, 01=un, 02=deux, 03= trois, 04= autre……..	⌊_⌊_⌋	
q.44	Quel est l'équivalent monétaire la rémunération de cette main d'œuvre par mois?.....333.....		
	I.3. Propriété foncière et Nature de propriété foncière et utilisations des terres forestières		
q.44	Avez-vous le droit de convertir une petite partie de la forêt vierge pour pratiquer l'agriculture ? 00= Non/ 01 = Oui/ 02=Je ne sais pas	⌊_⌊_⌋	
q.45	Que faites-vous des produits que vous ramassez dans la forêt ?		

	PFNL	bois	gibiers
00= je ne ramasse pas, 01= nous consommons, 02=nous consommons et nous vendons le reste, 03= nous vendons uniquement, 04=Autre……	03	02	04

q.46	Avez-vous le droit de vendre une partie des produits ramassés récoltées ou prélevés dans la forêt ? 01=Oui, 00=Non, **02=Je ne sais pas**		
q.47	Avez-vous le droit de donner ou de vendre une partie de vos terres à quelqu'un du village? 00= Non/ 01= Oui/ 02=Je ne sais pas	⌊_⌊_⌋	
q.48	Que souhaiteriez-vous faire de vos terres à votre vieillesse? 01=vendre, 02=louer, 03=léguer aux enfants, 04=autres préciser……	⌊_⌊_⌋	
q.49	Combien de parcelle de terres (champs) avez-vous aujourd'hui ? 00=aucun, 01=…..20……	⌊_⌊_⌋	Si 00, allez à Q54

Quelle est la superficie de l'ensemble de vos champs ? ...8,5..... ha

q.50 Quelqu'un mène t-il des activités agricoles dans votre ménage? 00= Non/ (01)= Oui

q.51 Veuillez décrire dans le tableau ci-dessous les pratiques d'utilisation de chacune de vos parcelles de terres

N°	Quelle est l'année d'acquisition ?	Quel a été le mode d'acquisition 01= Achat 02= héritage 03= défrichage (brulis) 04= location 05= don 06= admin foncière	Superficie M²	Quel était le coût d'acquisition (au m²) ?	Avez-vous un titre foncier ? 01 = Oui 00= Non	Avant de commencer votre activité, de quel type de terres était votre champ ? 01=Forêt, 02=agriculture, 03=jachère 04=autre…	Durée de Jachère	Distance au village en Min	Quel est le volume de production et de vente des spéculations suivantes ? (Mettre les numéros et préciser les quantités pour chaque parcelle) 01 : Cacao (sac) 02 : Café (sac) 03 : huile de palme (litre) 04 : Banane/plantain (régime) 05 : Manioc (sac) 06 : Mais (sac) 07 : arachide (sac) 08 : ananas, 09 : macabo (sac) 10 : légumes filets 11 : **Noix de palme (sac)** **12 : Mangues (sac) 13 : Igname (sac) 14 : Papaye 15 : Piment (sac) 16 : Avocat (Sac) 17 : Hévéa (Litres) 18 : Concombre (Sacs) 19 : Tomate (kg) 20 : Gombo (Sac) 21 : Safout (Filets) 22 : Patate 23=orange**								Coordonnées GPS
									N°07			N°....			N°...		
									Pdct	Vte	PU	Pdct	Vte	PU	Pdct	Vte	PU
1	1990	02	2	1,75	00	04		40	3	3	72500						
2	2006	03	1	1,15	00	02		20	40	20	1000	5	1	1500	2	0	10000
3	2008	03	1	0,9	00	02		20	40	20	1000	6	1	1500	2	1	10000
4	2010	03	0,5	0,3	00	02		10	4	1	1500	1	0	10000			
5	2013	03	0,5		00	02		20	4	1	1500	1	0	10000	1	0	
6																	

Superficie mesurée au GPS

q.52 Si on vous apprenait une nouvelle technique culturale qui permette d'intensifier la production, de produire plus de quantité qu'aujourd'hui en utilisant un champ de moins, accepteriez-vous ? 00=Non, (01)=Oui, 02=Je ne sais pas

q.53 Dans quels types de marché vendez-vous vos produits ? 01=marché local, 02=marché urbain, 03=exportation, 04=autre (précisez)…….. …… (01) |__|__|

q.54 Combien de parcelles (champs) avez-vous vendues durant les dix dernières années ? 00=aucune, 01=…… (00) |__|__| Si 00, allez à Q56

q.55 Veuillez décrire dans le tableau ci-dessous les parcelles que vous avez déjà cédées ou prêtées

N°	Quelle était le mode de transfert ? 01=location 02=vente 03=héritage 04=don 05=autre ……	Surface (ha)	Quel est le prix de vente (à l'hectare) ?	En quelle année l'aviez-vous transférée ?	Aviez-vous un titre foncier avant le transfert? 01 = Oui 00= Non	Avant de commencer votre activité, de quel type de terres était votre parcelle ? 01=Forêt, 02=agriculture, 03=jachère 04= autre……	Distance au village en Min
1							
2							
3							

q.56 Veuillez nous fournir quelques informations sur les intrants que vous avez utilisés les 12 derniers mois

	Brouette (nbre)	Hache (nbre)	Lime (nbre)	Sac (nbre)	**Houes**	**Tronçonneuse**	Rateaux	Pirogue (nbre)	Coupe-coupe (nbre)	Moto (nbre)	Autre ……	Semences Coût (CFA)	Engrais Coût (CFA)	**Fingicide, Herbicide** Coût (CFA)	Tracteur Coût (CFA)	Traction animale Coût (CFA)
Quantité	0	1	2	0	4	0	0		3	0						
Prix		500	1000		1000				1500			0	0	0		

q.57 Appartenez-vous à une association ou groupement de producteur? (01) = Oui ; 00= Non,… |__|__| Si 00, allez à Q59

q.58 De quel type de groupement s'agit-il? 01=Association de producteurs agricole, 02=GIC/GIE, 03=autre…… |__|__|

GIC CACAO

Utilisations de terres à propriété commune

q.59 Quelle quantité de produits avez-vous tirée de la forêt durant le mois derniers?

Produits de forêt	2013 Qté produite par an (KG)	Qté Conso par an (KG)	Qté vendue par an (KG)	Temps de récolte (Jrs par mois)	Prix de vente unitaire (CFA/Kg)	Bien vouloir inscrire le numéro correspondant au lieu de récolte 01= Forêt communaut/Communale 02= Concession forestière 03= Zones de chasse (cyn, com) 04= Aires Protégées 05= vos champs agricoles 06= forêt vierge 07=jachère 08=Autre…marécage	Technique de récol 01=ramassage 02=écorçage 03=défrichage 04=cueillette 05=abattage 06=Achat 07= autre ……
Okok (**paquets de 2.5 kg**) 12 mois							
Ndjassang (seau 5litres⇔7.5kg) 2 mois/an; 12seaux de 5l = 1 sac=90kg	0	02	0		833		06
peke /Ndo'o (seau 5litres⇔4kg) ; 2-3mois 12seaux de 5l = 1 sac=48kg	0	0	0				
Noix de palm (seau 5litres=1Régime=7.5kg) 12 mois ; 12seaux de 5l = 1 sac=90kg,	48	48	0	2		05 07	04
Champignon (seau de 5litres=2,5 kg) ; 5mois	12,5	12,5	0	26		06	01
Noisettes (seau de 5litres 6 kg) ; 2-3mois 12seaux de 5litres = 1 sac=72kg	0	0	0				
Bita kola (seau de 5litres=7,5kg) ; 3mois 12seaux de 5l = 1 sac=90kg	0	0	0				
Cola spp (seau de 5 litres=10kg), 3mois 12seaux de 5l = 1 sac=120kg	6	6	0	7		06	01
Pepe/nding (seau de 5 litres=5 kg), 3mois 12seaux de 5l = 1 sac=60kg	0	0	0				
Ecorce (5kg)	10	10	0	2			
Safout (seau 5litres=7.5kg) 3 mois ; 12seaux de 5l = 1 sac=90kg,							
Rotin (paquet/fagot, **Kg**)	10	10	0			09	05
Poivre ; (seau 5litres=6kg) 12 mois ; 12seaux de 5l = 1 sac=72kg,	0	0	0				
Raphia (fagots)	0	0	0				
Fruits noirs (seau 5litres=7.5kg) 12 mois ; 12seaux de 5l = 1 sac=90kg,	0	0	0				
Bois de feu (1hôtte = 25 kg)	1300	1300		4		05 02 06	01,05
Vin de palm(Litres)	1304	312	992	30	150	05 02	04
Adjap/moabi (litres d'huile)	0	0	0				
Ndong, Tondo (seau 5litres=6kg) 12 mois ; 12seaux de 5l = 1 sac=72Kg,	0	0	0				
Nguimba sihé (seau de 5 litres=5 kg), 3mois 12seaux de 5l = 1 sac=60kg	0	0	0				
Autre…Vin…de…raphia	800	100	700	20	150	09	04
Autre ……							

