Essays on development and biodiversity conservation in Sub-Saharan Africa

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ESSAYS ON DEVELOPPEMENT AND BIODIVERSITY CONSERVATION IN SUB-SAHARAN AFRICA

Thèse Nouveau Régime
Présentée et soutenue publiquement le 3 Décembre 2014
Pour l'obtention du titre de Docteur ès Sciences Economiques

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Sous la direction de

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A Célestin et Stéphane

Remerciements

Mes remerciements vont tout d'abord à Béniaanh International, ONG ivoirienne de promotion de l'excellence, qui en finançant de façon bénévole mon Master, m'a ouvert la voie pour cette thèse. Ensuite à Modeste Kinane, pour son rôle déterminant dans mon engagement dans ce projet de thèse et à Mr Aka Kouamé, directeur de l'Institut Universitaire d'Abidjan pour son soutien financier.

Je remercie le Pr Pascale Combes Motel pour m'avoir fait confiance en acceptant de m'encadrer pour cette thèse. Ces conseils et relectures expliquent une part importante de la qualité de ce travail. Je voudrais par la même occasion témoigner ma gratitude à l'égard des enseignants et du personnel administratif du CERDI, avec une pensée particulière pour Annie Cuer.

Ma profonde reconnaissance au Pr Inza Koné, un de mes coauteurs, par le biais de qui j'ai intégré le Centre Suisse de Recherche Scientifique (CSRS) à Abidjan qui m'a accueilli pour mes études de terrain en Côte d'Ivoire. Ma reconnaissance va également au Pr Bonfoh Bassirou, Directeur du CSRS ainsi qu'à l'ensemble du personnel administratif et l'équipe de recherche du Département Biodiversité et sécurité alimentaire (DBSA) qui ont facilité et pris une part active aux enquêtes. Un grand merci également aux autorités administratives et aux différents hôtes dans les villages qui ont accueilli nos équipes de recherche au cours des enquêtes.

J'ai une pensée particulière pour mes autres coauteurs, Johanna Choumert, Julie Zähringer, Gudrun Schwilch, qui, de par leur collaboration et nos échanges ont apporté beaucoup à mes travaux de recherche.

Une part non négligeable de l'accomplissement de ce travail, est à mettre au compte des heures de détente et d'échanges en dehors de la recherche. J'ai une pensée particulière pour mes amis tant en Côte d'Ivoire, qu'en France. Et plus particulièrement mes très chers amis Lydie, Sandra, Ghislaine, et Serge-Armand, mes collègues cerdiens, la grande famille des doctorants cerdiens, mes amis du lycée scientifique de Yamoussoukro, mes amis burkinabés rencontrés à Clermont-Ferrand, mes amis des associations africaines d'Auvergne et mes amis de l'association des ivoiriens en Auvergne.

A ma famille qui a toujours cru en moi, et grâce aux prières de qui j'en suis arrivé là. Enfin, à Paul-David mon fils, qui a vu sacrifier la présence maternelle au profit de cette thèse et dont le soutien est pourtant indéfectible.

Résumé

La présente thèse est composée d'un ensemble de travaux de recherche en économie appliquée qui s'inscrivent dans le champ contemporain de l'économie de la biodiversité. La thèse s'intéresse spécifiquement aux liens entre développement économique, bien-être local et conservation de la biodiversité avec comme zone d'étude l'Afrique subsaharienne. Un chapitre introductif présente les questions de recherche débattues dans cette thèse et situe notre contribution dans la littérature.

Le reste de la thèse est composé de deux parties regroupées en études macroéconomiques et en études de terrain. La partie 1 (composé du chapitre 2 et du chapitre 3) aborde le lien biodiversité-développement sous un angle macroéconomique en considérant les interactions spatiales entre pays. Le chapitre 2 examine l'impact du développement en Afrique Subsaharienne sur la biodiversité mesuré à partir d'indicateurs récents sur les espèces menacés. Le chapitre 3 s'intéresse aux mécanismes qui soutiennent les politiques publiques de conservation en Afrique Subsaharienne et teste l'effet du tourisme, de l'aide environnementale et des effets transfrontaliers sur l'effort de conservation. La partie 2 (composé du chapitre 4 et du chapitre 5) présente deux études de cas en Côte d'Ivoire. Le chapitre 4 évalue monétairement les coûts et les bénéfices de la conservation pour les populations locales. Le chapitre 5 examine les préférences des populations pour la conservation et identifie les facteurs clés qui déterminent ces préférences locales. Le chapitre 6 fait une synthèse des résultats en tire les implications en termes de recommandations de politiques et présente de potentielles extensions de la thèse.

Abstract

This thesis is composed of a set of research in applied economics that enroll in the contemporary field of economics of biodiversity. The thesis focuses specifically on the links between economic development, local welfare and biodiversity conservation in sub-Saharan Africa region. An introductory chapter presents the subject of the thesis as well as the research field and situates our contribution.

The rest of the thesis is composed of two parts divided into macroeconomic studies and case studies. Part 1 (composed of chapter 2 and chapter 3) addresses the link biodiversity and development under a macroeconomic perspective by taking into account spatial interactions between countries. In chapter 2, we examine the impact of development in sub-Saharan Africa on biodiversity using recent indicators on threatened species. In chapter 3, we focus on the mechanisms that support public conservation policies in Sub-Saharan Africa and tested the effect of tourism, environmental aid and spillover effects on conservation effort. Part 2 (composed of chapter 4 and chapter 5) presents two case studies in Ivory Coast. Chapter 4 presents a cost benefit analysis using contingent valuation and market price method. It evaluates the costs and benefits of conservation for local populations. In chapter 5 we examine people's preferences for conservation and identify key factors that determine local preferences. In the last chapter we draw implications of results and present potential extensions of this thesis.

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CHAPTER I

I. Introduction Générale

La convention sur la diversité biologique définit la biodiversité comme étant « la variabilité au sein des organismes vivants de toute origine y compris, entre autres, les écosystèmes terrestres, marins et autres systèmes aquatiques et les complexes écologiques dont ils font partie; cela comprend la diversité au sein des espèces, entre les espèces et les écosystèmes » (CBD, 1992). Cette variabilité biologique est aujourd'hui menacée et le rôle de l'activité humaine dans ce processus de dégradation est largement documenté (Ehrlich and Ehrlich, 1992; Rockström et al., 2009; Sala, 2000; Steffen et al., 2007; Vitousek, 1994). L'érosion de la diversité au sein des espèces, entre les espèces et les écosystèmes représente pourtant une menace pour un développement durable (Costanza and Daly, 1992; Díaz et al., 2006; MEA, 2005; Munang et al., 2010; Pearce, 2000).

Le taux d'extinction des espèces est de 100 à 1000 fois plus élevé que les niveaux prédits d'extinction naturel (Pimm et al., 1995) laissant présager une sixième extinction massive (Leakey and Lewin, 1995). Ce niveau de perte de biodiversité menace la résilience et le fonctionnement des services écosystémiques, tels qu'identifiés par le rapport TEEB et l'évaluation des écosystèmes pour le millénaire (MEA, 2005; TEEB, 2010a), indispensables à la vie sur terre (Rockström et al., 2009). De nombreux travaux confirment le rôle de la biodiversité dans la résilience et dans la capacité des écosystèmes à assurer leurs services de support et de régulation (Bennett and Balvanera, 2007; Folke et al., 2004; Loreau et al., 2001; Naeem, 2002). Des auteurs ont mis en évidence le lien entre la diversité biologique et la régulation du climat (Vitousek, 1994), la protection contre les catastrophes naturelles (Diaz et al., 2005), le maintien de la productivité des sols et des plantes (Hooper et al., 2012; Kremen et al., 2007; Tilman et al., 1997), ou encore la régulation de l'eau (Costanza et al., 2006) etc. Les changements dans la diversité biologique, menacent également l'offre des services de prélèvement des écosystèmes, et compromettent ainsi directement les modes de vie et le bien-être humain (Cardinale et al., 2012; Chapin et al., 2000; Daily, 1997; Raudsepp-Hearne et al., 2010; Sala, 2000). En effet, la biodiversité fournit des biens matériels d'usage direct, pour se nourrir, se soigner, se chauffer, se loger, etc. (Haines-Young and Potschin, 2010; MEA, 2005). L'érosion de la biodiversité soulève également de nombreuses autres questions d'ordre éthique et moral (Ehrlich and Ehrlich, 1992; Norton, 1988; Noss and Cooperrider, 1994) ; elle compromet aussi des bénéfices immatériels d'ordre esthétique (Chapin et al., 2000; Hooper et al., 2005; Noss and Cooperrider, 1994), culturel (Krutilla, 1967; Sher et al., 2010), et scientifique (Simpson et al., 1996).

En définitive, on peut affirmer que la biodiversité offre des bénéfices non-négligeables à l'humanité. La conservation de la biodiversité apparait par conséquent comme un choix rationnel pour l'humanité. L'érosion de la diversité biologique évolue pourtant toujours de façon croissante depuis les quatre dernières décennies (Butchart et al., 2010). De plus sans les efforts de conservation cette tendance de dégradation de la biodiversité serait beaucoup plus importante (Hoffmann et al., 2010).

Pour atténuer l'érosion de la biodiversité et maintenir les services écosystémiques qui y sont liés, un agenda de recherche a été identifié dans le sillage de la conférence de Rio et de la convention sur la diversité biologique (Perrings et al., 1992). Les chantiers de recherche à explorer incluent la compréhension de la nature et des conséquences des changements dans la diversité biologique, la mesure de la valeur de la perte de la biodiversité, l'identification des déterminants de la perte de la biodiversité et la recherche d'instruments pour influer sur les comportements humains qui menace la biodiversité. Les programmes de recherche ont évolué depuis la conférence de Rio et des questions actuelles sont celles du lien entre biodiversité et services écosystémiques, des déterminants et plus précisément du rôle du changement climatique et de l'intégration économique mondiale dans l'érosion de la diversité biologique et du développement d'instruments pour capter les bénéfices globaux de la biodiversité (Perrings, 2010).

L'analyse économique peut contribuer à cette « économie de la biodiversité » (Bateman et al., 2011; Bingham et al., 1995; Costanza, 1991; De Groot, 1992; Liu et al., 2010; Pearce and Moran, 1994; Perrings et al., 1995; TEEB, 2010b). Elle est par exemple nécessaire à l'étude des questions de soutenabilité, la mise au point de cadres comptables, à l'évaluation d'instruments nouveaux de préservation ainsi que de méthodes d'évaluation de la biodiversité (Costanza et al., 1991). Certains chercheurs sont assez nuancés quant au rôle de l'économie dans ce champ d'étude (Kallis et al., 2013; Spangenberg and Settele, 2010). L'économie de la biodiversité connait pourtant un intérêt croissant, la conférence des parties de Nagoya sur la diversité biologique l'ayant retenu comme thématique fondamentale (Rodriguez-Labajos and Martinez-Alier, 2013).

Un exemple de la contribution de l’analyse économique à l’économie de la biodiversité est donné par la multitude des travaux sur la valeur de la biodiversité (Daily et al., 2000; De Groot, 1994; Farber et al., 2002; Pearce, 1992; Randall, 1988). Ces trente dernières années, l’évaluation économique des services environnementaux a connu la plus rapide et la plus importante évolution, dans le domaine de l’économie de l’environnement et de la biodiversité (Turner et al., 2003). L’estimation de la valeur monétaire des biens et services offerts par la biodiversité, est nécessaire afin de corriger les défaillances de marché inhérent à l’usage du bien « biodiversité ». En effet, avec ses caractéristiques de bien public, non exclusif et de non rivalité, la biodiversité génère des externalités locales et globales non prises en compte par les marchés. Les défaillances de marché au niveau local et global entrainent des disparités entre les coûts et les bénéfices privés et les coûts et les bénéfices sociaux de la biodiversité. Du point de vue de Pearce and Moran, (1994) ces disparités entre coûts et bénéfices, représentent sous un angle économique la raison fondamentale de la perte de la biodiversité. À ces défaillances de marché, s’ajoutent des défaillances au niveau des politiques publiques qui par la subvention de certains secteurs d’activités créent des incitations pour l’érosion de la biodiversité. La mesure économique de la valeur de la biodiversité est également importante pour guider les choix relatifs à la conservation (Brown, 2005; Myers et al., 2000; Pearce and Moran, 1994).

De nombreux exemples de monétarisation de la biodiversité existent dans la littérature (Costanza et al., 1997; de Groot et al., 2012; Gallai et al., 2009; Geoghegan et al., 1997; Kotchen and Reiling, 2000; Loomis et al., 2000; Loomis and White, 1996; Losey and Vaughan, 2006; Perrings and Walker, 1995; Pimentel et al., 1997; Wilson and Carpenter, 1999). Ces études visent à évaluer partiellement ou en totalité la valeur économique totale de la biodiversité, composé des valeurs de non-usage, des valeurs d’usage direct, des valeurs d’usage indirect et des valeurs d’option (Barbier, 1994; Pearce, 1990). Les méthodes d’évaluation incluent des approches indirectes basées sur l’observation de comportement dont la méthode des coûts de transport, la méthode des prix hédonistes, l’observation des fonctions de production, et des approches directes telles que l’évaluation contingente et la méthode des prix de marché (Desaigues and Point, 1993; Garrod and Willis, 1999; Pearce and Moran, 1994). La méthode d’évaluation contingente est la plus utilisée dans le domaine de la valorisation de la biodiversité car elle est plus pertinente que les approches indirectes pour évaluer les valeurs de non-usage inhérentes à la biodiversité (Bockstael et al., 2000; Christie et al., 2006; Daily et al., 2000; Nunes and van den Bergh, 2001; Pearce and Moran, 1994).

Les exemples de valorisation économique de la biodiversité dans les pays en développement sont limités comparativement à la littérature existante (Christie et al., 2012). De plus, les bénéfices de non usage de la biodiversité sont plus souvent évalués dans les pays développés que dans les pays en voie de développement (Albers and Ferraro, 2003). Pearce and Moran, (1994) relevaient que peu d'études, estimaient un consentement à payer, donc un bénéfice pour la conservation de la biodiversité, dans le contexte de pays pauvres. Malgré l'évolution des études dans le domaine, encore très peu d'exemples existent. Les bénéfices de la biodiversité évalués dans les pays en développement sont donc très souvent restreints à la valeur d'usage directe. Cela représente une limite compte tenu du fait que les bénéfices de non usage sont une part importante de la valeur économique totale de la biodiversité dans les régions pauvres (Nunes and van den Bergh, 2001). L'évaluation de la valeur économique de la biodiversité dans les pays pauvres demeurent donc un domaine d'étude prometteur pour la littérature en économie de la biodiversité (Christie et al., 2008).

Les méthodes d'évaluation économique restent pourtant limitées dans leur capacité à capter l'ensemble des bénéfices de la biodiversité, et à intégrer la complexité des processus et les questions d'incertitude inhérents à la biodiversité (Admiraal et al., 2013; Nunes and van den Bergh, 2001; Salles, 2011; Toman, 1998; Turner, 2000). Elles fournissent tout de même des arguments économiques important pour la conservation (Lamb, 2013; OECD, 2001). Des axes de recherche sur ces thématiques visent justement à améliorer les méthodes d'évaluation. La méthode des choix discrets ou multi-attributs qui permet des évaluations plus détaillées occupe ainsi une place de plus en plus importante dans les évaluations (Adamowicz et al., 1998; Carlsson et al., 2003; Garrod and Willis, 1997; Hanley et al., 1998; Li and Mattsson, 1995; Rolfe et al., 2000).

L'évaluation même exacte des bénéfices offerts par la biodiversité ne suffira pas à assurer la préservation de la biodiversité, ce qui importe ce sont les incitations que les décideurs individuels ou nationaux ont pour conserver ou ne pas conserver la biodiversité (Dixon and Pagiola, 2001). Une question qui relève également de l'économie de la biodiversité, est celle de la recherche d'instruments innovants capable de modifier le comportement des agents économiques, pour substituer et/ou renforcer les approches coercitives et de régulation traditionnelles (Costanza, 1991). Dans la catégorie d'instruments innovants, les incitatifs économiques offrent une approche plus flexible et efficiente pour la conservation de la biodiversité (McNeely, 2006, 1988; Pagiola et al., 2012; Ring et al., 2010). Les incitatifs économiques, en modifiant les coûts et les bénéfices de la conservation et/ou des alternatives, ont montré de nombreux avantages sur les instruments traditionnels dans les pays développés (Bräuer et al., 2006; OECD, 1999). Leur efficacité dans les pays en développement est beaucoup plus nuancé dû à des institutions de marché et administratives moins efficace (Chakraborty, 1997; Milne and Niesten, 2009).

Un autre exemple de la contribution de l'analyse économique à l'économie de la biodiversité vient des travaux qui visent à examiner les processus de décision individuels à la base de la dégradation ou la conservation de la biodiversité (Nelson et al., 2008; Turpie et al., 2003). Peu de travaux s'attèlent à analyser ces décisions à un niveau national ou global. En d'autres termes, des études sur l'offre de biodiversité, pour faire référence aux politiques publiques de conservation, au niveau national ou global sont très peu représentées dans cette littérature. Qu'est ce qui détermine les politiques publiques de conservation, quels sont les facteurs capables d'influencer ces politiques de conservation, demeurent autant de questions de recherche encore peu explorées. Il est important de comprendre comment les décisions prises à un niveau national influencent la biodiversité car elles ont des répercussions sur les décisions individuelles (OECD, 2001).

La recherche de déterminants directs i.e. de facteurs économiques, institutionnels et sociaux responsable de la perte de la biodiversité fait aussi partie du champ disciplinaire de l'économie de la biodiversité. Les effets de facteurs, tels que la pression démographique (Cincotta et al., 2000; Luck, 2007; Luck et al., 2010; McKee et al., 2004), la croissance économique (Czech et al., 2012; Dietz and Adger, 2003; Mills and Waite, 2009; Rosales, 2008; Tisdell, 2003; Wilkie et al., 2000), les changements climatiques (Hughes et al., 2003; Jetz et al., 2007; Parmesan and Yohe, 2003; Pearson and Dawson, 2003; Pimm, 2008; Thomas et al., 2004) sur la perte de biodiversité sont abondamment discutés. Le rôle de la perte des habitats, due à la conversion des terres pour l'exploitation agricole, dans la perte de la biodiversité est par contre largement établie (Aldrich et al., 2006; Donald et al., 2001; Foley et al., 2005; Gockowski et al., 2001; Perrings and Lovett, 1999; Reidsma et al., 2006; Tilman et al., 2001; Tomich et al., 2005).

Des questions transversales non explorées ou peu débattues sont celles relatives à la prise en compte de la dimension transfrontalière de la biodiversité et ce notamment dans le contexte de pays en développement.

La littérature récente souligne la nécessité de prendre en compte les interactions spatiales dans les problématiques liées à la biodiversité (Kerr and Burkey, 2002; McPherson and Nieswiadomy, 2005; Mills and Waite, 2009; Pandit and Laband, 2007a, 2007b; Tevie et al., 2011). Les raisons sont d'abord écologiques car la distribution de la biodiversité dans une zone donnée ne respecte pas forcement les frontières administratives et politiques des pays. D'autres raisons sont liées à de potentiels comportements mimétiques ou stratégiques des pays dans leurs politiques de conservation, ou à des effets de débordement de facteurs exogènes impactant la biodiversité dans un pays donné. Enfin, la raison est aussi méthodologique puisque ignorer la dimension spatiale liée à un phénomène risque d'entrainer des erreurs dans la spécification des modèles économétriques et de conduire à des conclusions erronées (Anselin, 1988; Elhorst, 2014).

Dans la problématique de la préservation de la diversité biologique, les zones caractérisées par un fort potentiel de risques anthropiques méritent un intérêt particulier. C'est le cas pour les régions tropicales pauvres. En effet, les régions tropicales concentrent la majorité de la diversité biologique (Fisher and Christopher, 2007; Leh et al., 2013; Naughton-Treves et al., 2005; Sutton and Costanza, 2002). Elles sont soumises à des pressions d'origine anthropique (Mittermeier et al., 1998; Myers et al., 2000; Pearce and Moran, 1994) en raison d'une aspiration au développement économique et à la réduction de la pauvreté (Sunderlin et al., 2005). Les risques anthropiques font peser une menace d'autant plus forte sur le bien-être des populations pauvres qui sont très dépendantes des services écosystémiques, et ce dans un contexte de croissance démographique et de faible capacité des pays à faire face aux problèmes environnementaux (Albers and Ferraro, 2003; Christie et al., 2012). La compréhension des dynamiques liées à l'érosion et à la conservation de la biodiversité dans ces régions est donc capitale pour le maintien de la biodiversité.