Combien de fois visitez-vous vos pièges par semaine ? 7

Combien de personne tendent les pièges dans votre ménage ? 1

Parmi les gibiers suivants, les quels parvenez-vous à attraper dans vos pièges ? **00=aucun** ; 01= Céphalophes/biches, 02= Porc-épic (1unité = 7kg en moyenne) ; 03= Singes ; 04=Chenilles ; 05= serpent; 06=**Rat palmiste**; 06= Pangolin ; 07=Babouin ; 08=Civette ; 09=Potamo/Hylochère ; 10=oiseaux/Pigeon ; 11=lièvre ; 12=Ecureuil ; 13= **hérissons, 14=Sanglier, 15=antilope**, 16=autre……

Produits de faune	Quelle est la quantité chassée Nbre	(kg)	Quelle est la quantité Conso par an (kg)	Quelle est la quantité vendue (Kg)	Temps de chasse (Jrs par mois)	Prix de vente unitaire (CFA)	**Bien vouloir inscrire le numéro correspondant au lieu de récolte** **01= Forêt communaut/Communale** **02= Concession forestière** **03= Zones de chasse (cyn, com)** **04= Aires Protégées** **05= vos champs agricoles** **06= forêt vierge** **07=jachère** **08=Autre……**	Technique de chass (plusieurs réponses) 01=câble 02=fusil 03=lance **04=achat** **05=utre ……ramassage**
Céphalophes/biches	0		6	0				04
Porc-épic (1unité = 7kg en moyenne) (1kg)	1	16	16	0			05 02	01
Eléphant (consommation)								
Chenilles : (seau 5litres⇔4kg) 12mois		10	10	0				05
Singes	0	0	10	0				01
Rat palmiste-hérisson (Aulacodes (5kg)	10	50	50	0		500	05 02	01
Pangolin (4kg)	3	12	12	0			06	05
Civette	0		0					
Potamo/Hylochère	0		0					
oiseaux/Pigeon/toucan/Calaos (nbre) (1½g)	92	0	2				05 02 06	01
lièvre (5kg)	36	180	60	130		3500	05 02	01
Ecureuil								
Autre Vipère (8kg)	1	8	8	0			06	01

Produit de pêche	2013 Qté pêchée (kg)	Qté Conso par an (kg)	Qté vendue (Kg)	Temps de pêche (Jrs par mois)	Prix de vente unitaire CFA/Kg	Bien vouloir inscrire le numéro correspondant au lieu de récolte 01= Forêt communaut/Communale 02= Concession forestière 03= Zones de chasse (cyn, com) 04= Aires Protégées 05= vos champs agricoles 06= forêt vierge 07=jachère 08=Village 08=Autre………					Technique de pêch 01=filet 02=nasse 03=ligne 04=barrage traditic 05= empoisonnem 06=Achat 07=autre………
Autre						|_|_|	|_|_|	|_|_|	|_|_|	|_|_|	
Crabes						|_|_|	|_|_|	|_|_|	|_|_|	|_|_|	
crevettes		1,5	0			|_|_|	|_|_|	|_|_|	|_|_|	|_|_|	06
huîtres,						|_|_|	|_|_|	|_|_|	|_|_|	|_|_|	
tortues						|_|_|	|_|_|	|_|_|	|_|_|	|_|_|	
silure		8	0		[illegible]	|_|_|	|_|_|	|_|_|	|_|_|	|_|_|	06
Carpes		1,5	0		500	|_|_|	|_|_|	|_|_|	|_|_|	|_|_|	06
autre ……						|_|_|	|_|_|	|_|_|	|_|_|	|_|_|	

q.60 S'il vous arrive d'élever quelques animaux, veuillez renseigner le tableau ci-dessous?

	2013 Qté achetée (nbre)	Coûts d'achat unitaire	Qté après reproduction	Qtés consommée par an, (nbre ; litre)	Qtés vendues (nbre, litre)	Prix de vente unitaire	Technique d'élevage/récolte 01=enclos 02=plein air 03=Autre………..	De quoi s'alimente t-il ? 01=provendes, 02=déchet de ménage 03=feuilles et herbes 04=autre…	Coûts d'élevage d'un individu
Aulacodes (hérisson, rat palmiste)	0								
Vache	0								
Porc	0		30	0	0		02	01, 02, 03	0
mouton	0								
Chèvre	0								
Poulet/canard	0		0						
Abeille/Miel	0--	--						-	

1.5 Conflit, accaparement des terres, Chevauchement de limites et superposition des droits d'usage

q.61	Avez-vous déjà été en conflit d'utilisation des terres avec une ou plusieurs parties prenantes depuis votre installation dans ce village? 00=non ; 01= Oui	|__|__|	Si 00, allez à Q63
q.62	Pour chaque type de parties prenantes contenues dans le tableau ci-dessous, dites si vous avez été en conflit d'utilisation des terres et quel en a été l'impact?		

		Ménages Voisin 01=Oui, 00=Non, |01|	Autorité administrative 01=Oui, 00=Non, |__|__|	Concession forestière (UFA) 01=Oui, 00=Non, |__|__|	Concession minière 01=Oui, 00=Non, |__|__|	Agriculteur industrielle 01=Oui, 00=Non, |__|__|	Concession d'orpaillage 01=Oui, 00=Non, |__|__|	Producteur de Culture de rente Cacao /Café 01=Oui, 00=Non, |__|__|
Nombre de parcelles en conflit		2						
Distance entre votre parcelle en conflit et celle de (du)								
Nature des conflits	Destruction des plantations							
	Chevauchement des limites	01						
	Interdiction d'accéder à mes parcelles							
	Héritage familiale/partage de terrain	01						
	Autre…………………..							
Quel a été l'impact des conflits ? bien vouloir quantifier l'impact.	Pourcentage de production perdue							
	Superficie de parcelle en conflit (m^2)							
	superficie de nouvelles parcelles recherchée/acquises (m^2)							
	Superficie de nouvelles parcelles achetées (m^2)							
	Coûts d'achat de nouvelles parcelles							
Avez-vous reçu une compensation ?								
Quel type de compensation avez vous reçu ?	J'ai reçu une compensation monétaire de (montant)							
	Nouvelles terres forestière (superficie en m^2)							

q.63	Avez-vous déjà été victime de confiscation des terres? 01 = Oui ; 00= Non	|__|__|	Si 00, allez à

* Note : [illegible]

			Q66
q.64	Qui a eu à confisquer vos terres? 01=un voisin, 02=une autorité, 03=un membre de ma famille, 04=une entreprise, 05=autre……		
q.65	Suite à la confiscation de vos terres qu'avez-vous fait ? 01=j'ai cherché de nouvelles terres dans la forêt, 02=j'ai acheté une nouvelle parcelle, 03=je n'ai rien fait, **04=j'ai récupéré mon terrain, 05=encours, 06=autre……**		
	Infrastructure de transport, Urbanisation		
q.66	Quels moyens de transport utilisez-vous pour sortir vos produits de la forêt (plusieurs réponses sont possibles)? 01=Pousse/charrette, 02= Moto, 03=Transport commun, 04=camion, 05=vélo, 06=je vais à pieds, 07=grumier, 08=Voiture personnel, 09=autre ……	|__|__|	
q.67	Quels types de route empruntez-vous pour aller au champ (plusieurs réponses sont possibles)? 01=route forestière, 02=route publique, 03=route minière, 04=route des Zone de Chasse, 05=sentier créé par vous-même, 06=sentier commun, ……	|__|__|	
q.68	Pendant la saison des pluies, avez-vous des difficultés liées au réseau routier pour accéder au marché? 01=oui, 00=non	|__|__|	Si 00, allez à Q70
q.69	Quel est le pourcentage de perte de production liée à cette difficulté d'accès ?……0……%		
	Accès aux services de base		
q.70	Votre ménage accède t-il aux services suivants? 01 = Oui		