1. Objectifs de la thèse et questions de recherche

Cette thèse s'inscrit dans la littérature ci-dessus présentée et se décline en 4 objectifs spécifiques, dont deux relèvent de problématiques de nature macroéconomique et deux autres de nature microéconomique.

- Le premier objectif de la thèse est de proposer une analyse qui s'inscrit dans la recherche de facteurs expliquant l'érosion de la biodiversité. L'étude intègre la dimension transfrontalière de la biodiversité et fait un focus sur des pays tropicaux pauvres. La question de recherche est posée en ces termes : « *Vu que les pays tropicaux pauvres tendent à rattraper leur retard en matière de croissance et de développement économique et que cela implique la mise en œuvre d'activités économiques intensives en capital naturel, et vu que les approches intégrées de développement qui incluent la conservation de la biodiversité vont vraisemblablement prendre du temps à être effective et efficaces dans ces pays, dans quelles mesures les objectifs de développement dans ces pays compromettent-ils la diversité biologique ?* »

- Le second objectif de la thèse est de proposer une étude relative à l'offre de biodiversité. L'étude intègre également une dimension transfrontalière dans les politiques de conservation de la biodiversité et fait un focus sur des pays tropicaux pauvres. La question de recherche est posée en ces termes : « *Vu qu'il est important de renforcer le dévouement des décideurs publics dans la mise en œuvre de politiques de conservation, les incitatifs économiques sont-ils efficaces au niveau national pour impacter les efforts de conservation des pays ?* »

- Le troisième objectif de la thèse est de proposer une étude relative à l'évaluation monétaire de la biodiversité dans le contexte de pays pauvres. L'étude propose un exemple d'évaluation de bénéfices de non usage de la biodiversité pour des populations rurales pauvres. La question de recherche est posée en ces termes : « *Vu qu'il est nécessaire de saisir les contraintes mais également les arbitrages qui s'imposent aux populations locales qui vivent aux alentours des aires protégées, quelle est la valeur des coûts et les bénéfices de la conservation de la biodiversité pour les populations vivant à proximité d'une aire protégée ?* »

- le quatrième objectif de la thèse est de proposer une étude relative à la demande locale de conservation de la biodiversité. L'étude propose une procédure de choix empruntée à la méthodologie des choix multi-attributs pour l'identification des préférences locales pour la biodiversité. La question de recherche est posée en ces termes : « *Vu qu'il est nécessaire de comprendre les parties prenantes locales que sont les populations pour l'établissement d'aires protégées et d'identifier les asymétries entre demande locale et offre de services environnementaux, quelles sont* *les préférences des populations rurales locales pour la conservation et les facteurs qui les déterminent ?* »

2. Contributions de la thèse

La contribution générale de cette thèse au niveau macroéconomique est de compléter la littérature existante en faisant un focus sur l'Afrique Sub-Saharienne (ASS) et de prendre en compte les potentielles interactions spatiales. Dans les études microéconomiques notre contribution est constituée d'études de cas pour la Côte d'ivoire. Le travail s'est appuyé sur une analyse bibliographique menée sur Web of Science à l'aide de mots clés en lien avec les différents thèmes de la thèse. Les mots clés utilisés pour cette recherche sont présentés dans l'annexe I-A**.** Les résultats sont résumés dans les figures I.2 et I.3. Les contributions spécifiques de la thèse sont détaillées dans chacun des chapitres.

✓ Focus sur l'Afrique subsaharienne comme contribution de la thèse

Les régions en développement ne réduisent pas avec la même efficacité les niveaux de pauvreté (Haughton and Khandker, 2009; Monchuk, 2014). Ces disparités vis-à-vis du décollage économique peuvent également instaurer des inégalités dans la capacité des pays à considérer les problèmes environnementaux.

L'ASS, en abritant la majorité des « points chaud » de la biodiversité en Afrique (cf. figure I.1) et en combinant forte prévalence de la pauvreté, dépendance de l'économie au secteur primaire et endettement (Perrings and Lovett, 1999), apparait comme une zone critique pour le maintien de la biodiversité et des services écosystémiques au niveau global (Fisher and Christopher, 2007; MacKinnon and MacKinnon, 1986). L'ASS abrite le second massif forestier après la forêt amazonienne en Afrique centrale, ce qui représente 15% des forêts tropicales mondiales (FAO, 2010). La région abrite un cinquième des mangroves dans le monde dont 70% en Afrique de l'Ouest (Corcoran et al., 2007). La majorité de la population rurale en ASS est pauvre, est en insécurité alimentaire et est dépendante de l'agriculture (Jalloh et al., 2012). Les risques anthropiques pour la biodiversité dans la région sont donc importants. Pour preuve, plus de 65% des écosystèmes originels y ont déjà été convertis dans les années 1980 (MacKinnon and MacKinnon, 1986). Dans la plupart des pays pauvres en Afrique la conversion de forêts en terres agricoles a cru à un rythme accéléré (Barbier, 2004).

Les activités intensives de collecte et de chasse sont également en ASS une des causes majeures de la perte de biodiversité, au point où certaines espèces ne survivent que du fait de programmes spécifiques de conservation (Perrings and Lovett, 1999).

Le choix de l'Afrique Subsaharienne comme zone d'étude dans la problématique biodiversité-développement est donc un choix qui a tout son sens. Pourtant les études macroéconomiques sur cette problématique pour l'ASS sont très peu représentées dans la littérature (cf. figure I-2). De notre analyse bibliographique sur Web of Science, il ressort que 18% d'articles et/ou de chapitre de livres proches de notre première question de recherche font un focus sur l'ASS et on n'en relève que 16% pour la seconde question de recherche.

✓ Interactions spatiales : contribution méthodologique de la thèse

Les articles existants dans la littérature qui se rapprochent du chapitre 2 (McPherson and Nieswiadomy, 2005; Pandit and Laband, 2007a, 2007b) ne considèrent que des processus spatiaux endogènes dans l'explication de l'érosion de la biodiversité. Des interdépendances spatiales inhérentes à des effets transfrontaliers de facteurs exogènes peuvent pourtant exister. C'est ce que nous considérons dans cette thèse et ce qui différencie cette étude des études existantes dans la littérature. En effet, si 0,6% des études répertoriées dans notre analyse bibliographique intègre l'interdépendance spatiale dans leur analyse (cf. figure I-2), aucune ne teste l'existence de processus spatiaux exogènes liés à l'érosion de la biodiversité. Dans notre seconde étude macroéconomique (chapitre 3), nous considérons l'existence potentielle d'interdépendances spatiales dans les décisions de conservation en ASS. En outre, parmi les études qui se rapprochent du chapitre 3, un faible pourcentage prend en compte l'interdépendance spatiale (0,5%) (cf. figure I-2).

✓ Etudes de cas sur la Côte d'Ivoire : contribution en économie appliquée de la thèse

En ASS, la conversion des habitats, qui est la cause directe principale de la perte de biodiversité, est plus importante en Afrique de l'Ouest que partout ailleurs sur le continent (Perrings and Lovett, 1999). Les forêts guinéennes de l'Afrique de l'Ouest, qui incluent la région forestière australe de la Côte d'Ivoire, font partie des « points chauds » de biodiversité sur le continent (Myers et al., 2000).

La Côte d'Ivoire est en Afrique de l'Ouest l'un des pays le plus riche en termes de biodiversité avec plus de 1200 espèces animales répertoriés (226 espèces de mammifères, 732 espèces de d'oiseaux, 96 espèces de amphibiens, et 153 espèces de poissons) et 3853 espèces de plantes (Konaté and Kampmann, 2010). Son territoire est recouvert en 2012 par 64,8% de terres agricoles, 32,7% de forêts (WDI, 2013). On dénombre 254 aires protégées qui occupent 22,9% du territoire (UNEP-WCMC, 2014) parmi lesquelles des sites classés au patrimoine mondial et réserve de biosphère (Parc National de la Comoé, Parc National de Taï).

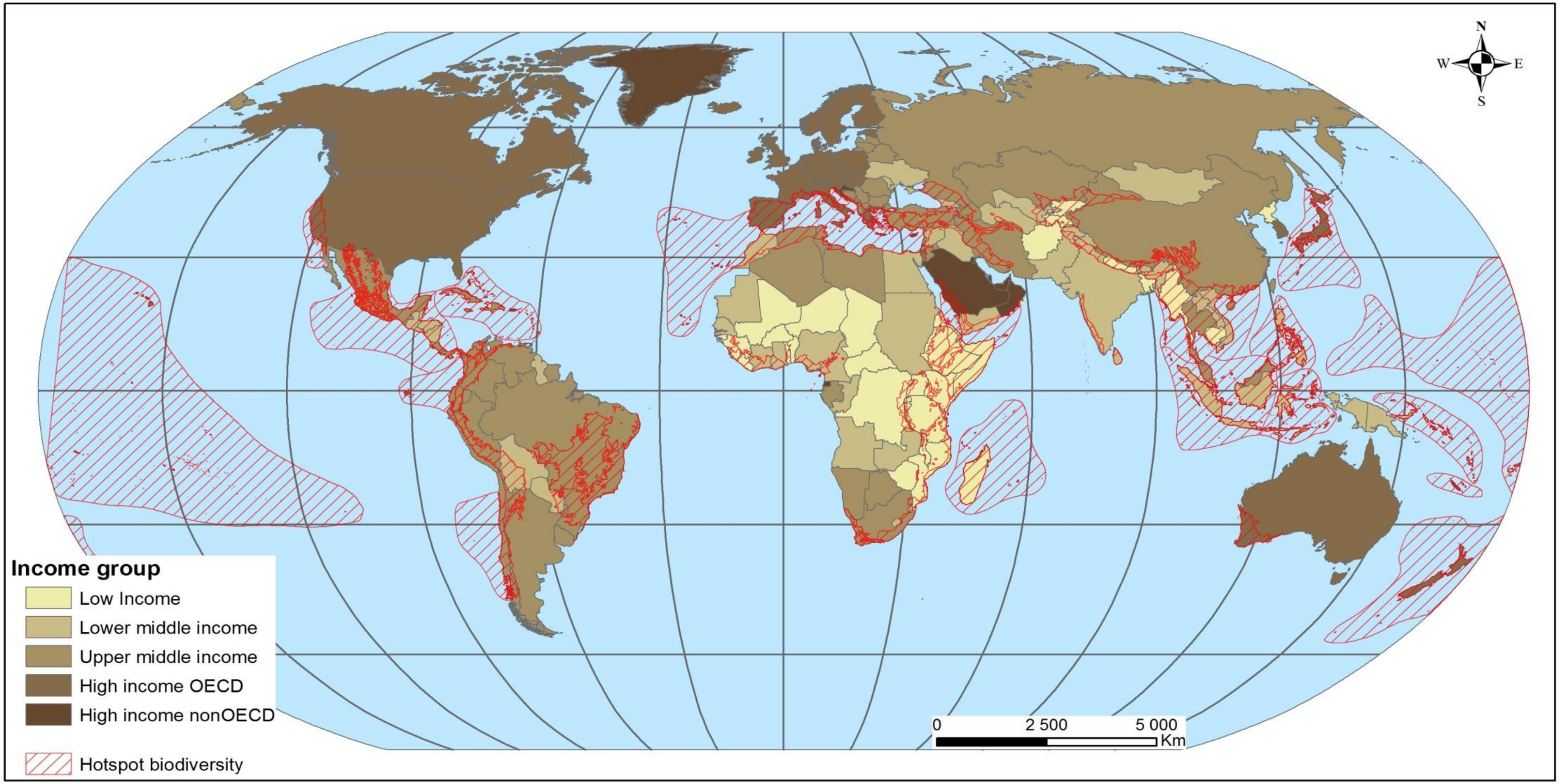
Le maintien des écosystèmes forestiers et partant de la biodiversité est de plus en plus menacé en Côte d'Ivoire par de fortes pression anthropique (IUCN, 2008). Les taux de déforestation annuels y ont été longtemps parmi les plus élevé au monde du fait de la conversion des forêts en terre agricole (Chatelain et al., 2004; Ehui and Hertel, 1992; Poorter et al., 2004). Le taux de déforestation était de 7,6% par an entre 1981 et 1990, et entre 1958 et 1993, 80% de la forêt primaire a disparu.

Des études prouvent empiriquement que les changements dans l'utilisation des terres en Côte d'ivoire impactent négativement les habitats naturels et certains services écosystémiques, entre autres la séquestration du carbone, la purification de l'eau (Leh et al., 2013), la productivité des sols et les rendements agricoles (Ehui and Hertel, 1992).

Les articles traitant de la biodiversité avec un focus sur la Côte d'Ivoire, s'inscrivent en majorité dans les champs disciplinaires de l'écologie (119/408[1] soit 29%) et de la zoologie (118/408 soit 29%) et concernent des études en sciences environnementales. Les dimensions sociales, humaines et économiques de la conservation de la biodiversité en Côte d'Ivoire restent un domaine de recherche à explorer (cf. figure I-3). En effet, nous n'avons trouvé aucune étude à partir de notre analyse bibliographique, relative aux coûts et bénéfices de la biodiversité et relative aux préférences locales pour la biodiversité en Côte d'Ivoire. Pour nos études de cas sur les liens entre aires protégées, bien-être et préférences locales, la Côte d'Ivoire est donc un terrain d'étude valable.

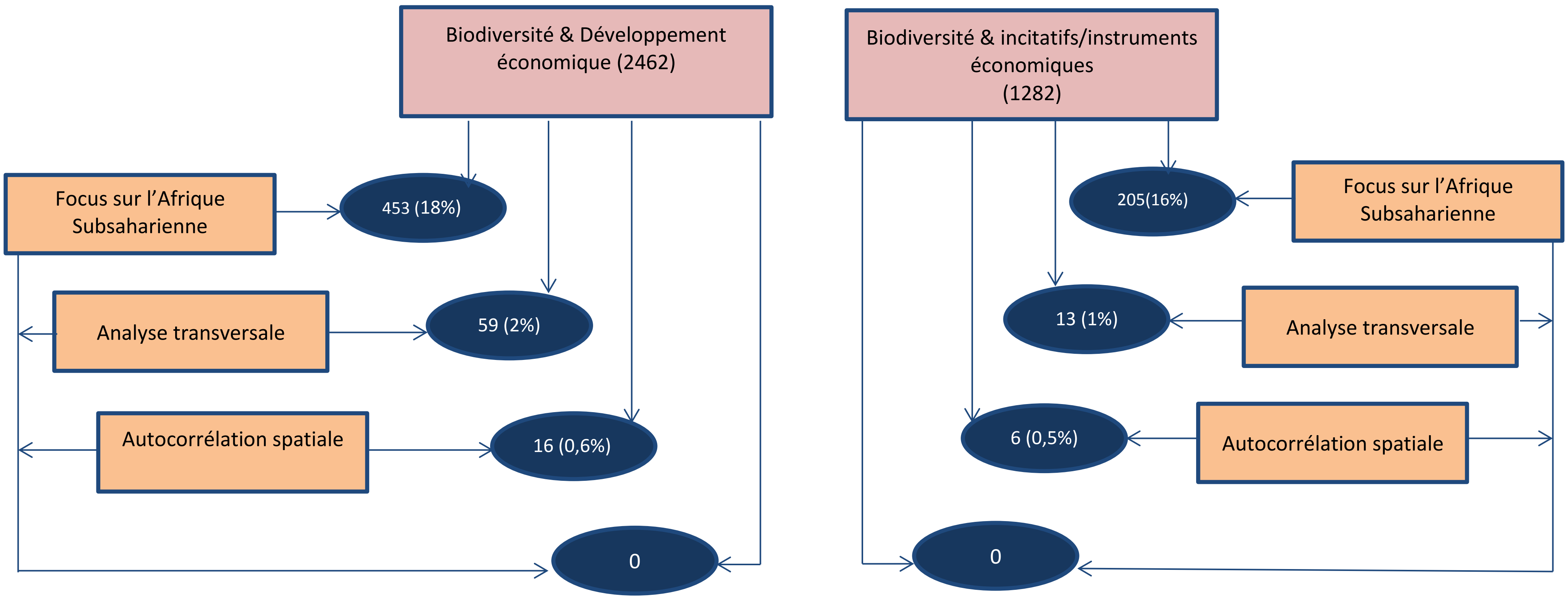
[1] Nombre d'articles et de chapitre le livre sur Web of Science avec les mots clés relatifs à la biodiversité et la Côte d'Ivoire, (TOPIC=(mots clés biodiversité) AND TOPIC=(« Côte d'Ivoire » ou « Ivory Coast »)).

Figure I-1. Développement économique et "points chauds" de la biodiversité



Source: Elaboration par l'auteur sur la base de données provenant des indicateurs de la Banque Mondiale (2012) et de données GIS sur les « points chaud de biodiversité » de Conservation Internationale (2004) (http://www.conservation.org/search/pages/results.aspx?k=%20hotspot%20shape%20file).

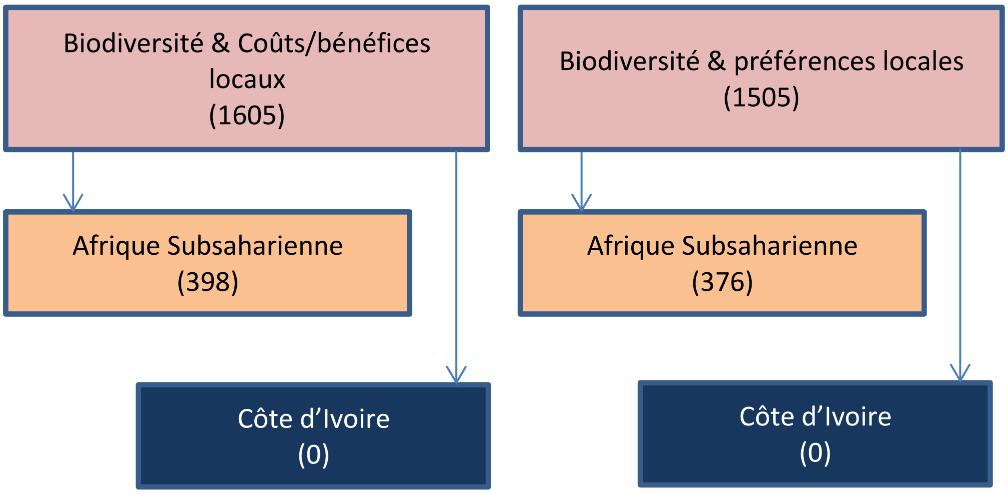
Figure I-2. Nombre d'articles et de chapitre de livres dans la littérature scientifique[2] en rapport avec les thèmes développés dans les articles macroéconomiques de la thèse



Source : Résultats d'analyse bibliographique sur Web of science menée par l'auteur

[2] La liste d'articles et de chapitre de livres est probablement non exhaustive du fait de la spécificité des mots clés. Cette analyse bibliographique permet tout de même d'apprécier l'importance de la recherche en rapport avec les thèmes de recherche développés dans cette thèse.

Figure I-3. Nombre d'articles et de chapitre de livres dans la littérature scientifique en rapport avec les thèmes développés dans les articles microéconomiques de la thèse



Source : Résultats d'analyse bibliographique sur Web of science menée par l'auteur

Appendix I-A. Mots clés utilisés dans l'analyse bibliographique

Thème de recherche	Mots clés
Biodiversité	TOPIC=("biodiversity" or "biological diversity" or "species diversity" or "habitat diversity" or "landscape diversity" or "genetic diversity" or "biodiversity conservation" or "biological conservation" or "species conservation" or "habitat conservation" or "conservation polic*y" or "species loss" or "biodiversity loss" or "ecosystem* services" or "ecological services" or "national park*" or "protected areas*" or "protected area" or "conservation effort" or "biodiversity performance*" or "preserved land*" or "wildlife") OR TOPIC=("forest*" AND biodiversity) OR TOPIC=("endangered spe*cies" or "imperilment spec*ies" or "threatened spec*ies" AND biodiversity)
Afrique subsaharienne	TOPIC: (Angola or Benin or Botswana or "Burkina Faso" or Burundi or Cameroon or cameroun or "Cape Verde" or "Central African Republic" or Chad or Tchad or Comoros or "Congo Democratic Republic" or Zaire or "Congo Republic" or "congo" or "Cote d'Ivoire" or "Ivory coast" or Djibouti or "Equatorial Guinea" or Eritrea or Ethiopia or Gabon or Gambia or Gambie or Ghana or Guinea or Guinée or Guinea-Bissau or guinée_bissau or Kenya or Lesotho or Liberia or libéria or Madagascar or Malawi or Mali or Mauritania or Mauritanie or Mauritius or Maurice or Mozambique or Namibia or Niger or Nigeria or Rwanda or "Sao Tome and Principe" or Senegal or Seychelles or "Sierra Leone" or Somalia or Somalie or "South Africa" or Sudan or Swaziland or Tanzania or Togo or Uganda or Zambia or Zimbabwe or "Sub-saharan africa")
Instruments/incitatifs économiques	TOPIC=("economic* instrument*" or "economic* incentive*" or incentive* or disincentive* or "marked-based instrument*")
Développement économique	TOPIC: ("economic development" or "poverty" or "economic progress" or "economic growth" or "human wellbeing" or "prosperity" or "welfare")
Analyse transversale / Autocorrelation spatial	TOPIC: ("cross section" or panel or "time* serie*") AND TOPIC: (spatial autocorrelation or spatial econometric*)
Côuts /bénéfices locaux	TOPIC=(cost* or benefit* or "opportunity cost*") and TOPIC=(valuation* or value* or "economic valuation" or assess* or estimat*) and TOPIC=(local communities or local community or local people* or rural household* or "local livelihood*" or livelihood* or homeowner* or "neighbouring communities" or "neighbouring community" or local)
Préférences locales	TOPIC: (perception* or attitude* or preference* or "people's participation" or participation) and TOPIC=(local communities or local community or local people* or rural household* or "local livelihood*" or livelihood* or homeowner* or "neighbouring communities" or "neighbouring community" or local)

Part 1: Macro-economic analysis of Biodiversity loss and conservation effort in Sub-Saharan African countries

Partie 1 : Analyse macroéconomique de la perte de biodiversité et de l'effort de conservation de la biodiversité en Afrique Subsaharienne.

CHAPTER II

II. Development and Biodiversity Conservation in Sub-Saharan Africa: a Spatial Analysis[3]

Abstract

The current study seeks to provide a sound analysis of the relationship between economic development and biodiversity loss in Sub-Saharan African countries. The motivation is that a better understanding of the impact of economic development on biodiversity loss is of great relevance, given the current rapid extinction of species along with challenges born from the context of economic development in poor countries. The analysis draws on the most up-to-date data on threatened species from 48 sub-Saharan African countries. Assuming that spatial autocorrelation is a typical problem for biodiversity data, we use Maximum-likelihood estimators to account for spatial-autoregressiveness in the dependent variable, as well as in the explanatory variables of the models. We find evidence that supports a decrease of biodiversity loss, measured as the percent of threatened bird species, with increasing income per capita. The results also reveal some species-level differences in the biodiversity-development relationship, since we find no significant impact of economic development measured as per capita income on threatened mammal species. This analysis contributes to the literature by partially challenging the paradigm of a strictly positive relationship between biodiversity loss and economic growth in a developing countries context.

JEL codes: C21, Q32, Q56

Keywords: Biodiversity, threatened species, spatial econometrics, spatial Durbin model

[3] This chapter draws on a research paper "Development and biodiversity conservation in Sub-Saharan Africa: A spatial analysis," Working Papers 201302, CERDI, in collaboration with Dr Choumert Johanna, Associate Professor of Economics, CERDI, School of Economics, University Auvergne.

1. Introduction

The depletion of biodiversity is now one of the most important environmental threats that humanity faces (Chapin et al., 2000; MEA, 2005; Tilman et al., 1997). Regarding the consequences of biodiversity loss, not all people are impacted equally. Changes in ecosystems disproportionately harm many of the world's poorest people, who are less able to adjust to these changes and for whom poverty means they have limited access to substitutes or alternatives (MEA, 2005). The less developed regions in the world, where the poorest people who are most vulnerable to biodiversity loss live, are also regions where threats to biodiversity are the highest (Billé et al., 2012; Roe, 2010; Turner et al., 2012). The Sub-Saharan Africa (SSA) region is a good illustration of such a developing region that is at the forefront of priorities in terms of conservation as well as development needs (Fisher and Christopher, 2007) (Cf. Figure I.1, p 13). Indeed, the needs for reducing poverty and vulnerability are the greatest in SSA according to World Bank reports (Monchuk, 2014). The SSA region is also home to almost one-quarter of the “biodiversity hotspots,” i.e. areas around the world where exceptional concentrations of endemic species are undergoing exceptional loss of habitat (Myers et al., 2000).

The CBD (Convention on Biological Diversity) decisions (UNEP, 2012) and Aichi targets (UNEP, 2010) recommend moving forward with integrated strategies that tackle conservation and development issues together. Despite some progress being made towards achievement of these goals through the implementation of incentives like REDD+ (Reducing Emissions from Deforestation and forest Degradation) and PES (Payments for Ecosystem Services), it would be a fairly safe assumption that the current impacts of these pro-conservation tools are not very perceptible in the on-going development strategies in developing areas. It is therefore important to further discuss whether continued efforts to meet development and poverty reduction targets will not lastingly compromise biodiversity. In others words, since we need to deal with development and poverty challenges for regions which are also “biodiversity hotspots,” shall we be optimistic or pessimistic about biodiversity and the maintenance of related environmental services?

The matter of whether economic development worsens or strengthens biodiversity conservation has been widely analyzed in the literature. A number of researchers share a pessimistic view and forecast a conflict between economic growth and biodiversity conservation (Chambers et al., 2000; Czech, 2003; Trauger, 2003). Some works have found that increased growth of the economy implies higher threats to biodiversity (Asafu-Adjaye, 2003; Freytag et al., 2012). Other scholars reject the monotonic relationship assumption and argue that the relationship between economic growth and biodiversity conservation varies along the development path. They predict a “virtuous circle” after a threshold of development is reached (McPherson and Nieswiadomy, 2005; Mills and Waite, 2009; Naidoo and Adamowicz, 2001; Pandit and Laband, 2007a) and advocate for a biodiversity Kuznets curve (BKC). The logic is that when enough financial wealth accumulates, especially in per capita terms, society refocuses on solving environmental problems (Czech, 2008). As we can see, empirical findings have not yet provided a clear-cut answer to the question of the impact of economic development on biodiversity. In this paper, we propose further investigation on the issue and provide the first sound analysis for the SSA region with a focus on spatial interactions in our modeling techniques.

Including spatial interactions in the development-biodiversity relationship is important for several reasons. First, the distribution of species is determined by geophysical, atmospheric, and ecological factors that cut across political jurisdictions (Kerr and Burkey, 2002; Pandit and Laband, 2007a). Factors that threaten biodiversity may extend or operate beyond arbitrary political boundaries and risks to biodiversity in one country may similarly impact biodiversity in neighboring countries through spillover effects (see (McPherson and Nieswiadomy, 2005; Mills and Waite, 2009; Pandit and Laband, 2007a)). Second, national policies for conservation may be influenced by policies in neighboring countries or by regional policies, resulting in a pattern of political spatial dependence (Sauquet et al., 2012). Third, unobserved variables may be related by a spatial process; in the case of biodiversity, these may be climatic variables. As a matter of fact, regarding biodiversity, there may be several sources of spatial dependence between countries.

The argument proceeds in five parts. First, we present previous findings in analyzing the link biodiversity-development by focusing on methodological issues. Second, we describe our methodology. Third, we present the data. Fourth, we present our results. Then we discuss the results, while a final section concludes and shows how our findings can inform policymakers.

2. Assessing impact of economic development on biodiversity loss: previous findings and methodological issues

A number of works investigated the impacts of economic development on biodiversity loss (see appendix II-A for a comprehensive view). They have considered some methodological issues. The first is related to the choice of biodiversity indicator, the second to the shape of the relationship, the third to spatial autocorrelation in data.

2.1 On the choice of biodiversity indicator

Studies of how development path affects biodiversity loss run into difficulties in measuring threat to biodiversity. How should the threat to biodiversity be measured? What dimensions of threat should be considered?

The theoretical arguments that could support the empirical evidence for a relationship between economic development and biodiversity loss provide some answers. According to (Naidoo and Adamowicz, 2001), the changes on threat to biodiversity along the development path is a result of the interaction of income elasticity, institutional design, and biological characteristics. The rise of income per capita would result in a higher demand for biodiversity conservation that would induce policy responses, manifested by more stringent conservation policies. To the extent that individual preferences may be expressed, it is likely that the link income-biodiversity will vary by its components. As evidence, diverse studies show that conservation efforts have been motivated less by the degree of threat and more by whether some species belong to a particular charismatic taxonomic group (Dawson and Shogren, 2001; Mahoney, 2009; Metrick and Weitzman, 1998, 1996; Simon et al., 1995). Furthermore, according to (Czech et al., 1998), some taxa (birds and mammals) are particularly advantaged in terms of both their social construction and the amount of political power endowed to them by various conservation groups. Following these arguments, biodiversity should not be considered as a whole in applied works investigating a biodiversity-development relationship.

In this vein, many studies use threatened species as biodiversity indicators (Kerr and Currie, 1995; McPherson and Nieswiadomy, 2005; Naidoo and Adamowicz, 2001; Pandit and Laband, 2007a). They find robust evidence for a biodiversity-development relationship but not for all taxonomic groups, confirming species-level difference in the biodiversity-development relationship.

Using threatened species as biodiversity threat indicator is criticized for not considering ecosystem sustainability. This indicator provides in fact little information on whether the health of ecosystem is compromised or not, as some index do. The Ecological Footprint (EF) has been widely used a leading indicator of biophysical or ecological dimension of sustainability with respect to development indicators (Bagliani et al., 2008; Caviglia-Harris et al., 2009; Jorgenson and Burns, 2007; Wang et al., 2013).

Biodiversity indicators based on threat to specific species have also been criticized for not including a dimension of state's response towards threat. In this direction, Mozumder et al. (2006) use the National Biodiversity Risk Assessment Index (NABRAI) that includes conservations measures to investigate about patterns of development and their relationship to biodiversity. The studies using a multidimensional indicator do not support, in general, a biodiversity-development relationship for biodiversity (Mozumder et al., 2006; Tevie et al., 2011). That likely reveals the ambiguousness of a global indicator in analyzing biodiversity-development relationship. A problem would be the interpretation of a multidimensional indicator in a biodiversity-development relationship. Taking the example of an indicator that include different risk dimension, it would be quite difficult to identify a differentiated impact of economic growth on each one.

As the purpose of our study is to check for the impact of development on pressure to biodiversity specifically, and following previous findings on species-level differences, we then rely on threat measure by taxon as indicator.

2.2 On the shape of the biodiversity-development relationship

Another important striking point in the literature on biodiversity-development relationship is the shape of the relationship. Is the relationship monotonic or non-linear? How is the shape of the curve if the relationship is non-linear?

A non-linear relationship in the light of the Environmental Kuznets Curve (EKC) hypothesis admits the expectation to see a "rising limb" at higher income levels, assuming, for instance, an increase in species diversity of the same magnitude of their loss. Yet, biodiversity belongs to a special class of environmental degradation that involves complex ecosystems the loss of which cannot be recovered by technological advances (Asafu-Adjaye, 2003). Furthermore, the process by which species become extinct proceeds markedly more rapidly than that by which new species are created (Schubert and Dietz, 2001), so such replenishment of species diversity at the same rate of their loss seems impossible. It is thus more likely that threat to biodiversity increases (or decreases) monotonically with income levels (Bagliani et al., 2008). Linear relationship evidence has been found in many papers with no test of others specification (Asafu-Adjaye, 2003; Freytag et al., 2012; Kerr and Currie, 1995), and while other specifications were tested (Clausen and York, 2008; Pandit and Laband, 2009; Wang et al., 2013).

Even if the irreversibility of the relationship is understandable, due to ecological thresholds (Dasgupta, 2000) and the unique nature of the damage (e.g., loss of critical habitat and keystone species), a biodiversity Kuznets curve (BKC) is theoretically possible, albeit perhaps very difficult to achieve (Mills and Waite, 2009). Wealthier countries are better able to afford policies designed to protect threatened species and may substitute towards industrial and agricultural technologies that are less damaging to the environment (McPherson and Nieswiadomy, 2005). Wealthier countries can also more easily undertake ecological restoration programs (natural recolonization or reintroduction), which would reverse biodiversity losses and thus support the BKC. These anthropic actions to overcome the loss of biodiversity are however criticized for encouraging the exploitation of biodiversity and for their mixed effectiveness in restoring biodiversity (Bullock et al., 2011)

Schubert and Dietz (2001) proposed that, instead of a quadratic shape, the BKC may be modeled as a hyperbolic curve. The hyperbolic BKC postulates that structural changes or income elasticity of demand for biodiversity cannot reverse the impact of development acceleration on biodiversity loss but instead slow down biodiversity loss. They have tested a linear, quadratic, and hyperbolic functional form, for species richness and income per capita. They found that the quadratic form has no better fit than the others but failed to empirically identify the best shape for the relation between income and biodiversity. Dietz and Adger (2003) also failed to provide evidence to justify preference for a hyperbolic BKC in comparison with a linear relationship. Mills and Waite (2009) notice that Dietz and Adger (2003) inadvertently obscure a parabolic relationship by the way they graphed their data. Extending the work of Dietz and Adger (2003), and using species richness they find that the quadratic model is significant and better than linear and hyperbolic models. Testing linear and quadratic functional form, the findings of Naidoo and Adamowicz (2001) indicate a U-shape relationship for Birds and a positive and linear relationship between threatened species and income for others taxonomic group, advocating a species-level difference.

As there is no clear cut evidence for the shape of the biodiversity development relationship, this study will provide estimations for linear, quadratic as well as hyperbolic functional forms.

2.3 Spatial interactions

A recent development in literature on the link between environment and development is the incorporation of spatial information to account for spatial autocorrelation. That comes in answer to a critic of Rupasingha et al., (2004) stating that although geographical areas (or cross-sectional units) form the basic unit of analysis in most environment-development studies, virtually all have ignored underlying spatial relationships among units. Ignoring spatial dependence leads to model misspecification (Anselin, 1988). Accounting for transboundary influences could significantly alter the perceived shape of the relation environment-development (Maddison, 2006).

Concerning biodiversity, spatial autocorrelation is a typical problem (Kerr and Burkey, 2002). Indeed, the distribution of plants and animal species is determined by geophysical, atmospheric, and ecological factors that cut across political jurisdictions (Pandit and Laband, 2007b). Consequently, factors that influence biodiversity threats may extend or operate beyond arbitrary political boundaries and risks to biodiversity in one country may similarly impact biodiversity in neighboring countries through spillover effects.

McPherson and Nieswiadomy (2005) were the first to consider the problems surrounding spatial autocorrelation, investigating biodiversity-development relationship. They find evidence for both endogenous interaction effects (spatial autoregressive model-SAR) and interaction effects among the error terms (spatial error model-SEM). In others words, they find that the percentage of threatened species in one country is jointly determined with that of neighboring countries and that unobserved shocks follow a spatial pattern. Evidence of significant spatial autocorrelation with respect to biodiversity indicators through SAR model have been found in different works (Pandit and Laband, 2009, 2007a, 2007b; Tevie et al., 2011). Only one study establishes that SEM models result in greater explanatory power than SAR models for threatened mammals, birds, amphibians, and vascular plants (Pandit and Laband, 2007b). Using ecological footprint as indicator, Wang et al. (2013) indicate that SEM model should be employed to capture the geographic spillover effects.

Regarding the impact of spatial information on findings, (Pandit and Laband 2007b, 2007c) notice that spatial dependence affects their results only for mammals and amphibians. Mills and Waite (2009) on the contrary, find that the inclusion of the spatial covariates does not change the results or the direction of any of their previous models with species richness as biodiversity indicator. In Tevie et al. (2011), spatial specifications outperform significantly ordinary least square model but don't change their findings on income variables. In Wang et al. (2013) incorporation of spatial autocorrelation plays an important role in shaping the income–footprints relationship.

Development of spatial econometrics advocates for models that include both endogenous and exogenous interaction effects (Corrado and Fingleton, 2011; Elhorst, 2010; LeSage and Pace, 2009) , in a model labelled spatial Durbin model (SDM). The SDM is a special case of spatial lag, which adds spatial lag on independent variables (Anselin, 1988). This model admits that the dependent variable of a particular unit depends on independent explanatory variables of others units (Elhorst, 2014). According to Corrado and Fingleton (2011), the significativity of spatial scalar in classic spatial lag models may capture the omission of spatially correlated omitted variables.

Face to the plethora of alternative model specifications, LeSage (2014) indicates that there are only two model specifications worth considering for applied work, SDM (spatial Durbin model) and SDEM (spatial Durbin error model) that subsume others specification: "*If one can narrow down the relationship being investigated as reflecting a local spillover situation, then the SDEM model is the only model one needs to estimate and for the case where a global spillover specification is implied by theoretical or substantive aspects of the problem, one need only estimate an SDM specification*". Local spillovers occur when endogenous interaction and feedback effects are not present otherwise the spatial pattern is a global spillover scenario (LeSage 2014). To the best of our knowledge, the study of Wang et al., (2013) is the only one that has estimated a SDM model investigating biodiversity-development relationship. They found that explanatory variables in neighborhood countries influence domestic measure of pressure on ecosystems.

Given the fact that there is more evidence in previous findings for a spatial pattern related to endogenous interaction with single-species indicator in literature as described earlier, we then rely on a global spillover specification and run a spatial Durbin model. In this way, our paper is the first to consider a spatial Durbin model, investigating the impact of economic development on biodiversity loss at regional scale.

3. Methodology

Firstly, in order to choose the functional form between biodiversity and economic development (lin-lin, log-log, lin-log, or log-lin form relationship), we shall test a Box-Cox transformation, as described below:

$$Y_i^{(\theta)} = \alpha_0 + \sum_{k=1}^{K_1} \alpha_k . x_{1ik}^{(\lambda)} + \sum_{k=K_1}^{K_2} \alpha_k . x_{2ik} + u_i \ , \qquad [1]$$

where $i = 1, \ldots, 48$ countries; Y_i: the biodiversity threat measure in country i; x_{1k}: the K_1 transformed quantitative variables; and x_{2k}: the other K_2 quantitative variables. And where $Y_i^{(\theta)}$ and $x_{1ik}^{(\lambda)}$ are respectively, the Box-Cox transformations of the biodiversity threat measure and countries' characteristics.

$Y_i^{(\theta)} = (Y_i^{(\theta)} - 1)/\theta$ if $\theta \neq 0$, $Y_i^{(\theta)} = \ln(Y_i)$ otherwise.

$x_{1ik}^{(\lambda)} = (x_{1ik}^{(\lambda)} - 1)/\lambda$ if $\lambda \neq 0$, $x_{1ik}^{(\lambda)} = \ln(x_{1ik})$ otherwise.

We shall then estimate the model on a set of different values of θ and λ and find out the best functional form.

Secondly, to capture spatial dependence among countries, we shall use spatial econometric techniques. To take into account spatial dependence and its magnitude among countries belonging to our sample, we look for evidence that the values for the percentage of threatened species of a taxon in SSA countries are more spatially clustered than they would be under random assignment. Spatial autocorrelation measures the intensity of the relationship between observations and their degree of resemblance. Each observation is described by one attribute (the dependent variable) and by proximity relations (weight matrices). If the presence of the attribute in one country makes its presence in a nearby country more or less likely, then there is spatial autocorrelation. There is no spatial autocorrelation if there is no relationship between the proximity of countries and their degree of resemblance. Whatever the source of spatial dependence, standard econometric techniques are no longer appropriate, especially the method of ordinary least squares. Instead, other estimators are proposed in the literature (see Anselin 1988, LeSage and Pace, 2009).