Accès à l'eau de boisson	Accès à l'eau de ménage et lessive	Accès à l'énergie électrique	Télécommunication	Moyens d– transport
|__| Raccordement direct	|__| Raccordement direct	|__| Raccordement direct	|__| Téléphone portable	|__| Mobylette/moto
|__| Raccordement indirect	|__| Raccordement indirect	|__| Raccordement indirect	|__| Téléphone fixe	|__| Vélo/bicyclette
|__| Forage	|__| Forage	|__| Groupe électrogène	|__| Téléviseur	|__| voiture personnel
|__| Robinet communautaire	|__| Robinet communautaire	|__| Lampe à pétrole/gaz	|__| Poste radio	|__| Transport commun
|__| eau de source	|__| eau de source	|__| **Bougies**	|__| Autre……	|__| Camion
|__| Rivière	|__| Rivière	|__| **Torche/lame solaire**	|__| Lecteur VCD/DVD	|__| Aucun
|__| puits protégé	|__| puits protégé	|__| Autres….	|__| Câble /parabole	**Autres équipements**
|__| Puits non protégé	|__| Puits non protégé			|__| Fer à repasser
|__| Eau de pluie	|__| Eau de pluie			|__| Réfrigérateur
|__| Eau minérale	|__| Eau minérale			|__| Ventilateur
|__| Autre ……	|__| Autre ……			

	Caractéristiques du logement		
q.71	Entourer le numéro qui correspond aux caractéristiques du logement de l'enquêté (Bâtiment – toiture – sol)		

Bâtiment	**Toiture**	**Sol**
01=Terre battue ; 02=bois/**planche** ; 03=brique ; 04=Mungulu, 05=pailles, 06=maison en dur	01= paille 02=tôle	01=terre ; **02=ciment ; 03=carreaux**

q.72	A quelle distance se trouve votre principal lieu de collecte de l'eau? ……..…… Minutes		
q.73	Comment trouvez-vous l'eau que vous consommez? 01=très bonne qualité, **02= bonne qualité, 03=mauvaise qualité, 04= très mauvaise qualité**	|_|_|	
q.74	Quel moyen utilisez-vous pour traiter votre eau de boisson (plusieurs réponses sont possibles) ? 00=aucun, 01=ébullition, 02= décantation, 03=filtre à coton, 04=javellisation, 05= filtre céramique, 06=filtre à sable/charbon, 07= soleil, 08 =autre	|_|_|	Si 00, allez à Q76
q.75	Combien dépensez-vous par mois pour le traitement de votre eau de boisson ?		
q.76	Quel type de Sanitaire utilisez-vous (plusieurs réponses sont possibles)? 01= W.C moderne avec chasse d'eau, 02=Latrines améliorées, 03=Fosse rudimentaire, 04=Pas de toilettes/nature, 05=Autre	|_|_|	
q.77	Que faites vous de vos déchets ménagers (plusieurs réponses sont possibles) ? 01=je les jette derrière la maison (plusieurs réponses sont possibles), 02= je les mets dans la poubelle pour la société d'hygiène, 03= je les brûle, 04=je déverse dans une fosse	|_|_|	
	Sources d'énergies		
q.78	A partir du tableau ci-dessous, veuillez donner quelques informations sur vos sources d'énergie		

	Quantité consonnée par an	Source : 01=produit par le ménage ; 02=achat ; 03=don	Coût d'achat unitaire
Charbon	0…sacs		
Gaz,	……Bouteille		
Pétrole	……Litres	02	500
Bois de feu	6……fagots	01	0
Copeaux	…0….Sacs		
Bougies	…0……unité		
Electricité	…0…Kw		**Prix du Kw**……

q.79	Quelle est votre technique de production du bois ? 01=ramassage, 02=abattage, 03=brulis, 04=autre……	|_|_|	
q.80	Quel type de foyer utilisez-vous ? 01=Foyer en pierres, 02=jante de roue/**Foyer métallique**, 03=foyer	|_|	

en terre, 04=amélioré 05=autre.....

q.81 A quelle distance de la maison se situe le lieu de collecte habituel du bois ? ....40.....Minutes

Santé et éducation des Membres du Ménage

q.82 Veuillez décrire dans le tableau ci-dessous l'état de santé et le niveau d'éducation de votre ménage en 2013

	Membres de votre ménage (Mettre les noms)	Age	Sexe 01=M 02=F	Relation au chef de ménage 1 = Chef de ménage 2 = Epoux (se) 3 = fils/fille 4 = cousin/cousine 5 = petit fils/petite fille 6 = Parent 7 = beau parent 8 = frère/sœur 9 = beau frère/belle sœur 10 = oncle 11 = neveu/nièce 12 = ami de la famille 13 = autre préciser 14= autre préciser 15 = autre préciser	Parmi les membres de votre ménage, dites lesquels ont souffert au moins d'une des maladies suivantes en 2013 (plusieurs réponses sont possibles)? 01=Choléra 02=Diarrhée ; 03=Mal de ventre et vers ; 04=Fièvres typhoïde ; 05=Hépatite ; 06=Paludisme ; 07=Autre	Quelles sommes d'argent en moyenne avez-vous dépensé pour les soigner ?	Quel est le niveau de scolarisation des membres de votre ménage ? 01=université ; 02=entre 3ème et terminale 03=entre 6ème et 4ème ; 04=primaire **05=maternelle** **06= sans éducation**	Quel est le niveau escompté si éducation encours	Quelle somme d'argent dépensez par an pour leur scolarité ?
1.	CM								
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									
11.									
12.									
13.									
14.									
15.									
16.									
17.									

Utilisations des terres et Sécurité alimentaire

q.83 Combien de fois est-ce que vous mangez par jour ?01= 3 fois, 02=2 fois, 03=une fois, 04=autre |__|__|

q.84 Vos activités vous procurent-t-elles une quantité de nourriture suffisante pour votre ménage?(01)=Oui, 00=Non, 02=Je ne sais pas |__|__|

MULTIFONCTIONNALITE DU PAYSAGE

Valeur culturelle, savoir traditionnelle, spirituelle et valeur génétique de la forêt pour les populations

q.85 Est-il déjà arrivé que vous soyez recruté ou payé par une personne, une société forestière ou une autre société pour être un guide dans la forêt, pour parler de la forêt, pour indiquer les espèces végétales, pour indiquer les médicaments ou alors pour un savoir traditionnel quelconque? (01)=Oui ; 00= Non |__|__| Si 00, allez à Q87

q.86 Combien en moyenne avez-vous reçu de rémunération durant les 12 derniers mois ?

q.87 Croyez-vous en un esprit ou un Dieu de la forêt ? 00 non ; 01=non Si 00, allez à Q89

q.88 Comment s'appelle t-il ?

q.89 Avez-vous été initié au zengui (jengui)? **00 non ; 01=non**

q.90 Le zengui (jengui) apparait-il encore de nos jours ? **00 non ; 01=non, 02=je ne sais pas**

q.91 si vous avez déjà contacté l'esprit de la forêt dites nous quel en était la raison ? 01=Je ne l'ai jamais fait, 02=pour la guérison de malades, 03=pour bien réussir la chasse, 04=pour me protéger, 05= pour prédire le futur, 06=nous avions perdu un être cher, 07=autre.....

Valeur génétique - médicinale

q.92 Avez-vous enregistré des cas de maladies dans votre ménage durant l'année dernière ? 00=non ; 01=oui

q.93 Combien de fois êtes-vous allé à l'hôpital avec un membre de votre ménage durant l'année dernière ? 00=aucune fois, 01=**au plus quatre fois, 02=entre 5 et 10 fois, 03= au moins 11 fois ....** Si 00, allez à Q96

q.94 Quelle somme d'argent avez-vous en tout dépensé à l'hôpital durant l'année dernière ?.....

q.95 En étiez-vous satisfait ? ": 01= oui Très satisfait, 02= oui satisfait, 03=Pas du tout satisfait

q.96 Combien de fois avez-vous acheté des médicaments en route durant l'année dernière ? 00=aucune fois, 01=**au plus quatre fois, 02=entre 5 et 10 fois, 03= au moins 11 fois ....** Si 00, allez à Q99

q.97 Quelle somme d'argent avez-vous en tout dépensé pour effectuer ces achats durant l'année dernière ?.....