We define two weight matrices: (i) Matrix W^{c}_{ij} is based on 1st order contiguity, i.e. two countries are neighbors if they share a common border and (ii) Matrix W^{B}_{ij} contains the length of common borders between two countries. Both are row-standardized.

Following recent developments in spatial econometrics (Corrado and Fingleton, 2011; Elhorst, 2010; LeSage, 2014), and, given the arguments discussed earlier, we estimate a spatial Durbin model, such that

$$Y = \lambda WY + \beta X + \theta WX + \varepsilon$$
$$\varepsilon \sim N(0, \sigma^2 I) \quad [2]$$

Y is the $N \times 1$ vector of values of the dependent variable. W is an $N \times N$ spatial weight matrix. X is an $N \times K$ matrix of K explanatory variables. β is a $K \times 1$ vector of parameters. ε is an $N \times 1$ vector of errors terms. WX is an $N \times k$ matrix of spatially lagged explanatory variables. λ and θ are scalar spatial parameters. λ reflects the magnitude of spatial dependence between observations. This spatial parameter measures the intensity of spatial interactions through the lagged dependent variable, i.e. the dependence of a country on nearby countries. θ is a measure of exogenous interactions effects. This spatial parameter measures the intensity of spatial interactions through independent explanatory variables of others units.

4. Data

The definition, interpretation, and sources of data are given in Appendix II-B. The Percentages of Threatened Species (PTS) for birds and mammals at the country level for SSA countries measure the pressure on biodiversity. Birds and mammals species are the only taxonomic groups for which all species have been reviewed by the International Union for Conservation of Nature (IUCN) (Hilton-Taylor and Mittermeier, 2000). Hence we will estimate the model for two dependent variables, PTS_{BIRD} and PTS_{MAM}. We calculate the latter for each taxon as the percentage of threatened species to known species in 2011 for mammals and in 2012 for birds. Gross domestic product per capita (PCGDP) in constant 2005 US$, normalized for purchasing power, is used as an indicator of economic development.

Socio-economic and ecological characteristics of countries are introduced as control variables. For socio-economic data, we use population density (per km^2) at the country level (DENS), as Dietz and Adger (2003), Asafu-Adjaye (2003), and Pandit and Laband (2007).

Following Kerr and Currie (1995), and Asafu-Adjaye (2003), we also employ the percentage of agricultural land area (AGRI). We use as ecological variable, the percentage of endemism in birds (PES_{BIRD}) and endemism in mammals (PES_{MAM}) in each country, as Naidoo and Adamowicz (2001), McPherson and Nieswiadomy (2005), Pandit and Laband (2007), and Pandit and Laband (2009). We consider national conservation policies as Naidoo and Adamowicz (2001), Freytag et al. (2012). To do so, we use the duration of existence of the first protected area in the country (DURPA). For the specific context of SSA, we control for experience of political instability and violence (PV) and for high rates of poverty (POV).

Variables are averaged over the 1992-2011 period, in line with McPherson and Nieswiadomy (2005). The intuition behind this procedure is to account for the fact that an indefinite span of time exists between anthropogenic factors and changes in biodiversity. This procedure also makes our study immune to short-term effects. Our sample consists of 48 observations which gather all sub-Saharan African countries (cf. Appendix II-C for the list of countries). Table II-1 presents descriptive statistics for all variables.

Table II-1. Descriptive statistics of variables used in the models

Variables	Unit	N	Mean	S.D.	Min	Max	Year
PTS_{BIRDS}	%	48	3.64	3.41	0.66	15.29	2012
PTS_{MAM}	%	48	9.44	5.81	3.22	31.58	2011
PCGDP	Constant 2005 US$	48	2747.83	4079.16	311.89	18245.49	
POV	%	48	51.12	15.35	9.53	81.2	
DENS	hab./km^2	48	76.62	106.68	2.32	587.74	
AGRI	%	48	47.94	21.25	8.24	86.54	
PV	score	48	-0.41	0.95	-2.69	1.36	
DURPA	number of years	48	63.81	25.82	6	117	
PES_{BIRDS}	%	48	2.86	8.02	0	43.98	2012
PES_{MAM}	%	48	4.17	11.93	0	80.09	2011

Unless otherwise stated all variables are averaged over the 1992-2011 period

5. Results

The estimation procedure[4] of the linear Box-Cox functional form (equation 1) indicates that the value of θ and λ are, respectively, 0.61 and 1.24 for mammals and 0.46 and -0.44 for birds. We perform a comparison test model which calculates the value of the following test: -2($LM_{constraint}$ - $LM_{non\ contsraint}$) where the term $LM_{constraint}$ (resp. $LM_{non\ constraint}$) corresponds to the value of the logarithm of the maximum likelihood of the constrained model (respectively of the non-constrained model). This formula can be adjusted by iterations to obtain the best possible transformation, according to maximum likelihood criterion. It allows estimating the model parameters with or without restrictions. This test follows, asymptotically, a χ^2 with two degrees of freedom. In the case of birds, the hypothesis θ=0 is accepted at the 1% threshold (the transformation of λ is rejected). The log-linear form is retained for the subsequent estimation for birds models. For mammals, the linear form is retained.

In our model, there is no issue of multicollinearity. We use Variance Inflation Factors (VIFs) to detect it. VIF values for variables other than PCGDP and $PCGDP^2$ do not exceed 2.02[5], which is in line with the most conservative rule of thumb.

Following the spatial tests in Appendix II-D, we can reject the hypothesis that the models allow for both sources of spatial dependence, i.e. spatial lag on the dependent variable and spatially autocorrelated residuals. Furthermore, the robust LM tests validate spatial lag term instead of spatially correlated error structure. Testing the SDM, which adds spatial lagged independent variables to the model, the Likelihood Ratio test (WX's=0) does not reject the hypothesis that the set of spatially lagged independent variables are significant in all specifications and with the two matrices for birds and mammals models (see Table II-2 and Table II-3). We retain, therefore, the SDM specification for birds and mammals models.

Spatial models fit better than models that omit spatial dependence, with respect to some model selection diagnostic criteria (adjusted R^2, log-likelihood and Akaike information criterion (Table II-2 and Table II-3). The spatial analysis reveals also some species-level differences. We find that the percentage of threatened mammal species in one country depends mainly on the level of threatened mammal species in neighboring countries. The

[4] The econometric analysis is performed using STATA software.
[5] Mean VIFs range from 1.33 and 1.47 and reach 5.54 when both PCGDP and $PCGDP^2$ are included.

source of spatial dependence for threatened bird species is, however, mainly due to the intensity of some characteristics of neighboring countries. These results corroborate that spatial analysis needs to be done in order to explain the pattern of threatened species.

As robustness check for the specification, we compare SDM model to SDEM (model with spatially auto-correlated residuals) and to SLX (model with no spatial dependent variable) and we find SDM model more appropriate in all cases using the Akaike information criteria (Cf. Appendix II-E).

6. Discussion

The model for bird species shows evidence of a statistically significant relationship between income per capita and the percentage of threatened bird species in linear and hyperbolic specification with all weight matrices. The model for mammal species shows, on the contrary, that the percentage of threatened mammals in a SSA country is not related to income per capita. Income per capita is not significant in all mammals models, except the variable GDP_LAG, whose marginal effect (cf. Appendix II-F) is however null. Previous works (McPherson and Nieswiadomy, 2005; Pandit and Laband, 2007c) have found a significant relationship between threatened mammals and GDP but for a group of developed and developing countries. This result advocates for studies on homogenous group of countries and geographical areas.

The results reveal also some species-level differences in the biodiversity-development relationship, in line with previous findings (Kerr and Currie, 1995; Naidoo and Adamowicz, 2001; Pandit and Laband, 2007a). The results confirm then that the development-biodiversity relationship is complex and non-homogeneous across taxa groups. They also confirm the fact that the use of synthetic indicators in the biodiversity-development relationship is problematic.

The results also advocate for a hyperbolic, non-linear relationship between threatened birds and income per capita, rather than an inverted-U relationship. This is in line with Dietz and Adger (2003). The data also support a negative linear relationship between threatened birds and income per capita. The magnitude of the effect of income per capita in the linear model is however negligible (cf. Appendix II-F).

Table II-2. Non-spatial and DURBIN models log threatened birds

	Non -spatial models			DURBIN models with W^{C}_{ij}			DURBIN models with W^{B}_{ij}		
	Linear	Quadratic	Hyperbolic	Linear	Quadratic	Hyperbolic	Linear	Quadratic	Hyperbolic
PCGDP	-2.7E-05*	-6.00E-05		-3.5E-05***	0.1E-05		-4.9E-05***	-2.00E-05	
PCGDP2		2.14E-09			-2.32E-09			-1.83E-09	
$PCGDP^{-1}$			211.4842**			122.9622**			112.0014*
POV	-0.0127***	-0.0136***	-0.0161***	-0.0077***	-0.0059*	-0.0100***	-0.0095***	-0.0085***	-0.0110***
DENS	0.00112*	0.0010*	0.0007	0.0002	4.4E-05	0.0004	-7.3E-05	-0.0002	0.0003
AGRI	0.0037	0.0044	0.0064**	0.0025	0.0023	0.0044**	0.0035*	0.0033*	0.0047**
PV	-0.1087*	-0.1040*	-0.0760	-0.0962***	-0.0932**	-0.0803**	-0.1017***	-0.1026***	-0.0842**
DURPA	-0.0051**	-0.0052**	-0.0051**	-0.0018	-0.0017	-0.0020	-0.0023*	-0.0023*	-0.0028**
PES_{BIRDS}	0.0565***	0.0560***	0.0568***	0.0400***	0.0419***	0.0572***	0.0386***	0.0385**	0.0622***
PCGDP_LAG				6.5E-05***	8.5E-05		5.7E-05	3.7E-05	
PCGDP2_LAG					-2,06E-09			1,27E-09	
$PCGDP^{-1}$_LAG						-149.8664			91.0110
POV_LAG				0.0091	0.0100	0.0065	0.0035	0.0042	-0.0026
DENS_LAG				-0.0008	-0.0004	-0.0019*	-0.0011	-0.0010	-0.0031***
AGRI_LAG				0.0080**	0.0080**	0.0075*	0.0049	0.0049	0.0081**
PV_LAG				0.0206	0.0156	-0.0834	0.0247	0.0235	-0.0083
DURPA_LAG				-0.0050	-0.0046	-0.0055	-0.0045	-0.0039	-0.0030
PES_{BIRDS}_LAG				0.0235**	0.0292**	0.0117	0.0312**	0.0337**	0.0092
_cons	1.624110***	1.690984***	1.426297***	0.8154	0.6537	1.1676*	1.3813**	1.2647**	1.3580***
λ				-0.0746	-0.1593	-0.1167	-0.0717	-0.0962	-0.1108
N	48	48	48	48	48	48	48	48	48
r2_a	0.70	0.70	0.72	0.69	0.67	0.69	0.70	0.68	0.72
Log-likelihood	-12.581834	-12.314517	-11.280631	15.7670	16.6019	12.9705	13.4507	13.7532	12.1253
AICc	45.9005	48.5750	43.2981	17.7116	23.7633	17.7101	17.7065	23.7615	17.6961
LR test (wX's =0) P-Value > Chi2				0.0002	0.0002	0.0120	0.0019	0.0036	0.0225

*p<0.1; **p<0.05; ***p<0.01. Parameters estimation of the SDM is performed by Maximum Likelihood Estimation (MLE).

According to these results the pressure on biodiversity in the SSA context, measured as a percentage of threatened birds, could slow down as income per capita rises. Based on these findings, we can temper the pessimistic view concerning the development-biodiversity relationship in a developing country context with data from SSA countries. We can argue that economic development is not totally incompatible with species conservation even in developing areas like SSA countries.

In fact, our analysis provides evidence that a lessened threat on bird species is associated with higher income per capita in SSA. Previous works have demonstrated that in wealthy countries birds receive greater conservation attention than other taxonomic groups, regardless of relative degrees of threat (Simon et al., 1995). Based on our findings, we can also suppose that the protection of bird species is more stringent in wealthier countries in SSA. It seems more likely that certain institutions may make conservation of birds less difficult than that of other taxonomic groups (Naidoo and Adamowicz, 2001). Conservation efforts for mammal species could be more challenging, as many mammal species are relatively large and require much larger tracts of undisturbed habitat than birds to maintain viable populations (Noss et al., 1996). In addition, mammals, particularly large mammals, have also been vulnerable to the expansion of subsistence-oriented human economies for several reasons, including competition for resources, danger as predators, and value as food and clothing (Burghardt and Herzog, 1980; Kellert, 1985).

The results enable additional conclusions to be drawn explaining some sources of pressure on bird and mammal species in SSA. It seems that in the SSA context, the poorest countries where more people are below the poverty line exert less pressure on species. This could reflect the lack of *means* of these countries to implement intensive economic activities that would threaten biodiversity. This finding justifies the issue that is addressed in this study, as development and thus intensive economic activities, can lead to greater threats to biodiversity. The effect of poverty on threatened species is significant in all models for birds as well as for mammal species.

Threatened mammal species increase with increasing human population density. This indicates that the threat on mammal species increases in more densely populated countries. This result is in line with an anthropogenic theory of biodiversity loss, according to which population pressure leads to habitat destruction and reduction of resources for animal species.

Table II-3. Non-spatial and DURBIN models percent threatened mammals

	Non -spatial models			DURBIN models with W^{C}_{ij}			DURBIN models with W^{B}_{ij}		
	Linear	Quadratic	Hyperbolic	Linear	Quadratic	Hyperbolic	Linear	Quadratic	Hyperbolic
PCGDP	0.0001	-0.0004		-0.0001	0.0003		-0.0001	0.0004	
$PCGDP^2$		0.0000			-0.0000			-0.0000	
$PCGDP^{-1}$			-193.4642			558.9547			419.5503
POV	-0.0616*	-0.0769**	-0.0680*	-0.0331	-0.0641**	-0.0656*	-0.0424*	-0.0511*	-0.0566*
DENS	0.0289***	0.0277***	0.0295***	0.0163***	0.0119**	0.0184***	0.0134***	0.0123**	0.0175***
AGRI	-0.0442*	-0.0322	-0.0503**	-0.0164	-0.0234	-0.0170	-0.0178	-0.0206	-0.0190
PV	-0.3250	-0.2524	-0.3715	-0.3891	-0.8244**	-0.3646	-0.3310	-0.5042*	-0.2681
DURPA	-0.0478**	-0.0487**	-0.0508***	-0.0241	-0.0296**	-0.0366**	-0.0295**	-0.0342***	-0.0338**
PES_{MAM}	0.3123***	0.3088***	0.3146***	0.1944***	0.1155**	0.2495***	0.1462**	0.1610***	0.2076***
PCGDP_LAG				0.0003	-0.0030***		0.0004	-0.0021**	
$PCGDP^2$_LAG					0.0000***			0.0000***	
$PCGDP^{-1}$_LAG						1.03E+03			-9.95E+01
POV_LAG				0.0374	-0.1443*	-0.0724	0.0351	-0.0269	-0.0403
DENS_LAG				-0.0059	-0.0074	-0.0168	0.0091	-0.0059	-0.0033
AGRI_LAG				-0.0193	0.0426	-0.0286	-0.0386	0.0136	-0.0393
PV_LAG				1.5674**	0.3878	1.0577	1.7747***	1.2270**	1.3706**
DURPA_LAG				-0.0023	-0.0347	-0.0129	0.0111	0.0299	0.0043
PES_{MAM}_LAG				-0.0163	0.0432	-0.0206	-0.0114	-0.0293	-0.0284
_cons	13.8115***	14.9072***	15.0354***	5.7384	19.7868***	14.1478**	6.1404	9.1841	12.1150***
λ				0.602803***	0.5521***	0.5530***	0.6489***	0.6181***	0.6019***
N	48	48	48	48	48	48	48	48	48
r2_a	0.76	0.77	0.76	0.75	0.82	0.80	0.78	0.84	0.80
Log-likelihood	-114	-112	-114	-101	-95	-101	-97,6	-93,6	-98,4
AICc	247.7368	248.9459	248.7368	28.5017	31.7907	26.5931	27.3260	31.1917	26.4259
LR Test (wX's =0)									
P-Value > Chi2				0.0632	0.0002	0.0991	0.0089	0.0002	0.0252

*p<0.1; **p<0.05; ***p<0.01Parameters estimation of the SDM is performed by Maximum Likelihood Estimation (MLE).

A number of papers have found evidence for this theory and show that high population density increases the percentage of threatened species (Asafu-Adjaye, 2003; Freytag et al., 2012; McPherson and Nieswiadomy, 2005; Pandit and Laband, 2007c). The effect of human density on threatened birds is less clear. The significant effect of human density on bird species' imperilment disappears with spatial dependence. It seems that the influence of some adjacent countries' characteristics trumps the effect of human density on the imperilment of birds in a given country. We find significant evidence that the level of imperiled species among birds depends on increasing agricultural land in a given country, as well as in its neighboring countries.

This finding is consistent with previous ones that evidence the negative influence of agriculture on threatened species (Asafu-Adjaye, 2003; Kerr and Currie, 1995) and goes further by demonstrating the influence of a spillover effect through agriculture.

The percentage of threatened species in SSA is influenced by conservation policies. We find that the longer the conservation experience in a given country, the less species are threatened. That can support the establishment of protected areas as an instrument for species conservation.

Political instability and violence has also an influence on threatened species. Low instability is associated with less threat on species. The effect, however, is more significant on bird species than mammal species. The level of threatened mammal species depends also on the risk of instability in neighboring countries.

Finally, the results suggest that the percentage of threatened birds and mammals in SSA is positively and strongly correlated with the percentage of endemic species. This result is constant across all taxa groups. So countries in SSA that have a great number of species that are located exclusively within their borders are subject to higher imperilment. For bird species specifically, a greater number of endemic species in neighboring countries may also increase the threat to bird species in a given country. As birds' species are very mobile, some are migratory species, it is likely the case that more species in neighboring countries (endemic or not) contribute to an increase in the total number of species that could be threatened in a given country at a given period. This must draw policymakers and donors attention to focus on endemic areas for species conservation.

7. Conclusion

Our paper seeks to answer the question of whether and how economic development influences biodiversity in SSA. Our main contribution is to take spatial interdependencies into account. To this extent, we estimated a series of linear and non-linear spatial models, using percent of threatened bird and mammal species and per capita PPP income levels for 48 countries in SSA. The following are the main findings of the study.

Our result indicates that a biodiversity-income relationship may exist for birds but not for mammals in SSA. There is thus no significant empirical link between economic development as measured by per capita GDP and threatened mammal species in SSA, while a robust and significant link exist for bird species in SSA. As regards how economic development influence biodiversity, we find evidence for a linear negative relationship between GDP and percent of threatened bird species and a hyperbolic nonlinear relationship. That means, empirically, that -ceteris paribus- the wealthier a country is in SSA the less threatened bird species there are. Moreover, our results do not support a quadratic biodiversity Kuznets curve that claims for a replenishment of species in almost the same magnitude of species loss once a certain economic level is attained in SSA. The results support a hyperbolic biodiversity Kuznets curve, thus a slowing of biodiversity loss with economic development in SSA. These results attenuate the pessimistic view of the link between development and biodiversity in developing area contexts. They do not however advocate promoting development while disregarding conservation needs, since the difficulties of considering irreversibility and uncertainty in the models leads us to interpret the findings with caution.

Our findings also evidence that spatial econometrics techniques provide a much clearer picture of the evolution of biodiversity. Indeed, we find that the imperilment of mammal species in one country is affected by pressure on mammal species in adjacent countries. These interactions are however conditional on ecological and socio-economic characteristics in neighboring countries. Our results also suggest that omitting spatial dependence alters statistical inference.

From a policy perspective, these findings suggest that development and conservation are not strictly separate policy realms, even in the context of underdevelopment, as found in SSA. Furthermore, the presence of spatial interactions supports the promotion of regional strategies for maintaining biodiversity and related environmental services in SSA

Appendix II-A. Brief description of literature.