q.98 En étiez-vous satisfait ? ": 01= oui Très satisfait, 02= oui satisfait, 03=Pas du tout satisfait

q.99	Combien de fois êtes-vous allé chez le guérisseur traditionnel durant l'année dernière ? 00=aucune fois, 01=**au plus quatre fois, 02=entre 5 et 10 fois, 03= au moins 11 fois ….**		Si 00, allez à Q102
q.100	Quelle somme d'argent avez-vous en tout dépensé à cet effet durant l'année dernière ?.....		
q.101	En étiez-vous satisfait ? ": 01= oui Très satisfait, 02= oui satisfait, 03=Pas du tout satisfait		
q.102	Combien de fois avez-vous accédé à un produit de la forêt pour soigner une maladie dans votre ménage durant l'année dernière ? 00=aucune fois, 01=**au plus quatre fois, 02=entre 5 et 10 fois, 03= au moins 11 fois ….**		Si 00, allez à Q104
q.103	En étiez-vous satisfait ? ": 01= oui Très satisfait, 02= oui satisfait, 03=Pas du tout satisfait		
q.104	Combien de fois avez-vous acheté des médicaments en pharmacie durant l'année dernière ? 00=aucune fois, 01=**au plus quatre fois, 02=entre 5 et 10 fois, 03= au moins 11 fois ….**		Si 00, allez à Q106
q.105	Quelle somme d'argent avez-vous en tout dépensé ?...10000F		
q.106	En étiez-vous satisfait ? ": 01= oui Très satisfait, 02= oui satisfait, 03=Pas du tout satisfait		
	Valeur culturelle + Conservation		
q.106	Conserver plus de forêt est important pour la biodiversité, pour vous et pour vos enfants. Imaginons que le gouvernement veuille augmenter la superficie forestière : S'il vous est proposé d'abandonner une partie de vos terres au profit de la forêt sans contrepartie seriez-vous d'accord ? 01 = Oui ; 00= Non |__|__|		Si 01, allez à Q108
q.107	Quel montant accepteriez-vous de recevoir au m^2 et par an pour abandonner une partie de vos terres? 1000F		
q.108	Quelle surface seriez-vous prêt à abandonner ? 2ha.		
q.109	Avez-vous déjà été victime de conflit Homme-éléphant depuis que vous êtes dans ce village ? 00=Non, 01= Oui		Si 00, allez à Q116
q.110	En quelle année ?		
q.111	Quelle était la nature de ce conflit ?		
q.112	A combien estimez-vous le dommage encouru lors de ce conflit ?		
q.113	Quel est le type de compensation que vous recevez ?00=aucun, 01=monétaire, 02=autre……		Si 00, allez à Q116
q.114	Quel en est l'équivalent monétaire ?		
q.115	Qui vous verse cette compensation ?		
q.116 (c)	L'éléphant est une espèce très importante pour trois raisons : • Il représente une source de viande pour les peuples de forêt • Il permet à certaines populations de rester en contact avec les esprits • Il favorise une bonne dissémination de certaines espèces végétales comme le moabi en parsemant les graines lors de leurs déplacements, ce qui régule l'approvisionnement en fruit et huile de moabi. Aujourd'hui, il y a une tendance à disparition des populations d'éléphants du fait du grand braconnage transfrontalier dans votre région. Une solution efficace à cette situation est la mise sur pied d'un programme de protection de l'éléphant. Un programme qui permet de saisir les armes de guerres aujourd'hui utilisées par les braconniers, de lutter efficacement contre le braconnage transfrontalier en recrutant plus de jeunes, en impliquant les populations à travers un réseau d'information et de communication Si le gouvernement a besoin du soutien financier de tous les habitants de ce village pour développer ce programme de protection de l'éléphant, seriez-vous prêt à payer 2000FCFA par mois pour contribuer à ce programme? 00=Non, 01=Oui Avant de répondre, pensez à votre niveau de revenu mensuel, à vos sources de revenue, aux dépenses importantes que vous devez effectuer par mois. Soyez réaliste et rassurez-vous que vous pourriez effectivement payer ce montant par mois.		Si 00, aller à 117 Si 01 aller à 118
q.117 (c)	Si non, Seriez-vous prêt à payer 1500FCFA par mois ? 00=Non, 01=Oui		
q.118 (c)	Si oui sur q.116 Seriez-vous prêt à payer 2500FCFA par mois ? 00=Non, 01=Oui		
q.119 (c)	Quel montant maximal seriez-vous prêt à payer par mois pour la protection de l'éléphant ?.....5000.....		
q.120 (c)	Si **00** sur q.116, pourquoi ? a. Je ne vois aucune menace pour la population d'éléphants b. Je ne crois pas que mes paiements aideront les éléphants en raison de la corruption dans le gouvernement c. Les éléphants sont un coût pour moi car ils détruisent mes cultures d. Je ne tire aucun profit de l'éléphant, s'ils éteignent dans ma région, il n'y a pas de problème pour moi e. Je ne peux pas me permettre de payer pour l'éléphant f. Il ne revient pas seulement à nous de payer mais à d'autres populations aussi g. Il revient au gouvernement de payer pour un tel programme		

h. Il revient à l'industrie du bois de payer pour un tel programme
i. Je ne crois pas qu'il est possible de faire un programme de protection qui aidera les éléphants

Si **01** sur q.116, Pourquoi êtes-vous prêt à payer pour la protection des éléphants.

j. Je pense que la protection des éléphants est un objectif important
k. Il est important de protéger la biodiversité pour les générations futures
q.121 (c) l. La présence d'éléphants est importante pour mon identité et ma spiritualité
m. Ma contribution reflète mon point de vue sur la nécessité de protéger la biodiversité en général
n. Je suis satisfait de donner à une bonne cause
o. Je ne vais pas vraiment avoir à payer dans la réalité.
p. Pour la disponibilité du Moabi (ADJAP)

q.123 Parmi les événements environnementaux suivants, cochez ceux auxquels vous avez déjà été confrontés durant les 10 dernières années ?

1	**Chocs naturels**	I	Perturbation des cycles de pluies☐	Q	Raréfaction des PFNL☐
A	Erosion des sols☐	J	Pollution de l'eau☐	R	Baisse de la production agricole☐
B	Tempête de vent☐	K	Fortes Pluies ☐	S	Manque d'eau☐
C	Inondation☐	L	Saisons sèches plus longues ☐	T	Diminution du gibier☐
D	Feux de forêts☐	M	Diminution de la forêt☐	**3**	**Chocs de marché**
E	Hausse des températures☐	N	Maladie des plantations☐	U	Hausse des prix des intrants☐
F	Tarissement des cours d'eau☐	O	**Appauvrissement des sols**	V	baisse des prix à la production☐
G	vents violents permanents☐	**2**	**Chocs de production**		
H	Démarrage tardif des pluies☐	P	Diminution du poisson ☐		

q.124 Qu'est-ce qui peut être à l'origine des événements cités ci-dessus ? (cocher et/ou ajouter le ou les mos clés) 01 : la déforestation et la dégradation des sols☐, 02 : L'agriculture sur brulis☐, 03 : La pollution de l'air☐, 04 : Phénomène tout à fait naturel☐, 05 : la récolte du bois énergie, **06=l'action de l'homme☐, 07= Autre** .....☐

q.125 Quelles sont vos préoccupations vis-à-vis de ces événements ? 01= Ceci ne m'inquiète pas☐, 02 = Je m'inquiète parfois☐, 03 = Je m'inquiète très souvent☐, 04= Peur de vivre des catastrophes☐

q.126 Parmi les stratégies d'adaptation et d'atténuation suivantes, lesquelles avez-vous déjà adoptées ? ou alors comptez vous adopter prochainement ? (matérialiser par le nombre 01)

	Stratégies	adoptée	Intension d'adopter	Je ne fais rien
A	Diversifier les cultures agricoles	01		
B	Introduction de nouvelles activités		01	
C	Pratique de l'agroforesterie (association des cultures)	01		
D	Reboisement (nombre de plant par an.....10.....)	01		
E	Protection des arbres	01		
F	Adoption de nouvelles techniques culturales	01		
G	Technique de fertilisation du sol (engrais verts, fumiers, compost)			01
H	Recherche de nouvelles terres pour mon activité	01		
I	Abandon des cultures itinérantes sur brûlis		01	
J	Irrigation			01
K	Moins jeter de déchets sur le sol ou dans l'eau	01		
L	Utilisation de foyer amélioré		01	
M	Autre			

q.127 Il s'avère que la pratique du brûlis accroit la déforestation, nuit à l'environnement et accroit le réchauffement climatique. S'il vous est proposé de stopper les pratiques de brulis et le défrichage de la forêt sans contrepartie seriez-vous d'accord ? 01= Oui ; 00= Non ☐☐ Si01 aller à 129

q.128 Si non quel montant par mois accepteriez-vous de recevoir pour stopper ces pratiques 01=25000 FCFA, 02=50 000FCFA, 03=100 000 FCFA, 04=Autre?

q.129 S'il arrive que vous sous organisiez en coopérative, qu'on mette en votre disposition un tracteur, ainsi que des techniques permettant d'intensifier l'utilisation de vos terres (augmentation des rendements d'échelles), accepteriez-vous d'abandonner les pratiques de brulis ? 00=Non, 01=Oui, 03=Je ne sais pas

q.130 Suite aux changements climatiques, comment réagiriez-vous à une baisse de votre production agricole?