Authors	Dependent variable	Biodiversity-development relationship	Spatial model	Main results of income impact
(Kerr and Currie, 1995)	– threatened birds species, threatened mammal species	linear	no	– mammal species(linear negative) – birds species(NS)
(Naidoo and Adamowicz, 2001)	– threatened species (plants, mammals, birds, amphibians, reptiles, fishes and invertebrates)	linear, quadratic	no	– birds species(EKC) – Plants, amphibians, reptiles, and invertebrates species (linear positive)
(Schubert and Dietz, 2001)	– number of species in a given area	linear, quadratic, hyperbolic	no	– number of species in a given area(linear positive, hyperbolic negative) –
(Dietz and Adger, 2003)	– species richness	linear hyperbolic	no	– species richness (linear positive), (EKC), (hyperbolic negative)
(Asafu-Adjaye, 2003)	– number of known mammal species (bird species, higher plant)/10,000 sq Km, – % of bird and mammal species threatened with extinction, – average annual percentage change in the number of known mammal species	linear	no	– mammals and birds (linear negative) – higher plants (NS)
(McPherson and Nieswiadomy, 2005)	– percentage of birds, ,percentage of mammals	quadratic EKC	SAR	– birds, mammals species (EKC)
(Mozumder et al., 2006)	– NABRAI, National Biodiversity Risk Assessment Index – adjusted NABRAI, upgraded NABRAI	polinomial(linear, quadratic, cubic)	no	– NS
(Jorgenson and Burns, 2007)	– ecological footprint per capita 2001	linear	no	– ecological footprint (linear positive)

Authors	Dependent variable	Biodiversity-development relationship	Spatial model	Main results of income impact
(Pandit and Laband, 2007c)	– threatened species (%) (plants, mammals, birds, amphibians, reptiles)	quadratic	no	– birds species (EKC)
(Pandit and Laband, 2007b)	– threatened species (%) (plants, mammals, birds, amphibians, reptiles)	quadratic	SAR	– birds species, vascular plants (robust EKC) – mammals, amphibiens species (no robust EKC)
(Pandit and Laband, 2007a)	– threatened species (%) (plants, mammals, birds, amphibians, reptiles)	quadratic	SAR/SEM	– birds species (EKC), – mammals species (no robust EKC)
(Clausen and York, 2008)	– number of threatened fish species	linear, quadratic	no	– Fish species(linear positive)
(Bagliani et al., 2008)	– per capita ecological footprint 2001	linear, quadratic and cubic	no	– ecoclogical footprint (cubic)
(Caviglia-Harris et al., 2009)	– ecological footprint	quadratic	no	– Ecological Footprint (U shape)
(Pandit and Laband, 2009)	– imperiled plants, amphibians, reptiles, mammals, birds	linear, quadratic	SAR	– imperilment species (linear negative)
(Freytag et al., 2012)	– absolute amount of bird species, – all bird species per sqkm; – ratio of endangered bird species to all bird species	linear	no	– absolute amount of bird species (linear negative)
(Mills and Waite, 2009)	– Proportion of species conserved	Linear, hyperbolic, parabolic	spatial covariates	– species richness (linear positive), (EKC), (hyperbolic negative)
(Tevie et al., 2011)	– Modified Index (MODEX) (adaptation of a comprehensive – National Biodiversity Risk Assessment Index) –	polinomial(linear, quadratic, cubic)	SAR, SEM	– NS
(Wang et al., 2013)	– ecological footprint	linear, quadratic, cubic	SEM/SDM	– ecological footprint (linear positive)

Appendix II-B. Data definition and source.

	Variable	Definition /interpretation	Source
Dependent variables	PTS_{BIRD} / PTS_{MAM}	Percentage of threatened bird/mammal species / An increase refers to loss of biodiversity, a decrease refers to replenishment of biodiversity.	Birdlife International, 2012 http://www.birdlife.org/datazone/home Red list of International Union for Conservation of Nature and Natural Resources (IUCN, 2012)
Interest variable	PCGDP	Gross domestic product per capita in constant 2005 US$, normalized for purchasing power / An increase refers here to improvement of development level and living standards, a decrease to declining of development level and living standards.	World Development Indicators, 2012
Socio-economic control variables	POV	Poverty headcount ratio at national poverty line (% of population) / High values refer to poorest countries and low value to less poor countries in SSA.	World Development Indicators, 2012
	DENS	Number of people living per km^2/ An increase refers to rising of population pressure, a decrease to declining of population pressure.	World Development Indicators, 2012
	AGRI	Percentage of land area / An increase refers to rising of conversion of land to agriculture, a decrease to declining of conversion of land to agriculture.	World Development Indicators, 2012
Ecological control variables	PES_{BIRD} / PES_{MAM}	Percentage of endemic bird species/ mammal species. Endemism is the ecological state of being unique to a defined geographic location / High values refer to an area with high and unique biological diversity in terms of bird/mammals species, low values refer to an area with low biological diversity in terms of bird/mammal species.	Birdlife International, 2012 http://www.birdlife.org/datazone/home Red list of International Union for Conservation of Nature and Natural Resources (IUCN, 2012)
Governance control variables	DURPA	DURPA=[2012-n] with n=the year of creation of the 1st protected area / High values refer to a country with long experience in conservation policies, low values refer to short experience in conservation policies .	
	PV	Political stability and absence of violence/terrorism: perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism / High values correspond to low risk of instability and low values to high risk of instability.	Worldwide Governance Indicators, 2012
Weight matrices	W^{C}_{ij}	Contiguity matrix / Value of the matrix element is 1 if countries i, j share a border and 0 otherwise.	CEPII database (cf. Mayer and Zignago, 2006)
	W^{B}_{ij}	Length of borders matrix / Value of the matrix element is the length of common borders between 2 countries.	"CIA World Factbooks," 2012

Appendix II-C. Countries in the sample.

Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Cape Verde
Central African Republic
Chad
Comoros
Congo, Dem. Rep
Congo, Rep,
Cote d'Ivoire
Djibouti
Equatorial Guinea
Eritrea
Ethiopia
Gabon
Gambia, The
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Madagascar
Malawi
Mali
Mauritania
Mauritius
Mozambique
Namibia
Niger
Nigeria
Rwanda
São Tomé and Príncipe
Senegal
Seychelles
Sierra Leone
Somalia
South Africa
Sudan
Swaziland
Tanzania
Togo
Uganda
Zambia
Zimbabwe

Note: South Sudan is absent from the study

Appendix II-D. Spatial tests.

		Linear model				Quadratic model				Hyperbolic model			
	Matrices	WC		WB		WC		WB		WC		WB	
		Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Birds models	Spatial error												
	LM	0.266	0.606	2.068	0.150	0.402	0.526	2.339	0.126	0.010	0.921	1.363	0.243
	Robust LM	0.615	0.433	0.130	0.718	0.432	0.511	0.072	0.789	0.583	0.445	0.005	0.942
	Spatial lag												
	LM	2.930	0.087	6.572	0.010	2.649	0.104	6.321	0.012	0.695	0.405	3.906	0.048
	Robust LM	3.280	0.070	4.635	0.031	2.678	0.102	4.054	0.044	1.268	0.260	2.548	0.110
Mammals model	Spatial error												
	LM	6.267	0.012	7.016	0.008	4.145	0.042	4.485	0.034	5.145	0.023	5.212	0.022
	Robust LM	0.096	0.757	0.108	0.743	0.018	0.893	0.011	0.916	0.073	0.788	0.019	0.891
	Spatial lag												
	LM	11.635	0.001	13.254	0.000	9.133	0.003	10.661	0.001	11.403	0.001	12.609	0.000
	Robust LM	5.463	0.019	6.346	0.012	5.006	0.025	6.187	0.013	6.331	0.012	7.416	0.006

Appendix II-E. Models comparison.

	Birds models			Mammals models		
	Linear	Quadratic	Hyperbolic	Linear	Quadratic	Hyperbolic
			SDM			
AIC	0,1632	0,1771	0,1617	10,9533	8,2045	9,0447
AICc	17,7116	23,7633	17,7101	28,5017	31,7907	26,5931
BIC	0,2929	0,3436	0,2902	19,6561	15,9172	16,2311
			SDEM			
AIC	0,1643	0,1785	0,1636	15,9196	12,9619	10,1188
AICc	17,7127	23,7647	17,7120	33,4680	36,5481	27,6672
BIC	0,2948	0,3462	0,2936	28,5504	25,1468	18,1586
			SLX			
AIC	35,8145	34,8748	37,7954	243,0000	234,0000	243,0000
AICc	53,3628	58,4611	55,3438	260,5484	257,5862	260,5484
BIC	63,8825	64,8141	65,8634	271,0000	266,0000	271,0000

Appendix II-F. Total marginal effects

	Birds models						Mammals models					
	DURBIN models with W^{C}_{ij}			DURBIN models with W^{B}_{ij}			DURBIN models with W^{C}_{ij}			DURBIN models with W^{B}_{ij}		
	Linear	Quadratic	Hyperbolic	Linear	Quadratic	Hyperbolic	Linear	Quadratic	Hyperbolic	Linear	Quadratic	Hyperbolic
PCGDP	-0.0000	0.0000		-0.0000	-0.0000		-0.0001	0.0003		-0.0001	0.0004	
$PCGDP^{2}$		-0.0000			-0.0000			-0.0000			-0.0000	
$PCGDP^{-1}$			122.5686			111.6593			505.9774			371.3482
POV	-0.0077	-0.0059	-0.0100	-0.0094	-0.0085	-0.0109	-0.0293	-0.0581	-0.0594	-0.0366	-0.0448	-0.0501
DENS	0.0002	0.0000	0.0004	-0.0001	-0.0002	0.0003	0.0144	0.0108	0.0167	0.0115	0.0108	0.0155
AGRI	0.0025	0.0022	0.0044	0.0035	0.0033	0.0047	-0.0144	-0.0212	-0.0154	-0.0154	-0.0180	-0.0168
PV	-0.0960	-0.0927	-0.0800	-0.1016	-0.1024	-0.0839	-0.3436	-0.7465	-0.3301	-0.2852	-0.4424	-0.2373
DURPA	-0.0018	-0.0017	-0.0020	-0.0023	-0.0024	-0.0028	-0.0213	-0.0268	-0.0332	-0.0255	-0.0300	-0.0300
PES_{BIRDS}	0.0400	0.0416	0.0571	0.0385	0.0385	0.0621						
PES_{MAM}							0.1716	0.1046	0.2259	0.1260	0.1413	0.1837
PCGDP_LAG	0.0001	0.0001		0.0001	0.0000		0.0003	-0.0027		0.0003	-0.0018	
$PCGDP^{2}$_LAG		-0.0000			0.0000			0.0000			0.0000	
$PCGDP^{-1}$_LAG			-149.3867			90.7419			928.9843			-88.0285
POV_LAG	0.0091	0.0099	0.0065	0.0035	0.0042	-0.0026	0.0331	-0.1307	-0.0655	0.0303	-0.0236	-0.0357
DENS_LAG	-0.0008	-0.0004	-0.0019	-0.0011	-0.0010	-0.0031	-0.0052	-0.0067	-0.0152	0.0078	-0.0052	-0.0029
AGRI_LAG	0.0080	0.0080	0.0075	0.0047	0.0049	0.0081	-0.0170	0.0386	-0.0259	-0.0332	0.0119	-0.0348
PV_LAG	0.0206	0.0155	-0.0831	0.0247	0.0235	-0.0083	1.3840	0.3512	0.9575	1.5291	1.0766	1.2131
DURPA_LAG	-0.0050	-0.0046	-0.0055	-0.0045	-0.0039	-0.0030	-0.0020	-0.0314	-0.0117	0.0096	0.0263	0.0038
PES_{BIRDS}_LAG	0.0235	0.0291	0.0116	0.0312	0.0336	0.0092						
PES_{MAM}_LAG							-0.0144	0.0391	-0.0186	-0.0098	-0.0257	-0.0251

CHAPTER III

III. Exploring the role of economic incentives and spillover effects in biodiversity conservation policies in sub-Saharan Africa

Abstract

A vast array of empirical work investigates the issue of biodiversity conservation, but the focus is often limited on the search for possible causes of biodiversity erosion. Biodiversity conservation policymaking is still understudied. In this study, this gap is empirically addressed on a sample of 48 Sub-Saharan countries over the 1990 – 2009 period taking the "Ecoregion protection" score provided by the Center for International Earth Science Information Network (CIESIN) as a measure of biodiversity conservation policies. It is sought whether economic incentives such as biodiversity targeted international transfers as well as tourism revenues have an impact on biodiversity conservation policies. Moreover, spillover effects are also hypothesized owing to the public good character of biodiversity conservation policies. Our results are contrasted since international financial assistance is found to have an effect while tourism does not. Our results also evidence complementary spatial spillover effects between biodiversity conservation policies.

JEL codes: P48, Q57, C21

Keywords: Biodiversity, Ecoregion score, Spatial econometrics.

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1. Introduction

'Biodiversity' is an umbrella term that covers all variety of life on the planet, from the genetic level to terrestrial, freshwater, and marine habitats and ecosystems (TEEB, 2009). It can be thought of as an economic good, as it is obviously scarce, it satisfies human needs, and it allows people to achieve certain ends (Baumgärtner, 2007; Heal, 2000). 'Biodiversity' is also considered to be a global public good (Rands et al., 2010), as the benefits from biodiversity usually have most the characteristics defined in (Kaul et al., 1999): they are marked by nonrivalry in consumption and nonexcludability, along with being quasi-universal in terms of countries, people, and generations.

The supply of this "global public economic good" to humankind is increasingly threatened. The urgency has been borne out by different international reports (MEA, 2005; TEEB, 2010b). The overall cost of the current biodiversity loss is unknown. Yet, some parts of this cost, including the costs of lost bio-prospecting, the costs of lost carbon sinks, the costs of lost tourism business, and the costs of diminished watershed protection, amount to many tens of billions of dollars (Heal, 2005). It is estimated that 25 to 50% of the pharmaceutical industry relies on genetic diversity for drug developments, and that about US$ 650 billion per year is derived from genetic resources (TEEB, 2008). The total economic value of pollination worldwide amounted to 153 billion, 9.5% of the value of the world agricultural production in 2005 (Gallai et al., 2009). For the entire biosphere, the economic value of 17 ecosystem services has been approximated to be an average of US$33 trillion per year (Costanza et al., 1997[6]). Despite the lack of precise knowledge about the costs of biodiversity loss, the global recognition of the economic and human dimensions of biodiversity loss persists, along with the need for urgent action.

The debate on strategies for slowing the trend of biodiversity loss has led to an increasing interest on the part of practitioners and scientists regarding economic incentives for biodiversity conservation. As McNelly notes in his seminal work, "conservation needs to be promoted through the means of economic incentives to alter people's perceptions of which

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[6] These early figures provided by Costanza et al 1997 have been the subject of debate and criticism. For instance,(Pearce, 2007) quotes the "illicit literature on ecosystem valuation" and (Toman, 1998) asserts that "there is little that can usefully be done with a serious underestimate of infinity".

behaviors are in their self-interest, as resource exploitation is governed by the perceived self-interest of various individuals or groups” (McNeely, 1988). From the perspective of public economy theory, economic instruments are required to address externalities (OECD, 2010) and market failure associated with biodiversity, as it has public goods characteristics. This would lead to considering the real value of biodiversity and the broad cost associated with its loss when making decisions (Emerton, 2001). Economic measures in support of biodiversity are increasingly recommended to reinforce traditional ways of managing biological resources (Emerton, 2001; Holling and Meffe, 1996; OECD, 1999) , since progress toward the slowing of biodiversity loss is still insufficient (Butchart et al., 2010).

A number of case studies exist at the micro level illustrating how economic incentives work in altering the decisions of individuals, farmers, landowners, local communities, and firms towards biodiversity conservation (see (Secretariat of the Convention on Biological Diversity, 2011) for a review of case studies). Empirical investigation at the country level is limited and cross-country analysis is quite sparse. Indeed, the question still remains of whether economic instruments used at the global level can correct governments’ incentives toward more stringent conservation strategies. The question of the effectiveness of economic instruments at the global level in conservation strategies is especially important for tropical developing countries. These countries are home to the majority of biodiversity (Jablonski et al., 2006; Stattersfield et al., 1998) and, at the same time, the threat on biodiversity is the greatest (Mittermeier et al., 1998; Myers et al., 2000). The maintenance of global biodiversity therefore requires checking for the most efficient instruments for biodiversity conservation in these countries.

In this paper we propose to empirically test the contribution of economic incentives on biodiversity conservation at the country level for sub-Sahara African countries. The focus on the SSA region is guided by two considerations. First, the SSA region is home to the majority of the biodiversity “hot spots” (Myers et al., 2000) of Africa. Next, SSA is the poorest developing region, recording the highest (and relatively steady) poverty rate since 1981 (Haughton and Khandker, 2009). It is also a region where demographic transition is not complete (Conley et al., 2007) which may increase pressure on the environment. It is thus more likely that economic incentives at the global level would be more important in the implementation of national conservation strategies than anywhere else. Investigating the effectiveness of these instruments is then important. To the best of our knowledge, no empirical work exists on conservation policymaking for sub-Sahara African countries.

The contribution of the paper is twofold. First, we add to the literature on biodiversity conservation policy-making, where few empirical studies exist. There is a dearth of analyses that attempt to understand the mechanisms by which governments conduct conservation strategies and allocate public funds for biodiversity conservation. The studies that exist on governments' dedication to conservation are narrowed to species characteristics only (Dawson and Shogren, 2001; Mahoney, 2009; Metrick and Weitzman, 1998; Simon et al., 1995). A few studies focus on other determinants for biodiversity conservation policymaking, including the papers of (Archer and Orr, 2008; Dietz and Adger, 2003; Lightfoot, 1994). Lightfoot (1994) investigates whether a country's development level has a deterministic effect on its formal attempts to establish protected areas; he finds no conclusive result. Dietz and Adger (2003) find, on the contrary, that there is a possible tendency towards increased conservation efforts with increasing income. Archer and Orr (2008) test four groups of predictors of land protection: biodiversity, environmental threats, politics, and economics, ascertaining that environmental threats represent the strongest factor at the country level for land protection.

Second, we take into account the existence of spatial spillover as an important dimension to be considered for biodiversity issues. In fact, in conservation policymaking, the probability that country strategies are interconnected is high because several countries share and manage common resources. In SSA, examples of trans-boundary protected area initiatives exist, including: Nouabal-Ndoki National Park in Congo, contiguous with Dzanga-Ndoki in Central African Republic and adjacent to Lac Lobeke National Park in Cameroon; Kgalagadi trans-boundary park shared by South Africa and Botswana; the W National Park shared between Niger, Benin and Burkina Faso, etc. It is very likely to observe similar strategies or mimetic behavior between neighboring countries because of the similarity of ecosystems. Furthermore, we can observe strategic behavior induced by competition for economic benefits related to international economic incentives, especially for developing countries.

The next section presents the main hypotheses of the study. Section 3 presents the data and methodology used in the analysis, while Section 4 discusses the empirical results derived. Section 5 concludes.

2. Factors explaining conservation efforts: main hypotheses

In this section we focus on determinants of biodiversity conservation efforts. Attention is firstly paid to the role of international transfers and tourism to act as economic incentives at country level for biodiversity conservation efforts. Secondly, the issue of spatial dependence in conservation efforts is discussed.

2.1 Financing conservation effort

Local land users as well as public authorities might have no incentive to conserve biodiversity unless it generates benefits (Dixon and Pagiola, 2001). Incentives may therefore help meeting development and environmental issues and by the way may incite or motivate governments to conserve biological diversity (McNeely, 1993).

At a global level, international financing mechanisms may cover the 'incremental costs' of countries which host a great biological patrimony and are likely to provide global environmental goods (Pearce, 2007). International financing mechanisms include international biodiversity transfers, debt forgiveness or swaps, eco labeling and certification, ecosystem services markets, etc. Several of them have been implemented in the SSA region. For instance, Uganda National Parks receives funds from a credit-offset system relating to carbon emissions and greenhouse gases and also from a trust fund led by the Global Environment Facility. Madagascar, Zambia, Ghana, and Nigeria have benefited from debt-for-nature swaps in the 1990s. Ghana, Madagascar, Tanzania, and Zimbabwe have received concession fees and royalties from medical and pharmaceutical organizations for the in situ conservation of genetic resources (Emerton, 2000).