01=Oui, 00=Non	Réduction de 1%	Réduction de 5%	Réduction de 10%	Réduction de 30
J'arrêterais de produire	00	00	00	00
J'utiliserais plus d'engrais	00	00	00	00
Je rechercherais de nouvelles terres	00	00	00	00
Je ne ferais rien				
J'adopterai de nouvelles pratiques culturales	01	01	01	01
Autre				

PART 2 : RISK AVERSION

Loterie

S'il vous plait, nous interrompre l'enquête et vous proposer un petit jeu. Cependant, nous allons vous proposer trois groupes de 9, 5 et 3 différents jeux et voir lequel choisiriez-vous de jouer. Pour chaque groupe, vous avez droit à un jeu, vous avez 50% de chance de remporter le gain A et 50% de chance de gagner le gain B. Alors, étant donnée la distribution de gain ci-dessous, lequel des 9 jeux accepteriez-vous de jouer ?

	Gain A (50%)	Gain B (50%)
jeu 1	100	100
Jeu 2	80	128
jeu 3	60	160
jeu 4	40	195
jeu 5	30	215
jeu 6	20	229
jeu 7	18	232
jeu 8	10	234
jeu 9	3	235

	Gain A (50%)	Gain B (50%)
jeu 1	4	4
jeu 2	3	6
jeu 3	2	8
jeu 4	1	10
jeu 5	0	12

Pourquoi ????

A cause des changements climatiques, votre production peut baisser si vous êtes malchanceux ou alors augmenter si vous êtes chanceux suivant les trois situations A, B, et C. Dans quelle situation aimeriez-vous être ?

Entourer le Choix	Production actuelle	50 % de Chance	50% de Chance
A (-5% ou +10%)	100	95	110
B (-10% ou +20%)	100	90	120
C (-30% ou +50%)	100	72	150

PART 3 : Choice Experiment – BLOC 1

Présentation des attributs

La forêt assure un ensemble significatif de fonctions et d'avantages Économiques, sociaux et Environnementaux. Mais en raison de sa surexploitation, ces fonctions pourront disparaître à l'avenir si rien n'est fait. Par conséquent, les organismes gouvernementaux et les ONG considèrent la mise en œuvre des différentes politiques qui assureront l'approvisionnement future des biens et services environnementaux. Ces politiques pourront avoir une influence sur le mode de vie des populations de votre région. Cette étude évalue vos préférences pour les différentes politiques, sachant qu'elles varient en fonction des différents attributs:

Caractéristiques/attributs

1- La biodiversité

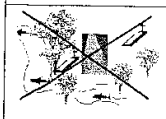
Du fait de la protection, les différentes politiques peuvent réduire ou maintenir l'accès aux espèces suivantes (adjap / Moabi, Manguier sauvage, Djansang, Yohimbe, Feuilles de Maranthacées (de jong), Nding, Bilinga, Bubinga, Ezezang, Chenilles, Essigang, Sapelli, Okan, Gibier). En effet, les politiques peuvent avoir les effets suivants sur la présence et l'abondance de ces espèces:

1. Soit une protection totale dans votre région	2. Soit vous les retrouvez à une distance de 30 minutes plus loin de votre résidence	3. Soit alors vous avez la même présence comme aujourd'hui.
		

2- Les espaces ressources/culturelles/spirituels

Les politiques pourront aussi avoir un impact sur la protection des sites existant dans la forêt qui ont une dimension traditionnelle, culturelle et spirituelle. Elles pourront donc affecter les pratiques liées à votre tradition et à votre identité culturelle que vous menez dans la forêt. A titre d'Exemple, les zones de Pêche par barrage traditionnelle, les espaces sacrés, les zones réservées aux cérémonies traditionnelles, rituelles, spirituelles, les espaces de méditation et/ou les lieux de recueillement, de cultes et d'initiation comme les cimetières des ancêtres, les églises, …

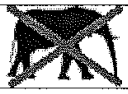
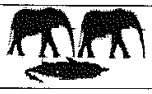
Les impacts peuvent être :

1. Soit une protection totale avec accès zero	2. Soit une Protection partielle excepté les espaces proche de la rivière	3. Soit alors vous avez la même présence comme aujourd'hui
		

3- L'existence des populations d'éléphants

Les politiques proposées peuvent avoir un impact sur la survie des éléphants et sur les conflits possibles avec les éléphants en matière de destruction de vos cultures, sur la réduction de ces conflits à travers les initiatives de gestion différents telles que la mise en place des corridors.

Les impacts des politiques peuvent être

1. Tendance à Disparition	2. Existence avec probabilité de conflits	3. Forte présence avec aménagement des corridors de mobilité pour prévenir les conflits
		

4- Le paysage et couvert forestier,

L'agriculture extensive et les pratiques de brulis sont parmi les causes majeures de la déforestation et donc de la perte de l'ensemble des biens et services que vous pouvez tirer de la forêt. L'utilisation d'une nouvelle technologie (engrais, variation des cultures, mécanisation...) peux permettre d'accroitre les rendements agricoles, d'obtenir un niveau de production identique sur une surface arable réduite.

Les politiques envisagées ici peuvent se traduire par une introduction des légumineuses et de certaines plantes fourragères dans vos espaces agricoles. Dans ce cas, les plantes agroforestières vous sont données gratuitement. La politique peut être combinée avec une dotation gratuite d'une nouvelle technologie qui permettra d'accroître la production agricole sur la partie de terres non convertie à la forêt. Donc en résumé, les politiques peuvent avoir l'impact suivant sur votre terre agricole.

Les impacts des politiques peuvent être

1. Maintien des surfaces actuelles et productions agricoles actuelles	2. Introduction de plantes agroforestières et maintien de la production	3. Introduction de plantes agroforestières et Adoption d'une nouvelle technologie permettant d'atteindre un niveau de production supérieur
		

5- subvention individuelle

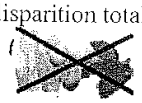
En fonction des différentes politiques, votre ménage il peut arrive que votre ménage reçoive une compensation monétaire mensuelle. Elle peut être payée par le gouvernement ou par une ONG. Les différents niveaux de payement peuvent être :

0 FCFA (Satut Quo) ; 3000CFA ; 6000CFA ; 9000FCFA ; 12000FCFA ; 21000 FCFA

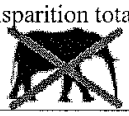
Maintenant, nous allons vous présenter plusieurs politiques alternatives par groupe de 3, et nous vous demandons après les avoir examiné attentivement de choisir entre ces trois politiques celle que vous préférez. Un tel choix entre trois politiques relatives à la protection de la forêt vous sera demandé 18 fois (2block de 9 à scinder).

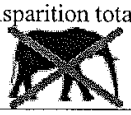
Supposez s'il vous plaît que la mise en œuvre des politiques de la protection de la forêt dépendra du résultat de ce questionnaire. Considérez chaque choix de manière indépendante du précédent. Ensuite, la politique est choisie parmi les alternatives préférées dans les choix effectués.

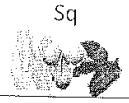
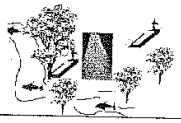
BLOC 1

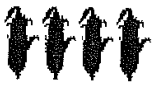
Set	1		
Politiques	**Politique 1**	**Politique 2**	**Pas de politique Comme aujourd'hui**
Biodiversité	disparition totale 	Sq 	Sq 
Durabilité des éléphants	disparition totale 		disparition totale 
Agriculture -> forêt			Sq 
Espace ressource/culturelle/spirituel	Sq 		Sq 
Subvention individuelle	FCFA 3000	FCFA 0	FCFA 0
COCHEZ ici →	☐	☒	☐

Set	2		
Politiques	**Politique 1**	**Politique 2**	**Pas de politique Comme aujourd'hui**
Biodiversité	disparition totale 		Sq 
Durabilité des éléphants			disparition totale 
Agriculture -> forêt	Sq 		Sq 
Espace ressource/culturelle/spirituel		disparition totale 	Sq 
Subvention individuelle	12000FCFA	9000FCFA	0 FCFA
COCHEZ ici →	☐	☒	☐

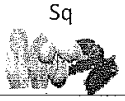
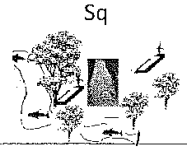
Set	3		
Politiques	Politique 1	Politique 2	Pas de politique Comme aujourd'hui
Biodiversité	disparition totale 		Sq !! EMBED PBrush 
Durabilité des éléphants		disparition totale 	disparition totale 
Agriculture -> forêt			Sq 
Espace ressource/culture lle/spirituel		Sq 	Sq 
Subvention individuelle	12000FCFA	6000CFA	0 FCFA
COCHEZ ici →	☐	☒	☐

Set	**4**		
Politiques	Politique 1	Politique 2	Pas de politique Comme aujourd'hui
Biodiversité	Sq 	 30 min plus loin	Sq 
Durabilité des éléphants		disparition totale 	disparition totale 
Agriculture -> forêt		Sq 	Sq 
Espace ressource/culturel le/spirituel	disparition totale 	Sq 	Sq 
Subvention individuelle	6000CFA	9000FCFA	0 FCFA
COCHEZ ici →	☒	☐	☐

Set	5		
Politiques	Politique 1	Politique 2	Pas de politique Comme aujourd'hui
Biodiversité	Sq 		Sq 
Durabilité des éléphants			disparition totale 
Agriculture -> forêt			Sq 
Espace ressource/culturelle/spirituel	Sq 		Sq 
Subvention individuelle	21000 FCFA	3000CFA	0 FCFA
COCHEZ ici →			

Set	6		
Politiques	Politique 1	Politique 2	Pas de politique Comme aujourd'hui
Biodiversité	Sq 	disparition totale 	Sq 
Durabilité des éléphants			disparition totale 
Agriculture -> forêt	Sq 		Sq 
Espace ressource/culturel le/spirituel	disparition totale 	Sq 	Sq 
Subvention individuelle	9000FCFA	3000CFA	0 FCFA
COCHEZ ici →			

Set	7		
Politiques	Politique 1	Politique 2	Pas de politique Comme aujourd'hui
Biodiversité		disparition totale 	Sq 
Durabilité des éléphants			disparition totale 
Agriculture -> forêt			Sq 
Espace ressource/culturelle/spirituel		Sq 	Sq 
Subvention individuelle	3000CFA	6000CFA	0 FCFA
COCHEZ ici →	☐	☐	☐

Set	8		
Politiques	Politique 1	Politique 2	Pas de politique Comme aujourd'hui
Biodiversité	Sq 	disparition totale 	Sq 
Durabilité des éléphants	disparition totale 		disparition totale 
Agriculture -> forêt		Sq 	Sq 
Espace ressource/culturel le/spirituel		disparition totale 	Sq 
Subvention individuelle	6000CFA	0 FCFA	0 FCFA
COCHEZ ici →	☐	☐	☐

Set	9		
Politiques	Politique 1	Politique 2	Pas de politique Comme aujourd'hui
Biodiversité	Sq 		Sq 
Durabilité des éléphants	disparition totale 		disparition totale 
Agriculture -> forêt			Sq 
Espace ressource/culturel le/spirituel	disparition totale 		Sq 
Subvention individuelle	3000CFA	6000CFA	0 FCFA
COCHEZ ici →			

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Résumé en francais

Contexte et Enjeux

Dans les paysages forestiers tropicaux, l'expansion agricole pour les moyens de subsistance et le commerce (Leblois et al. 2016) a transformé et fragmenté les habitats naturels forestiersà des taux alarmants dans certains biomes (Deakin et al., 2016 ; Laurance et al., 2014). Environ 80% de la déforestation mondiale (Gibbs et al. 2010 ; Kissinger et al., 2012) serait issue de cette expansion, contribuant pour 10 à 12 pourcent du total des émissions anthropiques mondiales annuelles de gaz à effet de serre (Pachauri et Reisinger, 2008 ; Verchot, 2014). La destruction de l'habitat naturel à grande échelle a eu pour effet de mettre en danger de multiples espèces de faune et de flore, alors que la capacité des écosystèmes à fournir les biens et services dépend aussi bien du nombre que de la diversité des d'espèces (Tilman et al. 2002 , 2001). De façon plus précise, si l'agriculture commerciale cause en moyenne 70 pourcent de la déforestation en Amérique latine, en Afrique tropicale, c'est l'agriculture de subsistance qui est le principal moteur de la conversion des terres forestières (FAO, 2016 ; Hosonuma et al, 2012). En 2005, l'Afrique a subi une perte nette continue de 21,4 pourcent de la superficie forestière comparativement à 23,6 pourcent en 1990, l'agriculture de subsistance étant responsable de plus de 50 pourcent de cette perte de forêt (Delacote, 2012).

En Afrique sub-saharienne, où les ménages font face à un risque accru quant à leur production agricole et leurs revenus, et où les droits de propriété sont précaires, les ménages ruraux adoptent des stratégies à faible risque, à faible rentabilité et à retour immédiat (FAO, 2015). Ces ménages adoptent la déforestation comme une stratégie de gestion des risques (Araujo et al. 2009). L'utilisation principale de technologies obsolètes a eu pour effet de creuser de grands écarts de rendements par rapport aux rendements potentiels (Laurance et al. 2014 ; Masters et al. 2013).

La principale technique d'acquisition des terres est l'itinérance sur brulis. Cette technique non-durable est pratiquée sans rotation optimale de culture.

Les ressources forestières contribuent de façon non négligeable aux moyens de subsistance des ménages (Angelsen, 2011). Comme l'ont souligné Ellis (2000b) et Scoones (1998), une proportion importante de ménages ruraux choisissent de diversifier leurs stratégies de survie, en intégrant l'agriculture vivrière, les cultures de rente, l'extraction des produits forestiers non ligneux (PFNL) et la chasse villageoise dans leurs portefeuilles d'activités. Tandis que d'autres ont tendance à se spécialiser soit dans les produits forestiers, soit dans l'agriculture. Les produits forestiers qui participent aux moyens de subsistance des ménages sont souvent extraits de manière peu durable. En conséquence, il y a une accentuation de la dégradation des forêts (Belcher et Schreckenberg , 2007 ; Hosonuma et al., 2012 ; Kissinger et al., 2012), ce qui conduit aussi à réduire la capacité des écosystèmes à fournir les biens et services (Tilman et al., 2002).

Dans ces conditions, il existe de fortes interconnexions entre, (1) les questions socio–économiques, (2) la préservation forestière et (3) la conservation de la biodiversité, le tout formant un système interdépendant.

Un large éventail de littérature a étudié (1) la relation entre des moyens de subsistance et la déforestation (Babigumira et al., 2014, Belcher et al., 2015 ; Vedeld et al., 2007 ; Wunder et al , 2014), (2) le lien entre l'agriculture et la déforestation (Angelsen , 1995 ; Angelsen et Wunder , 2003) (3) et le lien entre la déforestation et la conservation de la biodiversité (Amin et al. , 2014 ; Pfaff et al. , 2015)

Ces études ne considèrent pas et de façon explicite l'interdépendance entre ces questions auxquelles les solutions spécifiques génèrent parfois des externalités négatives sur d'autres composantes des écosystèmes. Ce qui contribuent à aggraver, plutôt qu' à améliorer le système (Holmgren, 2013). Ces externalités s'accentuent avec la compétition entre les utilisations des forêts. À titre d'exemple, en ignorant les conflits homme-faune lors de la recherche d'une compatibilité entre les moyens de subsistance des ménages et un faible niveau de déforestation, il peut y avoir une réduction des préférences des ménages pour la conservation de la biodiversité. C'est le cas de *loxodonta africana cyclotis* (éléphant de forêt) qui a subi une dynamique dévastatrice au cours des deux dernières décennies du fait du braconnage (Blake et al., 2007 ; Maisels et al., 2013). En outre, l'absence de prise en compte de la problématique de la conservation de la diversité biologique pourrait contribuer à fragiliser les systèmes de production des moyens de subsistance des ménages. Si on reprend le cas de

l'éléphant de forêt qui est une espèce phare, il a été démontré qu'il contribue à la restauration des équilibres écologiques, culturels et socio-économiques (Blake et al. 2009). Il contribue à l'enrichissement culturel et spirituel des peuples autochtones dans les régions tropicales africaines (Kent, 1996 ; Lewis, 2002). Il dissémine les semences de certains espèces végétales sur de longues distances (Beaune et al., 2013 ; Blake et al., 2009 ; Wang, 2008). Aujourd'hui, parmi les espèces forestières en voie de disparition du fait de leur forte valeur commerciale, on retrouve des arbres fruitiers, très demandés par les ménages pour les propriétés médicinales et pour la consommation. C'est le cas de *Baillonella toxisperma.* La disponibilité de cette espèce à certains endroits des forêts du Bassin du Congo est due à la présence des éléphants.