Direct financial transfer to countries is the main financing instrument for biodiversity conservation with the Global Environment Facility (GEF) established in 1991. GEF is considered to be the largest donor for environmental funds worldwide (Deke, 2008). Direct financial transfers, from GEF and other organizations paying for environmental services, to countries are important levers in the implementation of environmental strategies in most developing countries, which often have limited national budgets and face problems in areas, such as health and poverty. In Africa, GEF allocations amount to a total of $219 million in 2012 (GEF, 2013) The official aid and development assistance of OECD targeted to environment policy objectives have increased from US$ 865 million in 2006 to US$ 2439 million in 2009 in the SSA region. One may therefore argue that the trend in international assistance give economic signals to poor countries in support of sustainable development and towards more effort in biodiversity conservation.

At local level, ecotourism which generates income from biodiversity amenities can also favor conservation efforts (Brandon, 1996; Dixon and Pagiola, 2001; Wunder, 2000). Many touristic attractions in developing countries are closely linked to biodiversity, such as protected areas, unspoiled mountains, beaches and islands, traditional ways of life and native culture, charismatic wildlife, as well as natural landscapes (CBD, 2008). In terms of competition with other destinations, a site's biodiversity profile might give the destination site a competitive advantage (Macagno et al., 2009). The tourism industry may therefore benefit from environmental management through demand stimulation (Huybers and Bennett, 2003). It would be then a plausible assumption that an upward trend of ecotourism demand gives efficient economic signals to poor countries, supporting sustainable development and greater effort in biodiversity conservation. Over the last decade, nature and adventure travel has emerged as one of the fastest-growing segments of the touristic sector, much of this growth taking place in mega-diverse sites, areas harboring many species unique to that region (Christ et al., 2003). Tourism has recently become one of the most dynamic economic sectors in many developing countries. It represented over 70% of exports of services and was the primary source of foreign exchange earnings in 46 out of 50 of the world's least developed countries in 2005 (UNWTO, 2008). Tourism may be considered as a promising source of development in Sub-Saharan Africa (Christie and Crompton, 2001). According to the World Travel and Tourism (WTT) data (2011), the total contribution of travel and tourism to the region's GDP, including its wider economic impacts, grew from 4.76 % (1990) to 9.8% (2009), showing an increase of 106%. The total contribution to the region's GDP is expected to rise by 5.3% for the next ten years, and the total contribution to employment is forecasted to expand by 2.6% over the same period.

2.2 Spatial spillovers in conservation effort

Existence of spillover effects in policymaking is now a widely accepted hypothesis in various works on public policy (Brueckner and Saavedra, 2001; Devereux et al., 2008; Redoano, 2007). A few studies exist on environmental policymaking for climate (Fredriksson and Millimet, 2002; Murdoch et al., 1997; Sauquet, 2014), and more rarely on biodiversity conservation policymaking (Sauquet et al., 2012), although spatial patterns are strongly inherent to biodiversity (Kerr and Burkey, 2002; Pandit and Laband, 2007a).

In line with the assumptions on mimicking behavior in public policy, we assume that conservation strategies may be the subject of spatial interdependence. The starting point is that, as global integration proceeds, domestic policy objectives are increasingly subject to international forces (Howlett and Ramesh, 2002; Kaul et al., 1999). Those forces are reinforced by international agreements and treaties such as the convention on biological diversity (CBD) in the context of biodiversity conservation, which has recently defined the Aichi targets (UNEP, 2010). The international pressure lead to a race to the top or at least as a move towards more encompassing environmental policies (Kern et al., 2000). Increasing demand for improvements in the quality of global environmental goods, such as rain forests, global climate, or biodiversity, can directly or indirectly affect national decisions (Carraro and Siniscalco, 1992) or increase the likelihood that national decision-makers emulate the policies of other countries (Busch and Jörgens, 2005). Moreover, the existence of high negative externalities makes states benefit from choosing the same course of action (Botcheva and Martin, 2001). Thus, it is possible to observe a convergence in states' environmental strategies resulting in greater similarity between domestic environmental policies. As evidence, under the impetus of the World Conservation Strategy, we observe that national conservation strategies became increasingly institutionalized in Africa in the mid-1980s (Falloux et al., 1990). Moreover, in the period following the 1992 Rio Conference, more than half of African countries had drafted or were in the process of drafting their National Environmental Action Plans (NEAP), which included conservation strategies (Kamto, 1996). In light of this, it would be a plausible assumption that the diffusion of ideas, institutions, or instruments generated by global demand for biodiversity conservation leads to a spillover effect in countries' conservation strategies.

A spillover effect in biodiversity conservation policymaking can also arise from the strategic nature of domestic environmental policymaking. Its strategic nature refers to the fact that governments choose their level of environmental standards or regulation in a strategic fashion, with an eye on choices made elsewhere. The starting point is that we consider that the development of economic instruments has increased the economic value of species, genes, and ecosystems. The opportunity cost of biodiversity loss in developing countries, then, rises, as the benefits for conservation became more important. Considering that a country's choice of economic instruments is subject to performance-based or risk-based selectivity, it is then rational for policymakers to consider performance relative to other destinations in biodiversity management decisions. If the criterion to be recipient of a specific fund for instance is based on the comparative risk situation, then the best strategy is to be less efficient in order to attract maximum support. If the criterion is, rather, comparative performance, then the strategy is to show superior effort compared to other countries. For market-based instruments, such as ecotourism, with destinations involved in a win-lose competition, we can expect that comparative economic benefits will be more influential in conservation policymaking. It would be then a plausible assumption that biodiversity economic benefit gaps between countries lead to spillover effects in countries' conservation strategies.

3. Empirical evidence on the determinants of conservation effort

In this section the empirical methodology is presented. We start with the indicator measuring biodiversity conservation effort. Afterwards, explanatory variables are described. And finally, we discuss how we take spatial spillovers into account.

3.1 Ecoregion score as a measure of biodiversity conservation effort

We use the indicator "Ecoregion protection" (**ECOREG**) developed by the Center for International Earth Science Information Network (CIESIN) of Columbia University and the Yale Center for Environmental Law and Policy of Yale University, as the dependent variable. The Ecoregion protection score measures the degree to which a country achieves the target of protecting at least 10% of 14 terrestrial biomes within its country's land area. Biomes are defined as "the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment" (Campbell, 1996). The cap of 10% is consistent with the international target following the Convention on Biological Diversity (CBD) at its 7th Conference of the Parties. To calculate the indicator, a ratio is attributed to each biome in reference to its actual protection status and according to the target. The ratio of each biome is then weighted by the share of the biome's area in the country's land area, averaged and converted to a percentage to obtain a global score, scaled to 0-100. A score of 100% means that 10% of all biomes in a country are at least protected. (See http://sedac.ciesin.columbia.edu/es/epi/to for more details about the indicator).

Ecoregion, as a measure of environmental policies, reflects the actions undertaken by governments to protect biodiversity. Indeed the protected status of an area is most often a political decision and, by and large, stems from the policy process, political actors, and governmental decision making. While some conservation actions are initiated by NGOs, policies are usually implemented by the government.

Ecoregion score assessments of the degree of protection in a country do not provide information on the efficacy of conservation strategies. In fact, protected status is not sufficient for an ecological region to be “effectively conserved.” However, it is a necessary and an initial condition for committing state financial and administrative resources, as well as for actual protection to begin (Archer and Orr, 2008; CIESIN, 2010). As the aim of this paper is to assert predictors of state dedication to conservation, the indicator “Ecoregion score” is therefore considered as a valid and appropriate factor. (Archer and Orr, 2008) used also ecoregion score to measure country’s performance in biodiversity conservation. Determinants of biodiversity conservation efforts

The definition, interpretation, and sources of data are given in Appendix III-A. Descriptive statistics are provided in Appendix III-B.

For the variable of interest on ecotourism, we use data on international tourist arrivals by country of destination (**T.ARVL**) as a proxy, since we do not have exact information on ecotourism. For the variable of interest on international financial assistance, we use flows on official development assistance from all donors reported for only environmental policy and precisely for biodiversity, climate change, and desertification (**ODA.ENV**).

Following previous works, several control variables are taken into account. Some authors advocate that the relationship between economic development objectives and biodiversity conservation efforts is not strictly linear and may vary along the development path (Bimonte, 2002): GDP per capita (**GDP**) and its square (**GDP^2**) are introduced for the purpose of evidencing an Biodiversity Kuznets Curve. Czech, (2003) assumes that a conflict between economic growth and biodiversity conservation exists. This could happen through the transmission channels of population pressure (Freytag et al., 2012), agriculture (Kerr and Currie, 1995), or trade (Jorgenson and Kick, 2006). We then use the density of population expressed as people per square km of land area (**DENS**) and total population (**POP.TOT**) as demographic variables. We add the variable Trade, calculated as the sum of exports and imports of goods and services measured as a share of GDP (**TRADE**). We use exports in percentage of GDP (**EXPORT**) separately to show more precisely the effect of trade openness on biodiversity in the context of the sub-Saharan Africa region. Agriculture value added in percentage of GDP (**AGRI**) is also introduced in the model. Various authors argue that economic development may motivate a country's efforts for conservation (Dietz and Adger, 2003; Lightfoot, 1994; Shogren et al., 1999). This could be channeled by improvements in institutional quality (Dietz and Adger, 2003; Naidoo and Adamowicz, 2001) and education (Freytag et al., 2012). The World Bank's governance indicator of Government Effectiveness (**GOV.EFF**) is used as a proxy for the institutional quality of a country. The combined gross enrollment ratio in education (**EDUC**) is the number of students enrolled in primary, secondary and tertiary levels of education, regardless of age, as a percentage of the population of theoretical school age for the three levels. It controls for the educational level which is supposed to have a positive impact on efforts dedicated to biodiversity preservation. Archer and Orr (2008) suggest that biodiversity factors and environmental threats are primary incentives of protected land policies. Initial forest cover expressed in percentages of land area (**FOREST**) is then added to control for resource endowment. External influence also matters for environmental policy decisions, given the convergence mechanism (Busch and Jörgens, 2005). For biodiversity concerns, it is a valid hypothesis that external influences are induced by multilateral negotiations. We use then the percentage of expected reports submitted for the implementation of CITES (Convention on International Trade in Endangered Species) to measure countries' participation in environmental agreements and treaties (**CITES**).

3.2 Taking spatial spillovers between biodiversity conservation efforts into account

We adopt a step-by-step method with a simple model without spatial interaction and then the spatial interaction model.

The simple model specification is:

$$Y_i = X_i\alpha + Z_i\beta + \varepsilon_i, \qquad [1]$$

Where *i* denotes the country belonging to the 48 sub-Saharan African countries (see the list of countries in Appendix II-C) ; Y_i is the Ecoregion score, X_i stands for our interest variables i.e. tourism and international environmental aid indicators and Z_i, a set of control variables, α and β are vectors of unknown parameters. ε_i is the error term which is assumed to be normally distributed, homoscedastic, and independent across observations.

We opted to rely on a variable selection procedure to select the set of control variables to be considered beside our interest variables. We do this by invoking the command “vselect” (Lindsey and sheather, 2010) provided by the Stata software. It helps removing redundant predictors, determining which control variables should be included in the model, as well as obtaining the optimal model that optimizes several information criteria (adjusted R^2, Akaike’s Information Criterion (AIC), Akaike’s corrected Information criterion (AICc) and Bayesian Information criterion (BIC)). A model with all possible explanatory variables is run as a robustness check.

3.2.1 Spatial specifications

In order to consider spatial interaction in conservation policymaking among states, we consider several specifications: a spatial Durbin model (SDM) (equation 2) and a spatial Durbin error model (SDEM) (equation 3):

$$Y_i = \lambda \sum_{j=1}^{N} w_{ij} Y_j + X_i\alpha + Z_i\beta + \theta_1 \sum_{j=1}^{N} w_{ij} X_j + \theta_2 \sum_{j=1}^{N} w_{ij} Z_j + \varepsilon_i \qquad [2]$$

$$Y_i = X_i\alpha + Z_i\beta + \theta_1 \sum_{j=1}^{N} w_{ij} X_j + \theta_2 \sum_{j=1}^{N} w_{ij} Z_{j_i} + u_i,\ u_i = \rho \sum_{j=1}^{N} w_{ij} u_j + \varepsilon_i \qquad [3]$$

where W is an $N \times N$ spatial weight matrix, WY, WX, WZ and Wu represent, respectively, a linear combination of the dependent variable, interest variables and control variables from neighboring countries, and the vector of disturbances. λ, θ_1, θ_2 and ρ are spatial parameters.

The SDM implies that spillovers in conservation policymaking arise from neighboring countries’ performance in biodiversity conservation as well as from neighboring countries’ characteristics. The SDEM implies that conservation effort in a given country depends on independent explanatory variables of neighboring countries and that unobserved shocks follow a spatial pattern.

These two spatial models subsume other potential spatial specifications (LeSage, 2014). The Likelihood Ratio test, the significance of spatial parameters, and the Bayesian model comparison methods (we use here Bayesian Information Criterion) will provide pieces of information regarding the choice of the relevant spatial model.

3.2.2 Spatial weights

One major issue in spatial models is to define W_{ij}, the weighting matrix that assigns a value to each pair of states. Generally, W_{ij} has zero diagonal elements, and off-diagonal elements, w_{ij}. The values of each w_{ij} are specified arbitrarily and reflect expectations regarding the spatial pattern of interaction.

In the context of conservation efforts, as explained previously, it seems plausible that changes in a given country will lead to a mimetic reaction in peer countries, such as adjoining countries with very similar natural endowment. Furthermore the existence of common interest, the share of common resources for instance, would also increase the likelihood of connectivity between countries conservation policies. Finally a competition between countries for ecotourism or international assistance would likely exist if the countries have similar natural endowments. The likelihood of having the same natural endowment or shared natural resources is higher with geographical proximity. We then choose to use a binary contiguity weighting matrix, where the jth element of the ith row of W_{ij} equals 1 if i and j are neighbors and equals 0 otherwise.

3.2.3 Endogeneity issues

Two potential sources of endogeneity must be taken into account. First, we assume here that tourism development and international environmental aid are predictors of a given country's biodiversity conservation efforts. It is also likely the case that the volume of tourism arrivals in a country is influenced by the country's natural diversity, in turn influenced by conservation efforts. International environmental aid received by a country can also depend on that country's conservation efforts. There may therefore exist a simultaneity bias between tourism and conservation efforts as well as between international environmental aid and conservation efforts. We then use lagged values for tourism and international environmental aid to resolve the first source of endogeneity.

The second source of endogeneity is induced by feedback effects that may occur with spatial interactions. The hypothesis of feedback effects supposes that one state incorporates the level of conservation in neighboring states into its own decision-making process, and vice versa. The values of Y in the sample are, then, jointly determined in exactly the same fashion. The variable WY on the right-hand side of SDM is then endogenous. As a result, parameters of OLS are inconsistent for the estimation of model [2]. Other estimators are proposed in the literature (see (Anselin, 1988; LeSage and Pace, 2009). We use maximum likelihood (ML) estimation (Brueckner, 2003).

The countries' conservation effort can only be observed over time, we perform then a cross-sectional analysis where all explanatory variables are averaged for a period of 20 years (1990-2009) as in (McPherson and Nieswiadomy, 2005). This procedure allows us to focus on today's biodiversity conservation efforts based on factors that have influenced it over the past 20 years. It also makes our study better immune to short-term effects.

4. Results and discussion

4.1 Variable selection and results from simple model

Table III-1 contains the first set of estimation results. Invoking vselect (Lindsey and sheather, 2010) on the data to find the optimal model, we find that AIC and AICc both choose to include three control variables, FOREST, CITES, and POP.TOT (see appendix III-C). This is actually a model with five predictors including our two interest variables i.e. tourism and international transfer. R^2_{adj} also yields a model with five predictors. So we choose to include FOREST, CITES, and POP.TOT as control variables and retain the five-predictor model. This model yields no high variance inflation factors. VIF values for variables do not exceed 1.13, which is in line with the most conservative rules of thumb (see appendix III-C for more details on the variable selection). The optimal model accounts for 47% of the variance in Ecoregion score.

The model that results from our selection procedure has an intuitive meaning. Indeed, the selected model assumes that the scores of Ecoregion by countries can be explained by environmental and demographic factors, as well as factors related to international regulation. What is more, the inclusion of other potential control variables does not improve the model (see column 3 in Table III-1). The significant variables are the same and none of the other added variables is significant. We therefore use this optimal model in the rest of the paper.

The least square estimates of the model show evidence of a statistically significant relationship between economic incentives measured with environmental aid and Ecoregion score. The coefficient for ODA.ENV is positive and significant at a 1% level of significance. The magnitude of the effect of environmental aid on the Ecoregion score is the most important among predictors. In fact, an increase of one unit of environmental aid (US$1 million) leads to an increase of 2.2 in the Ecoregion score. The impact of environmental aid seems, then, to be very important in a country's performance according to the findings. In the context of SSA, financial assistance matters in terms of a state's dedication to biodiversity conservation. The coefficient for T.ARVL, however, is negative and not significant at a 1% level of significance. In the context of SSA, it seems that tourism development is not yet an important incentive in states' dedication to biodiversity conservation. Tourism as a conservation incentive for private landowners has been however evidenced in some tropical developing areas (Langholz et al., 2000; Wunder, 2000) and also in SSA (Emerton, 2001). Without stating a general conclusion in comparing a market-based instrument with financial assistance, we find in our specific case that the effect of international environmental aid on conservation efforts in SSA is more efficient than tourism development, at the country level.

Table III-1. Non-spatial model explaining Ecoregion score

Independent variables	OLS model *(Equation 1/Optimal model)*	OLS model *(Equation 1 with all predictors)*
T.ARVL	-0,0005	-0,0025
ODA.ENV	2,2056***	2,0474**
CITES	0,2040	0,2000
POP.TO	0,3522**	0,3891*
FOREST	0,8366***	0,7940***
GOV.EFF		5,6891
AGRI		0,1128
GDP		-27,5701
GDP^2		2,25457
EXPORT		-0,1006
DENS		-0,0397
EDUC		-0,0671
_cons	21,2262**	115,5654
N	48	48
r2_adjusted	0,4051	0,3110
Log Likelihood	-225,0873	-224,2347

*p<0.1; **p<0.05; ***p<0.01

Regarding the control variables, the resource endowment variable (FOREST) has a significant, positive effect on the Ecoregion score, indicating that the conservation effort is greater in countries with more protectable area. The population variable exhibits a significant, positive coefficient. Surprisingly, this result indicates that when prioritizing population size, conservation effort becomes more stringent. In fact, the widely accepted view, the anthropogenic hypothesis, points to an adverse effect of population on conservation. Nevertheless, some studies have found a positive impact of population on conservation effort (Archer and Orr, 2008; Dietz and Adger, 2003). Archer and Orr (2008) argue that population can positively drive conservation efforts though a reactionary policy approach as a rationale for protecting land or people's preference for beautiful areas. This story is however less relevant in Sub-Saharan Africa, where people have more basic needs in general and low influence on government decision. The variable CITES also has no effect on country conservation efforts.

4.2 Spillover effects

Results for the spatial models are presented in Table III-2. The z-value of Moran I test is positive and significant (statistic=1.801; p-value=0.072). This indicates the presence of positive spatial autocorrelation. The spatial coefficients in SDM (λ) and SDEM (ρ) are not statistically significant. This advocates for a SLX (spatial lag of explanatory variables) specification. The LR tests SDM versus SLX ($\lambda = 0$) and SDEM versus SLX ($\rho = 0$) confirm the SLX specification as the spatial model which describes the data best (see Table III-3).