Compte tenu des considérations qui précèdent, il est nécessaire de poser des diagnostics et de réaliser des recherches en vue de guider les décideurs vers l'adoption des solutions transversales ciblant et de façon combinée la production durable des moyens de subsistance des ménages, la conservation de la biodiversité et la préservation du couvert forestier.

Dans ces conditions, cette thèse vise à répondre à la question suivante: quels sont les principaux déterminants des choix des stratégies de subsistance des ménages et Comment leurs choix impactent-ils la déforestation ainsi que leurs préférences pour la conservation de la biodiversité? Cette interrogation peut donner lieu à plusieurs questions secondaires. Cependant, cette thèse considère trois questions secondaires plus adaptées aux comportements des ménages ruraux dans un paysage:

- Comment les ménages locaux et autochtones formulent-ils leurs préférences parmi les stratégies et moyens d'existence?
- Quel est l'impact de ces différentes stratégies sur la déforestation à petite échelle compte tenu des conflits homme-faune? Et enfin
- Compte tenu de la nature de l'interaction entre les ménages et la faune, compte tenu de leurs principales activités, quel est le consentement à payer des ménages pour la conservation des éléphants de forêt?

L'objectif de cette thèse est d'étudier les interactions entre les stratégies de subsistance des ménages, leur empreinte écologique en termes de déforestation et leur sensibilité à la conservation de la biodiversité, en utilisant les données collectées auprès des ménages dans le paysage de conservation du Tri national Dja-Odzala-Minkébé dans

le bassin du Congo. Cette recherche vise à promouvoir une gestion intégrée de ce paysage multifonctionnel.

Approches conceptuelle et théorique

Cette thèse adopte l'approche landscape comme principal fondement conceptuel. Cette approche permet de mieux envisager des solutions transversales pour des problèmes interconnectés au sein d'un paysage tels que le changement d'usage de la forêt à l'agriculture, la réduction de la déforestation et la conservation de la biodiversité avec moins d'externalités entre les composants (Holmgren, 2013). Suivant Sayer et al. (2013), l'approche landscape est considérée dans cette thèse comme un cadre pour la gestion des terres forestières par les ménages locaux de manière à optimiser (1) la gestion durable des forêts, la récolte et la production des moyens de subsistance d'origines agricole et forestière, (2) l'enrichissement spirituel et culturel des populations locales et autochtones, et (3) la conservation de la biodiversité. Cette thèse se réfère aussi au cadre théorique de l'analyse des biens et services de subsistance développé par DfID (1999), Ellis (2000a), Jansen et al. (2006), Scoones (1998), Soltani et al. (2012). En effet, ce cadre stipule que les choix des stratégies de subsistance des ménages sont fonction des actifs spécifiques qu'ils possèdent.

Cette thèse se réfère aussi au cadre théorique proposé par Angelsen et Kaimowitz (1999), Combes et al. (2015); Geist et Lambin (2002), pour analyser la déforestation des ménages. D'après ce cadre, pour un tel analyse, il convient tout d'abord d'en définir la source ou l'agent, d'en définir les causes immédiates à l'échelle des ménages, en distinguant les facteurs de décision des caractéristiques de l'agent de déforestation.

Cette thèse a également convoqué l'approche écosystémique développée par MEA (2005), afin de fournir une description synoptique des services écosystémiques et de la valeur économique total d'un actif du patrimoine naturel.

Enfin, en considérant les interactions spatiales comme une composante essentielle de l'approche landscape (Felbinger et Jonuschat, 2006), cette thèse se réfère à la théorie des interactions stratégiques développée par Brueckner (2003), afin de tenir compte et de façon explicite de l'impact des interactions sociales entre ménages.

Enquête de ménages

Le Paysage transfrontalier du tri national Dja-Odzala-Minkébé (Tridom-TCL)

L'enquête des ménages a eu lieu dans le paysage Tridom-TCL. Ce paysage de conservation transfrontalière couvre une zone géographique de 191541 km, représentant 7,5 pourcent de la superficie totale des forêts tropicales du bassin du Congo en Afrique centrale. Ce paysage a été créé en 2005 par un accord entre les gouvernements du Cameroun, du Gabon et du Congo, appelé "Tridom agreement". Il est l'un des douze "paysages prioritaires" du Partenariat pour les Forêts du Bassin du Congo (PFBC). La gestion de ce paysage est confiée à une unité de gestion régionale (URG), avec un représentant dans chacun des trois pays membres. Chaque représentant gère le segment correspondant du paysage suivant la législation nationale du pays. L'URG est appelée à agir au-delà des frontières nationales. Cet accord a pour mission: (1) d'assurer la gestion durable de la biodiversité transfrontalière, (2) de maintenir la connectivité sociale, écologique et économique du complexe, (3) d'assurer une conservation à long terme de son système d'aires protégées et (4) de favoriser le développement local à impact réduit sur l'environnement.

Le Tridom-TCL est composé d'un réseau de 10 aires protégées. Dans la partie camerounaise, on retrouve la réserve de biosphère du Dja, les parcs nationaux de Boumba-Bek et NKI et le sanctuaire à gorille de Mengamé. Dans la partie congolaise, on retrouve les parcs nationaux d'Odzala-Kokoua et de Lossi. Dans la partie gabonaise, on retrouve les parcs nationaux de Minkébé, d'Ivindo et de Mwagna. Ces aires protégées sont réparties sur 37.498 km et sont reliées par un large interzone de plus de 111 000 km avec une zone habitable de 40.000 km.

Le paysage Tridom-TCL comprend une flore et une faune riches et diversifiées. Il abrite la plus grande population de *Loxodonta africana cyclotis* (éléphants de forêt) dans le monde, avec la plus forte densité dans le parc national de Minkébé. Il a également une densité relativement élevée d'autres grands mammifères, tels que *Gorilla gorilla gorilla* (gorille de plaine occidental), *Syncerus caffer* (buffles), *Tragelaphus eurycerus* (bongo), *Manis gigantea* (pangolins géants) et *Cephalophus* (céphalophes), etc.

Les ménages dans le paysage

L'interzone habitable du paysage Tridom-TCL abrite les populations autochtones et locales qui dépendent de l'agriculture sur brûlis et des activités d'extraction des ressources forestières. La densité de la population humaine est comprise entre 1 et 7,9 habitants au km (Ngoufo et al. (2012). Le Tridom-TCL accueille des activités industrielles telles que les unités forestières d'aménagement, l'agriculture industrielle, les zones de safari de chasse et l'exploitation minière industrielle. Le paysage comprend également l'exploitation illégale des espèces forestières à haute valeur commerciale, l'exploitation minière illégale et le braconnage transfrontalier intensif.

Environ 78 pourcent des communautés autochtones et locales déclarent pratiquer à temps plein l'agriculture à petite échelle (40,9 pourcent), les cultures de rentes (19,6 pourcent), la chasse au gibier et la cueillette des PFNL (14,8 pourcent), ainsi que l'orpaillage traditionnel (3 pourcent). L'acquisition des terres est presque considérée comme un indicateur de notoriété. Ainsi, la rationalité économique n'est pas toujours le motif d'acquisition des terres.

En ce qui concerne l'interaction avec la faune, les ménages locaux subissent de nombreux conflits débouchant sur la destruction de leurs espaces ressources. Durant notre enquête, nous avons dénombré 28 pourcent de ménages victimes de dégâts causés par les éléphants de forêt dans les cultures. Ces confits peuvent conduire à une mauvaise perception de la conservation des éléphants de forêt. En outre, cela peut conduire à la participation des ménages locaux au braconnage. Considérant ce qui précède, l'accord Tridom est encore loin d'atteindre les objectifs fixés au départ. Au contraire, les pratiques en cours contribueraient à l'augmentation de la déforestation, à la fragmentation et à la désintégration du réseau d'aires protégées au sein du paysage, d'où l'urgente nécessité de réaliser la présente étude dans le Tridom-TCL.