Table III-2. Spatial models explaining Ecoregion score

Independent variables	Spatial Durbin Error Model (SDEM) (equation 3)	Spatial Durbin Model (SDM) (equation 2)	Spatial Lag of explanatory variables (SLX) (equation for $\lambda = \rho = 0$)
T.ARVL	0,0007	0,0007	0,0008
ODA.ENV	2,4370**	2,3355**	2,4686*
CITES	0,2388**	0,2182*	0,2451*
POP.TO	0,3488*	0,3286*	0,3484
FOREST	0,8436***	0,8411***	0,8474***
T.ARVL_LAG	-0,0059	-0,0059	-0,0062
ODA.ENV_LAG	2,2844	1,6461	2,1985
CITES_LAG	0,5292*	0,5113*	0,5491*
POP.TO_LAG	0,5365	0,4281	0,5601
FOREST_LAG	0,0669	-0,1433	0,0547
_cons	-34,5083	-37,1128	-36,2115
ρ	0,1323		
λ		0,2175	
Statistics			
BIC	492,7937	491,9313	485,4814
Log likelihood	-221,2340	-220,8028	-221,4491

*p<0.1; **p<0.05; ***p<0.01

Furthermore, the Bayesian information criterion is the smallest for SLX model. According to (LeSage, 2014), Bayesian model comparison works well in distinguishing spatial specifications.

Comparing the OLS model to the SLX, we note that the log-likelihood function value of the OLS model increases when this model is extended to include spatial interaction effects. Considering the LR test, however, the improvement in model fit from OLS to SLX is statistically significant only at 20%. The results of the LR test don't advocate that adding a spatial lag of X is not pertinent in our model, but that adding all spatial lags of explanatory variables as predictor variables together (not just individually) results in a somewhat statistically significant improvement in model fit. This indicates that only some of the lags of explanatory variables are relevant in the model.

Table III-3. Models comparison with likelihood ratio test[7]

Variable	SDEM vs SLX	SDM vs SLX	OLS vs SLX
H_0	$\rho = 0$	$\lambda = 0$	W(X+Z)'s = 0
Statistic	Chi2 (1)=0,4392	Chi2 (1)=1,3613	chi2(5)=7,28
P-Value > Chi2	0,5075	0,2433	0,199

Two major changes occur with the inclusion of the spatial interaction in the OLS model. First, the population variable, which had an opposite sign to the expected sign relative to the literature, is no longer significant. One could postulate that the significance of this variable in previous studies results from misspecification of the model, due to the absence of spatial interdependence in these models. This echoes the Anselin statement according to which failures to take the spatial dimension into account when it is present, leads to biased estimates.

The second point to note is the change of sign of the CITES variable. Taking into account interdependence between countries, the degree to which a country is involved in environmental agreements and treaties, such as CITES (Convention on International Trade in Endangered Species), became determinant in explaining countries' biodiversity conservation effort. Joining the CITES convention is found to remove barriers in the implementation of biodiversity policies. . Countries' involvement in CITES also has an indirect effect on their

[7] The LR test is based on minus two times the difference between the value of the log-likelihood function in the restricted model and the value of the log-likelihood function of the unrestricted model: -2*(logLrestricted-logLunrestricted) This statistic is distributed chi-squared with degrees of freedom equal to the difference in the number of degrees of freedom between the two models (i.e., the number of variables added to the model).

effort in biodiversity conservation that passes on to surrounding areas. We find here that this indirect effect has an even greater impact on conservation effort in a given country.

No insight is obtained allowing for a spillover effect through economic incentives provided by international transfers as well as touristic activities. The coefficient for the spatial lagged aid variable is not statistically significant, nor is the tourism spatial lag variable. This indicates that the aid gap and tourism arrival gap between a country and its neighbor has no influence on that country's effort in biodiversity conservation and neither of these gaps explains comparative conservation performance variations.

A realistic assumption would be that economic instruments lead to transboundary training effects, pushing the country to converge towards more effective conservations policies. Our results are, however, more in the sense of spillover effects related to international regulation in the context of SSA. The variables ODA.ENV and FOREST are still significant in the spatial model as in the OLS model.

5. Concluding remarks

Factors influencing biodiversity conservation effort is an area of expanding literature. This paper presents an empirical investigation of this issue for Sub-Saharan Africa countries, testing the role of economic incentives as well as trans-boundary influences on biodiversity policymaking as measured by the 2009 Ecoregion score provided by the CIESIN as a measure of a country's biodiversity protection level. Spatial models estimators were implemented on a data set of 48 countries spanning the period 1990-2009. .

The major findings of the analysis are the following. First, a country's protected biomes are primarily related to resource endowments, international agreements, and environmental aid flows. Second, data analysis suggests that countries are influenced by their contiguous neighbors in environmental policy for biodiversity management. Third, the interdependence between countries for conservation strategies is not a result of competition for tourism market shares or environmental aid but is more related to an international convergence mechanism.

Enhancing conservation effort in tropical regions is crucial, since these regions are at the forefront of conservation issues. In this respect, Sub-Saharan African countries should be supported through the provision of economic incentives, such as international financial assistance. One justification of this comes from the fact that biodiversity conservation may be considered as a weakest link. Since international diffusion mechanisms matter, sub-Saharan African countries should be encouraged to be better involved in environmental agreements and treaties. Regional cooperation in biodiversity conservation should also be encouraged. Implementation of transboundary protected areas could be an example. Further research concerning the scope for influencing decisions at national level in favor of biodiversity conservation, in tropical developing regions context, is warranted. Indeed, of the efforts in these “weakest links” in the chain (Perrings et al., 2002) i.e. tropical developing regions, will depend the global maintenance of biological diversity and ecosystem services.

Appendix III-A. Data definition and source.

	Variable	Definition /interpretation	Source
Dependent variable	ECOREG	The Ecoregion protection score measures the degree to which a country achieves the target of protecting at least 10% of each biome (desert, forest, grassland …) within its country's land area / An increase refers to more conservation effort. The ecoregion score is range from 0 to 100	Center for International Earth Science Information Network (CIESIN) of Columbia University and the Yale Center for Environmental Law and Policy of Yale University, 2010
Interest variables	T.ARVL	International tourism, number of arrivals / High values refer to more touristic country	World Development Indicators, 2012
	ODA.ENV	Flow of multilateral official development assistance for Biodiversity and Climate Change and Desertification in US dollars.	OECD statistics, 2010
Control variables	CITES	Percentage of received reports on expected reports / High values refer to countries involvement and participation in environmental agreements and low value to less involvement and participation.	Annual reports of CITES parties 2002, 2010
	POP.TO	Total population in the country.	World Development Indicators, 2010
	DENS	Number of people living per km^2/ An increase refers to rising of population pressure, a decrease to declining of population pressure.	World Development Indicators, 2010
	GDP	Gross Domestic Product per capita (current US$)	World Development Indicators, 2010

	EXPORT	Export of goods and services (% GDP) represent the value of all goods and other market services provided to the rest of the world.	World Development Indicators, 2010
	AGRI	Percentage of land area / An increase refers to rising of conversion of land to agriculture, a decrease to declining of conversion of land to agriculture.	World Development Indicators, 2010
	EDUC	Combined gross enrolment ratio in education for both sexes. The number of students enrolled in primary, secondary and tertiary levels of education, regardless of age, as a percentage of the population of theoretical school age for the three levels	International Human Development Indicators, 2010
	GOV.EFF	Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies/ High values refer to high government effectiveness. The indicator is range from -2,5 to 2,5.	Worldwide governance indicators 2010
	FOREST	Forest area in 1990 in percentage of land area / High values refer to important natural endowments	World Development Indicators, 2010

Appendix III-B. Descriptive statistics

Variable	Unit/Definitions	N	Mean	S.D.	Min	Max	Year
ECOREG	[0 ; 100]	48	69,91	36,48	0,01	100,00	2009
T.ARVL	numbers of tourist in thousand	48	435,22	960,49	0,00	6183,33	1995-2008
ODA.ENV	USD millions	48	1,50	3,56	0,00	17,75	2006-2008
CITES	% of submitted reports on expected reports	48	66,19	39,13	0,00	100,00	1990-2008
POP.TO	hab in millions	48	13,93	21,46	0,08	124,00	1990-2009
FOREST	% of land area	48	32,80	24,11	0,26	89,13	1990
GOV.EFF	[-2.5 ; 2.5]	48	-0,75	0,60	-2,09	0,63	1996-2009
AGRI	% of GDP	48	29,03	16,63	3,23	66,92	1990-2009
GDP	USD millions	48	1153,46	1724,59	137,78	7994,31	1990-2009
EXPORT	% of GDP	48	31,36	18,80	7,91	76,97	1990-2009
DENS	hab/sq.km	48	73,84	102,85	2,16	576,46	1990-2009
EDUC	% percentage of the population of theoretical school age for the three levels (primary, secondary and tertiary levels of education)	48	49,89	15,60	7,90	83,00	1990-2009

Appendix III-C. Model selection results

The first table give information criteria for the regression at each quantity of predictors in addition to fixed interest variables (T.ARVL, ODA.ENV). The control variables included in regression at each step are described just below. The criteria for the optimal subset variables are in bold. The Variance inflation factor (VIF) for the optimal model is presented below.

Predictors	R^2_{ADJ}	C	AIC	AIC_C	BIC
1	0,3495276	1,540767	464,6932	602,3399	472,178
2	0,3835633	0,4724551	463,01	601,2769	472,366
3	**0,4050875**	0,2656383	**462,1746**	**601,1927**	473,4018
4	0,3973258	1,864056	463,6401	603,5505	476,7385
5	0,3863194	3,628322	465,3236	606,2785	480,2932
6	0,3748424	5,387269	466,9977	609,1617	483,8385
7	0,3621137	7,181942	468,7184	612,2698	487,4304
8	0,3471874	9,057681	470,5485	615,6809	491,1318
9	0,32979	11,01921	472,4959	619,4198	494,9503
10	0,3110193	13	474,4695	623,4149	498,7951

Selected Predictors
1 : forest
2 : forest cites
3 : forest pop.to cites
4 : forest pop.to cites dens
5 : forest pop.to cites dens gov.eff
6 : forest pop.to cites dens gdp2 gdp
7 : forest pop.to cites dens gdp2 gdp gov.eff
8 : forest pop.to cites dens gdp2 gdp gov.eff export
9 : forest pop.to cites dens gdp2 gdp gov.eff export agri
10 : forest pop.to cites dens gdp2 gdp gov.eff export agri educ

Variables	VIF	1/VIF
POP.TO	1,33	0,753941
T.ARVL	1,29	0,773353
CITES	1,19	0,842759
ODA.ENV	1,13	0,886271
FOREST	1,09	0,914022
Mean VIF	1,21	

The higher the value of tolerance (1/VIF), the less overlap there is with other variables. A tolerance value of .50 or higher is generally considered acceptable (Tabachnick and Fidell, 2001)

Part II: Case studies in Biodiversity conservation in Ivory Coast

Partie II : Etudes de cas sur la conservation de la biodiversité en Côte d'Ivoire

CHAPTER IV

IV. People and protected areas: an assessment of cost and benefits of conservation to local people in South-Eastern Ivory Coast[8]

Abstract

The local socioeconomic context of protected areas is not well documented in Western Africa, despite the existence of priority conservation sites, along with the steady state of poverty in the region. This article presents a case study where perceived costs and benefits of a conservation project on rural household welfare are measured. The study uses the market price method along with contingent valuation methodology. The analyses provide empirical evidence that although protected areas reduce local welfare, there exist locally valued benefits associated with conservation. Those benefits are, however, inadequate to offset the costs incurred by local people. While the results confirm conventional wisdom that argues that protected areas reduce local economic welfare in developing areas, our findings qualify the statement according to which “protected areas are bad for local people.”

JEL Codes: D61, Q51, Q57, C24

Keywords: protected areas, local livelihoods, economic valuation, non-market valuation contingent valuation

[8] This chapter draws on a research paper funded by the Swiss Center for Scientific Research in Ivory Coast, in collaboration with Pr Inza Koné, a primatologist at the University of Abidjan Cocody and Director of department “Biodiversity and Food Security” at the Swiss Center for Scientific Research. **The paper has been accepted for publication in “Society & Natural Resources”.**

1. Introduction

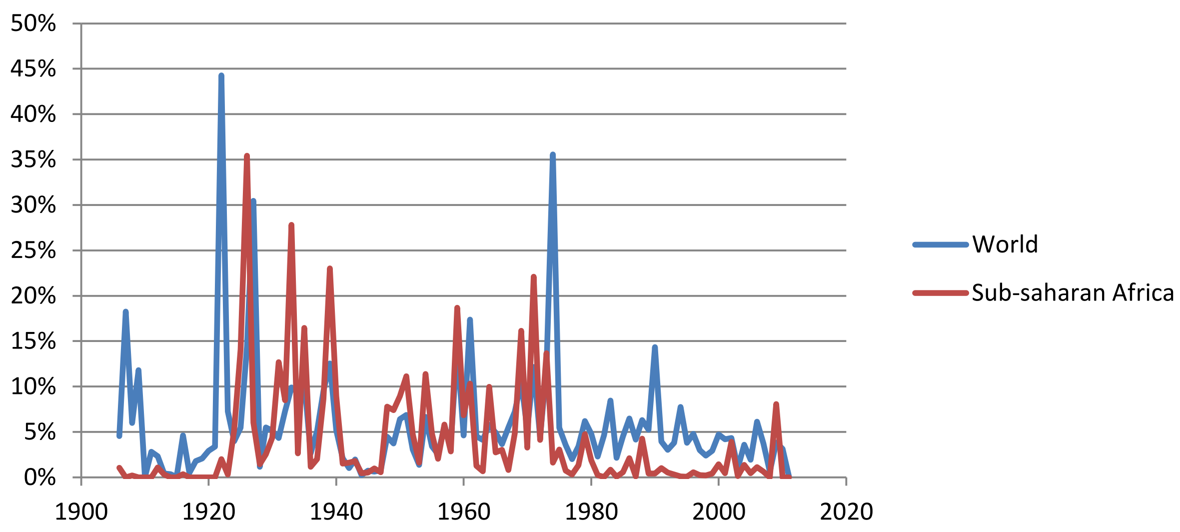
The establishment of protected areas (PAs) has traditionally been recognized as the single most important device for securing conservation of terrestrial animal species (Palmer and Di Falco, 2012). This has been a leading state response to the threats that biodiversity faces since the late 19th century (Adams et al., 2004). The number of PAs has expanded rapidly in the past century, especially in regions such as sub-saharan Africa (Cf. Figure IV-1). In SSA terrestrial PAs occupy 10% of surface area in 2011.

In the 1980s, the whole conservation paradigm underwent further change, which led to the idea of conservation through social inclusion rather than exclusion (Adams and Hulme, 2001; Hulme and Murphree, 1999). These changes came in the 1970s as a consequence of global interest in the manner in which the creation of PAs impacted local societies and economies (Adams and Hutton, 2007; Adams et al., 2004; Wilkie et al., 2006). In fact, the adverse effects that PAs have had on local populations and the urgency of global poverty elimination had made the relation between biodiversity conservation and poverty reduction an important element of debate in conservation policy (Ghimire et al., 1997; Sanderson and Redford, 2003).

Despite this greater awareness, the literature provides little rigorous empirical and quantitative evidence regarding the socioeconomic impacts of PAs in developing countries, as some authors emphasize (Christie et al., 2012; Ferraro, 2002; Sims, 2010; Wilkie et al., 2006). In the sub-Saharan Africa context, where poverty and biodiversity erosion are still challenging nested issues (Billé et al., 2012; Roe, 2010; Turner et al., 2012), few studies exist on the socioeconomic impacts of PAs. Some exceptions are Ruitenbeek (1992), Norton-Griffiths and Southey (1995), Shyamsundar and Kramer (1996), Ferraro (2002), Börner et al. (2009), Bush et al. (2011), Mackenzie and Ahabyona (2012). These studies have estimated what may be the costs for local people associated with conservation in SSA countries. The valuations of benefits when PAs are established in SSA focus on the regional or global nature of benefits, paying little attention to the potentially local nature of conservation benefits. As a consequence, only one part of the problem is examined and, therefore, potential trade-offs between conservation and local people livelihoods are disregarded.

The aim of this article is therefore to value conservation impacts in terms of costs as well as benefits perceived by local people. A particular attention will paid to locally valued benefits and to local costs borne by villagers in a developing area context. In addition, this case study conducted in Ivory Coast offers several advantages. First, quantitative studies assessing the impact of conservation on livelihoods are infrequent in Western Africa where the highest rate of deforestation in SSA has occurred (Hansen et al., 2013). Second, there is no published example, to the best of our knowledge, of an illustrative case study in the application of market price method and Contingent Valuation Methodology (CVM) to estimate impacts associated with the establishment of a park in Ivory coast.

Figure IV-1. The rate of growth of protected areas surface



Source: author elaboration[9]

2. Methods

2.1.Study area

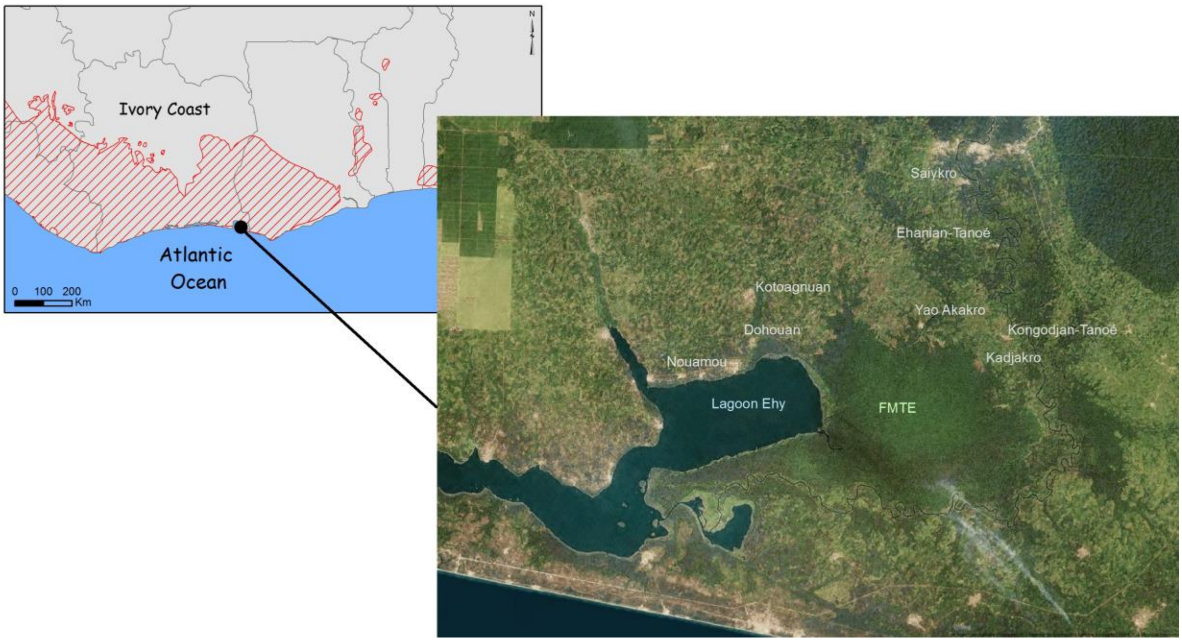
The Forest of Marais Tanoé-Ehy (FMTE) is an unprotected forest block located in south-eastern Ivory Coast (cf. Figure IV-2). It has been identified as the only forest where several endangered primate species still survive (Gonedelé Bi et al., 2008). The forest houses the

[9] Data are from The United Nations Environment Program World Conservation Monitoring Centre (UNEP-WCMC). The UNEP-WCMC adopts the International Union for Conservation of Nature's (IUCN) definition of a protected area. Protected areas are defined by the World Conservation Union (IUCN) as areas of land or sea "dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, managed through legal or other effective means"(Coad et al., 2008). The surfaces of PAs used have been recalculated with ARCGIS using the provided representation. The rate of growth is defined as $((PA_{t+1} - PA_t)/PA_t)$

Cercopithecus diana roloway and the *Piliocolobus badius waldronae* was also suspected in this forest. Both monkeys are among the 25 most threatened species of primates in the world (Mittermeier et al., 2007). Two other species found in this forest are in danger of extinction (*Colobus* and *Cercocebus atys lunulatus vellerosus*) and another one is near-threatened (Procolobus verus) (McGraw, 1998). The conservation of these endemic species in West African forests is therefore viewed as a priority for primate conservation in the region (Poorter et al., 2004).