Déroulement des enquêtes

L'organisation et la réalisation de l'enquête ont été faites de manière à réduire les problèmes de mise en œuvre généralement rencontrés lors de la mesure des moyens de subsistance et de la déforestation des ménages au sens d'Angelsen (2011). Après la détermination de la taille de l'échantillon et la conception des questionnaires, nous avons recruté et formés de manière adéquate les enquêteurs. Nous avons réalisé deux phases de pré-enquête sur le terrain en vue de valider le questionnaire. Nous

avons ensuite réalisé l'enquête principale. Enfin, nous avons procédé à la saisie, à l'apurement de données et aux analyses. L'enquête a été réalisée auprès d'un échantillon aléatoire et stratifié de 1035 ménages tirés parmi 65 140 ménages du Tridom-TCL. La taille de l'échantillon, statistiquement nécessaire à un niveau de confiance de 95, était de 384 ménages. Nous avons élargi la taille de l'échantillon 1035. En effet, il était important d'avoir des sous-échantillons statistiquement valides au niveau de chaque arrondissement pour améliorer la précision des analyses et mieux prendre en compte les interactions sociales entre ménages dans le cadre d'une modélisation explicite des effets spatiaux. Le questionnaire a été conçu sur la base d'une revue de la littérature autour de la problématique de la gestion communautaire intégrée des ressources naturelles au sein des paysages multifonctionnels. Le questionnaire a été organisé en seize rubriques parmi lesquelles, les déterminants de la déforestation des ménages, les droits d'usage et les stratégies de subsistance des ménages, les conflits d'utilisation des terres, la multifonctionnalité du paysage et la conservation de la biodiversité.

Résultats

Les données collectées ont été analysées pour rédiger trois articles scientifiques. Cette section présente les différents résultats obtenus dans chacun des chapitres.

Chapitre 1: Quels sont les déterminants des choix de stratégies de subsistance opérés par les ménages dans les zones rurales?

Ce premier chapitre examine les déterminants des choix de stratégies de subsistance opérés par les ménages dans les zones rurales à partir d'un modèle probit autorégressif spatial. L'intérêt de la composante spatiale est de prendre en compte l'impact des différentes interactions endogènes et exogènes résultant de la proximité entre les ménages. Très peu d'études scientifiques ont mis l'accent sur les déterminants de tels choix dans le bassin du Congo. En se référant au cadre théorique de l'analyse des biens et services de subsistance développé par Ellis (2000a); Jansen et al. (2006); Scoones (1998) et Soltani et al. (2012), nous examinons la contribution des ressources humaines, financières, naturelles dans le choix des stratégies de subsistance par les

ménages. Nous évaluons également la contribution des facteurs géographiques tels que la proximité à une aire protégée et la distance au marché.

Les résultats du modèle Probit spatial autorégressif révèlent des similitudes sur la probabilité des ménages les plus proches à préférer une stratégie d'existence donnée. En effet, les ménages auraient tendance à imiter leur voisinage lorsqu'ils expriment leur choix entre différentes stratégies de survie. En outre les caractéristiques socio-économiques, l'existence des conflits homme-faune ainsi que l'autochtonie, ont à la fois un effet direct sur les choix des ménages en faveur de la diversification et des activités liées à la conversion des terres par les ménages, avec un effet d'entraînement sur la probabilité des chefs de ménages appartenant au même voisinage à d'adopter les mêmes stratégies.

Chapitre 2: Quel est l'impact des différentes stratégies de subsistance des ménages sur la déforestation à petite échelle, compte tenu des conflits homme-faune?

Ce chapitre a pour objectif d'examiner les facteurs déterminants de la déforestation des ménages dans le Tridom-TCL, en accordant un intérêt particulier au rôle joué par les stratégies de subsistance des ménages. Il teste également les conséquences des dommages causés par les éléphants (conflits homme-éléphant) dans les décisions de déforestation des ménages. Le cadre de référence choisi est le cadre théorique pour l'analyse de la déforestation proposé par Angelsen et Kaimowitz (1999) Combes et al. (2015); Geist et Lambin (2002).

Les résultats du modèle spatial autorégressif stipulent que: (1) les ménages ont tendance à imiter les décisions de déforestation de leur plus proches voisins. (2) L'intégration des cultures de rente dans un portefeuille d'activité accroît de manière significative la déforestation des ménages avec un effet indirect important sur la déforestation au sein du voisinage. En effet, un investissement d'une unité monétaire pourrait générer en moyenne de 6 à 7 fois plus de déforestation dans ces portefeuilles, comparativement aux autres stratégies. Aussi, (3) les effets indirects de ces choix sur la déforestation des ménages voisins ont presque le même ordre de grandeur que les effets directs résultant des autres stratégies. (4) En outre, il n'y a pas une substituabilité travail/loisir dans les choix d'utilisation des terres. Les populations pygmées, principale main-d'œuvre à faibles coûts, sont employées dans les activités associées à une plus grande déforestation, alors que l'effet du temps du travail des

ménages est statistiquement nul. La part de l'autoconsommation des ménages est associée à une faible déforestation, en conséquence, une meilleure intégration des marchés peut conduire à une augmentation de la déforestation, si les pratiques restent inchangées.

Chapitre 3: quel est la valeur des éléphants de forêt en danger pour les communautés locales dans un paysage transfrontier de conservation ?

Cet article a été publié dans la revue "Ecological economics", CNRS, Rang 1, HCERES A.

Ce troisième chapitre a pour objectif de déterminer et de caractériser les préférences des ménages pour la conservation des éléphants de forêt, espèce en danger dans le paysage, compte tenu de leurs activités de subsistance. Pour y parvenir, nous avons combiné la méthode des choix dichotomiques doublement bornés et les questions ouvertes pour évaluer le consentement à payer (WTP) des ménages du Tridom-TCL pour la conservation des éléphants de forêt, en tenant compte des conflits homme-éléphant. Une analyse robuste à partir du model Tobit, des modèles de régression par intervalle et du modèle "heteroscedastic double hurdle" de Cragg (1971) révèle que: (1) les ménages locaux sont prêts à payer en moyenne 1.139,4 FCFA (soit 1.74€) par mois pour éviter l'extinction des éléphants de forêt, soit un total de 753.9 million de FCFA (1.15 million d'€) par an pour tous les habitants du paysage. Les populations autochtones sont de plus en plus disposées à payer comparativement aux autres ménages. Ceci est fort probablement dû aux services culturels et spirituels rendus par les éléphants. Les données spatiales suggèrent que les communautés locales préfèrent les éléphants, mais loin de leurs cultures. L'existence de conflits homme-éléphant a un effet neutre sur les préférences pour la conservation des éléphants. Ce résultat peut sembler paradoxal. Cependant, il peut s'expliquer par le fait que les ménages espèrent qu'en payant, ils payeraient par là-même pour un meilleur aménagement de la faune et une érection des corridors de mobilités des éléphants. Ils paieraient en quelques sortes, aussi, pour éviter les conflits homme-faune. Par conséquent, on peut dire que les communautés locales seraient disposées à participer à la conservation de la biodiversité, dès lors que les bénéfices publiques liés à la conservation s'accompagnent des bénéfices privées, telles

que l'évitement des conflits homme-éléphant.

En somme, on peut retenir de ces trois chapitre de qui suit. Les actifs financiers (transfer d'argent et emprunts), la distance au marché, les dommages résultant des conflits homme-éléphant et l'ethnicité, plus précisément, l'autochtonie comptent parmi les facteurs déterminants des choix de stratégies de subsistance des ménages ruraux dans le Tridom-TCL. Nous montrons en outre que l'intensité de déforestation des ménages varie significativement en fonction de ces stratégies de subsistance. Par conséquent, les engagements en faveur de la réduction de la déforestation peuvent être favorisés par une bonne prise en compte des facteurs qui gouvernent les choix des modes de subsistance opérés par les ménages. Ils peuvent également être favorisés par la prise en compte les interactions entre ménages ainsi que leur localisation dans le paysage. En effet, nous trouvons qu'il existe des effets d'imitation, dans la décision de déforestation, entre les ménages d'un même voisinage, avec des effets spatiaux indirects susceptibles d'amplifier la déforestation à petite échelle.

Les solutions transversales, aux trois questions abordées dans cette thèse, en faveur d'un paysage durable devraient viser l'optimisation des compromis entre les stratégies de subsistance des ménages, les forêts et/ou les habitats naturels de la faune. Par conséquent, les questions des espaces ressources des communautés, de l'aménagement et de la gestion des habitats naturels sont au cœur du problème. Les décideurs devraient, par exemple, procéder à l'intégration des corridors de mobilité de grands mammifères dont les éléphants de forêt, dans des zones à forte concentration de la faune et loin des espaces communautaires afin de réduire le risque de conflits hommes-faune.