A participatory diagnosis in 2006 showed local people's willingness to conserve the FMTE: local people regard it as natural heritage. In addition to being home of threatened species, it is documented that forests provide microclimate regulation services. Since then local communities have supported the establishment of the Voluntary Nature Reserve (VNR) of the FMTE. In terms of IUCN's PAs categories, VNR is designated as category VI, "Protected Area with Sustainable Use of Natural Resources." The management type is based on community management with shared authority between local communities, national agencies (Ministry of environment, regional authorities), and private actors. Specifically, the conservation program intends to set up differentiated levels of restriction for access to FMTE, in accordance with several management rules defined in cooperation with local people. As of the date of the survey it has been decided, with local communities, to totally restrict agriculture, hunting, and logging and to set up a partial restriction on fishing, collection of firewood, building materials, and medicinal plants. Cultural services i.e. ceremonials and rituals were not affected. Stakeholders were still discussing the extraction rules for the partial restriction as of the date of the survey, while the total restriction was implemented. A local committee composed of representatives of villages has been established to (1) organize and carry out forest surveillance, (2) sensitize poachers and other villagers about the importance of preserving the forest and its wildlife, and (3) provide support to conservation activities carried out in the forest. Seven villages (Kadjakro, Kongodjan-tanoé, Yao Akakro, Nouamou, Dohouan, Kotouagnoua, Atchimanou) neighbouring the FMTE and two villages with ancestral ties to the forest (Ehania Tanoé, Saykro) were identified as local stakeholders for the implementation of the project.

Figure IV-2. The Forest Marais Tanoé Ehy: part of the Guinean forests of West Africa, a "hotspot" for biodiversity in Africa



Source: authors' elaboration with base maps from bing map

2.2.Approach for assessing costs and benefits

Different methods are adopted to assess cost and benefits associated with conservation, in monetary terms, driven by their transferability to established markets. In the SSA context, adopted techniques included modelling approach (Börner et al., 2009; Ferraro, 2002) and stated preferences techniques (Shyamsundar and Kramer, 1996; Bush et al, 2011). When established local markets exist, market price method is applied (Mackenzie and Ahabyona, 2012; Ruitenbeek, 1992, Bush et al, 2011). Local impacts are defined locally in the study. Local costs are related to crop raiding by protected animals and to changes in forest products collection and consumption (cf section 4 for more details). As local markets exist for crop and forest products, we rely on market price method for assessing costs. Local benefits include use values, existence values, and option values. Stated preferences techniques, namely contingent valuation methodology (CVM) allow assessing benefits which include market and non-market goods and services.

Market-price approaches use prices and/or costs from actual markets related to the provision of an environmental good or service as a proxy for the value of that environmental good or service (Christie et al., 2012). In the SSA context, market price method is most frequently adopted in assessing the direct impact derived from changes in forest use values (Campbell et al., 1997; Godoy et al., 2002; Shackleton et al., 2002) and are employed marginally in assessing the indirect impact derived from ecosystem services (Ruitenbeek, 1992). Household surveys are used to assess the volume of goods produced on farms or harvested from the forest, often alongside other sources of household income, such as wage labor or small business activities, and market price values are used to estimate goods values (Bush et al., 2011).

CVM obtains an individual’s willingness to pay (WTP) for or willingness to accept (WTA) the change in environmental quality through the survey instrument (Hoyos and Mariel, 2010). WTA formats are often used to measure compensation for local people (Shyamsundar and Kramer, 1996) and then assess local cost. A WTP format is more appropriate than a WTA format if a change of the public good affects the same group of agents from both sides of the transaction (Carson, 1991). So, if local people perceive any benefits from conservation, then a WTP format is preferable. Studies adopting a WTP format for local benefits of conservation in SSA context primarily assessed globally valued biodiversity services through nature tourism (Lindsey et al., 2005; Mercer et al., 1995; Moyini and Uwimbabazi, 2000). Few studies addressed a WTP format questionnaire to local rural households to estimate locally valued conservation benefits. Some exceptions are Mekonnen (2000) in Ethiopia, Lynam et al. (2004) in Zimbabwe and Tsi et al. (2008) in Cameroon. WTP format directed towards local, rural households to assess locally valued conservation benefits is rare, for several reasons. First, some have found that local people do not perceive any benefits from conservation (Shyamsundar and Kramer, 1996). Second, the nature of some conservation benefits that are long term and diffusely distributed make it difficult for local people to recognize them as benefits (Ferraro, 2002). Third, while conservation benefits can be locally valuable it is difficult to measure (Norton-Griffiths and Southey, 1995). Finally, it will often be challenging for outside researchers to fully appreciate and account for specific local values in the design of their studies (Bourque and Fielder, 1995). This part of locally perceived benefits cannot still be missing since recent studies on preferences show that local resident in developing countries context (Karanth and Nepal, 2012) and also in the sub-Saharan Africa context (Tessema et al., 2010; Vodouhê et al., 2010) perceived some non-use benefits from conservation. As mentioned in Whittington (1998, 2002), in many indigenous communities, there may be strong cultural and/or spiritual values of biodiversity, as well as a range of local nuances that need to be adhered to.

2.3.Household survey

Our data is household based. We conducted in-person interviews with heads of households around the FMTE in December 2011. With no information on the structure of the population around the FMTE for the last ten years, we designed a random sampling to capture a representative number of observations (Kaltenborn et al., 2006). We divided each village into four zones from a given starting point (north, south, east, and west). Households were randomly selected in each zone during one full day. Furthermore, we corrected deviations between the sample and the population with a weight calculated as n_i/N_i with n_i being the number of households by village in the sample and N_i the estimated number of households by village in 2011. We estimated Ni with data from the last national census from 1998 and unofficial estimation on population size for 2011 from the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA). Each village was surveyed by two interviewers (of which one is a lead author) all at the doctorate level. As the survey was administered in local languages, the researchers were assisted by 2 members of the local project team within each village who were familiar with the conservation project and with survey techniques. They were thereby able to translate complex issues. Pre-tests were made together with the two interviewers in order to standardize the questionnaire and reduce interviewer effects in the analysis. 232 households in 8 out of 9 villages[10] around the FMTE were surveyed, which represent 11% of all the villages' households (Cf. Appendix IV-A for survey details). This household survey is a follow up of data collection episodes implemented over the 2006-2010 period in the neighbourhood of the FMTE that had involved 232 people in semi-structured individual and group (focus group) interviews and 200 households in a household survey. This data collection was helpful for the design of the questionnaire.

Along with socioeconomic variables, the questionnaire comprised two main sections (Cf. Appendix IV-B for a summary of type of information collected). The first part related to the estimation of local costs, starting with asking whether the respondent had once accessed the FMTE for their livelihood needs and whether this has changed. An open ended question asked

[10] Due to flood water, the village of Atchimanou and some zones in the village of Kadjakro were unattainable.

them why they have changed their access to the FMTE and thereafter in what extent they perceive the changes as a result of the project. This elicitation procedure seeks to avoid a systematic link between livelihoods changes and the project. They were then asked to give details about what they used to do in FMTE and in what extent their household livelihoods have changed.

The second part is related to the estimation of benefits from conservation through CVM. The survey was administered by the researchers that crafted the CVM scenario, thus avoiding the problem of poorly trained enumerators, such as Whittington (2002) mentioned. The questionnaire started by asking respondents about the most important aspects of forests for them, to what extent they were concerned about the state of forests in the future, whether they noticed increasing forest degradation in the region, and whether they found it important to initiate measures to prevent the degradation and loss of forests. They were then given more information about the conservation project. We reminded them that the main goal of the project is to maintain biodiversity and provision of ecosystem services in the region and what the project entails in terms of management rules and community participation. They were asked whether they were in favor of actions that were undertaken for the conservation of FMTE, whether they were in favor of installation of a village committee to ensure the conservation of FMTE, and whether they would like that the action of the village committee continues, decreases, increases, or stops. They were told that during the first phases of the project they would have to bear all costs related to the village committee, and that their answer would influence the work of the village committee in the conservation of the FMTE. They were told to imagine that a voluntary contribution has been introduced in their village for that purpose and households that perceived *any benefits* from conservation of FMTE are asked to participate. This process ensures that the preference survey questions meet the criteria for *consequential survey questions*, which are important for producing useful information about respondent's preferences (Carson and Groves, 2007). In such a case, standard economic theory applies and the response to the question should be interpretable using mechanism design theory concerning incentive structures (Carson and Groves, 2007).

The valuation question was phrased in terms of how much the household would be willing to pay monthly, given its budget, to participate in the project so that the village committee can complete its conservation mission. First, the respondents were asked a payment card format valuation question that exhibited desirable property in order to resolve the bias of anchoring, the problem of "yea-saying," and the cognitive effort expected of respondents (Reaves et al., 1999). We followed with an open-ended question about their maximum WTP for the project, which improves the statistical efficiency of the information by giving precise information on the value accorded to the goods or services (Carson and Hanemann, 2005). Voluntary contribution per household in CFA francs was selected as the best payment vehicle after a pre-test in one village. This is in line with local practices in rural areas in Ivory coast, where voluntary contributions are often asked for the funding of collective projects (Atta and Kamagaté, 2010). As is mentioned in Christie et al., (2012) methods of valuation need to be modified to account for local context. Follow-up questions were used after the valuation question to examine motivation for the zero bids, to identify what benefits respondents associated with conserving the FMTE, and also to check whether stated preferences refers really to the project's benefits.

3. Characteristics of surveyed population [11]

3.1. Socio-economic status

Two out of three households in the villages near the FMTE are not native to the region and have emigrated from neighbouring countries to work in farming in Ivory coast. 73% households have been settled in the region for over a generation (73%). The heads of household are mostly male (91%), illiterate (59%) and are between 30 and 59 years old (54%). The average number of children per household is 4.5. The villages around the FMTE are poor villages with a subsistence economy. Most respondents work in agriculture (83%), one third has a gainful secondary activity (31%), which is typically small-scale trade (8%), fishing (6%), farming (6%), and hunting (2%). The heads of households declare an average annual income comprised between 200,000 and 400,000 CFA francs (US$395- US$790; 1$ = 506.10 CFA francs in December 2011) which is around the poverty threshold range for rural areas in Ivory coast (241,926 CFA francs – US$478) (République de Côte d'Ivoire, 2009). Looking at the income distribution in more details, there is inter-village income inequality and this seems to be related to distance to FMTE. In fact, there is no household in the higher income bracket (>1,000,000 CFA francs) in Dohouan and Yao-akakro, two villages very close to the FMTE, while 15.6% and 7.6%, respectively, of households in Saykro and Ehania-

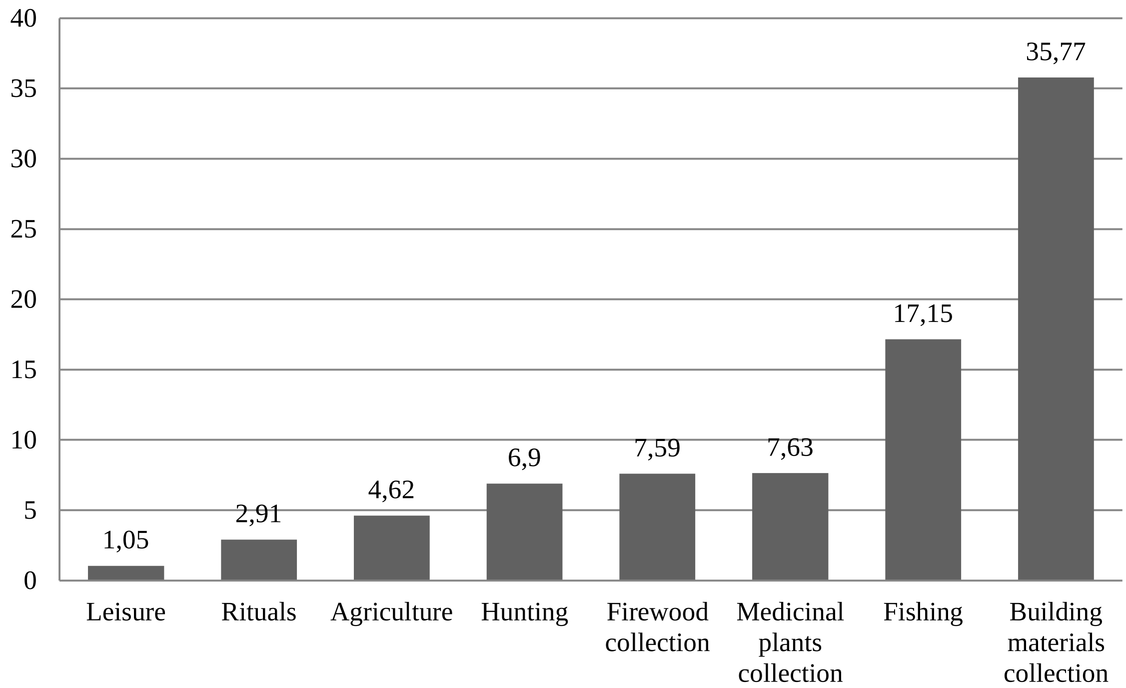
[11] The analysis accounts for survey design. The data has been svyset using the "svy" command and its associated arguments on Stata software. The data are thus weighted, with weights equal to the inverse of the probability of being sampled. The estimates are of the model that would be fitted if you had the entire population in the sample.

tanoé, the most remote villages from FMTE, have annual income greater than 1,000,000 CFA francs. Apart from the income disparities, the standard profile of households is almost the same for all villages (Cf. Appendix IV-C).

3.2.FMTE and local livelihoods

Half of households (50%) declared that they have used the resources of the FMTE at least once. This shows the importance of the FMTE for local livelihoods. The main activities in the FMTE were harvesting activities (fishing, hunting, collecting firewood, collecting building materials, and collecting medicinal plants) and cultural activities (ceremonials and rituals and leisure) (cf. Figure IV-3). Although the management rules are not yet well defined in terms of extraction and enforcement, especially for the partial restriction, there are yet many changes in FMTE utilization and hence in people's livelihoods. Indeed, among households that have accessed the FMTE once, 28% stated they continue to access the FMTE against 23% who stopped accessing the FMTE.

Figure IV-3. Distribution of villagers' activities in FMTE (data in %)



3.3.Villagers attitudes regarding FMTE conservation

Living around the forest, in general, is important for villagers, 90% of respondents asserted. As they emphasize, the forest represents the basis of their livelihoods, it is then invaluable to them.   Villagers are largely concerned about the future condition of the forest

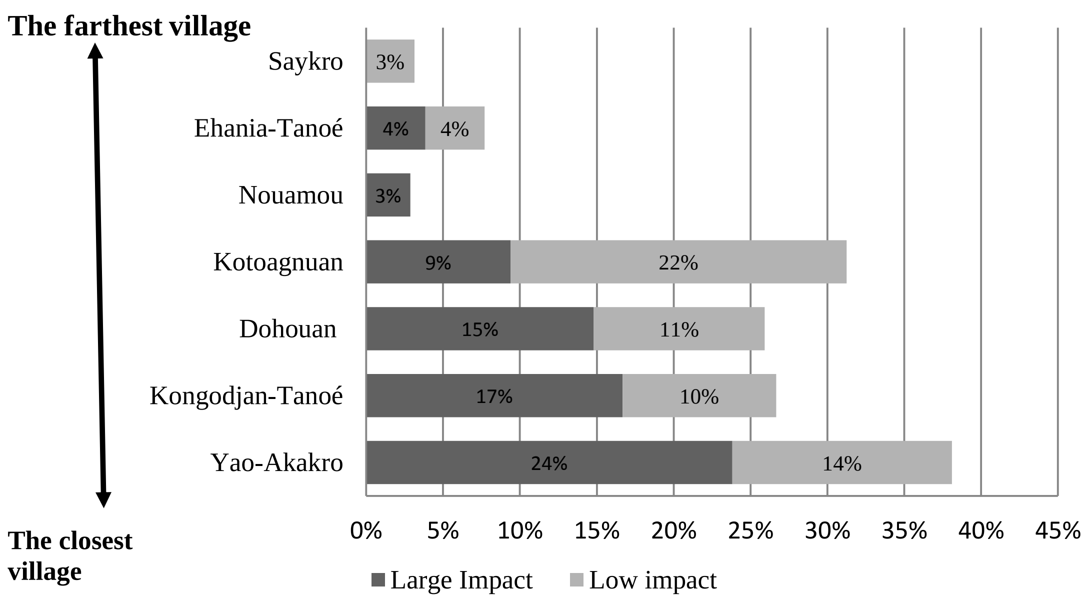
(88%). In fact, they have noted a significant degradation of forests in the region that they have perceived by the growing loss of virgin forests (92%). Therefore, a significant proportion of the population support the conservation project (95%) and also the community based conservation approach (89%). An notable proportion of households (89%) desire that villagers' involvement in conservation activities is maintained or increased against only 1% who want to see this approach removed. Respondents without an opinion represent 9%. The acceptability of the conservation project seems to be a fairly broad consensus among local populations.

4. Local cost

4.1. Local perception of FMTE conservation cost

The local cost as a result of the conservation project is relevant to 21% of the households near the FMTE. They claim that the project has impacted their livelihoods and their welfare. A part of them (9.2%) consider that the impact is relatively large and 10.7% perceived a relatively low impact. The distribution of the local costs per village shows, predictably, that the villages where households claim more against the project are those located in the immediate periphery of the FMTE (Cf. Figure IV-4).

Figure IV-4. Perception of negative impact by villages (data in % of households)



In detail the claims are more related to income-generating activities of households, to forest products consumption, or to crop raiding by animals in FMTE. The conservation project has led to the ban of certain lucrative practices, in particular, hunting and to a lesser extent logging. Before the project, hunting monkeys was a lucrative activity in the region. The ban on logging activities in the FMTE also represents an income shortfall for local populations, although this is marginal (1% of respondents indicated that they were active in this activity). The income impact has been cited by 3% of households.

The project affects some households' consumption habits. In fact, the ban on hunting and the restriction of fishing reduces the local supply of fish and bush meat. Fish and bush meat are the only source of affordable protein for poor households. Near the FMTE the villagers fish and hunt largely for their subsistence. The restricted access to FMTE has the effect of removing some food from the villagers' diet or increasing their daily expenditure to maintain their usual level of consumption. Impacts on consumption have been cited by 3% of households.

Farmers near the FMTE noted an increase in the destruction of their crops and seeds caused by small mammals. According to them, it is a consequence of the project, since they think that the ban on hunting, to protect primate species, has promoted the proliferation of small mammals. Small mammals attack fields of cassava, coffee, corn, and palm seeds. The monkeys of FMTE also damage some crops but only marginally. This destruction causes crop losses or additional expenses due to the need to purchase additional seeds and also causes some human-wildlife conflict. The harm from crop losses has been mentioned by 2% of households.

4.2.Estimation of local cost

Information on price was gathered first through the survey. We collected additional supplemental data from village leaders and directly from local markets. We were then able to value losses enumerated by households. The sale or resale of a monkey could bring at least 30.000 CFA francs (US$50.60) a month to a household. Businesses in the sector of artisanal logging generate between 50,000 and 80,000 CFA francs per month (US$99 - 158). The surplus of expenditure for substitute foods varies between 200 CFA francs and 800 CFA francs (US$0.4 -1.6) per day by household. The financial costs related to crop/seed losses are estimated between 50,000 and 100,000 CFA francs per year (US$99-197). This information and the share of total households that would potentially bear a cost, which we calculated by type of loss, were used to estimate the total local welfare loss, as perceived by households, of between US$143,000-594,000 per year in 2011, that we present in table IV-1 . Local people need thus compensation for forgone access to the FMTE resources ranging from US$68 to US$282 per household per year in 2011 considering all households (though, ranging from US$328 to US$1362 per household per year considering only households that would bear a cost, the cost for the others are assumed to be zero). The findings indicate that the respondents from villages near FMTE perceived substantial cost as a result of the conservation project.

Table IV-1. Estimation of local cost

Description	households concerned (% total household)	Annual cost per household		Total costs (Total population =2107)
		CFA francs	US dollar	US dollar
Income impact	7%	[360,000; 960,000]	[711; 1897]	[109,823; 292,860]
Consumption impact	6%	[73,000; 292,000]	[144; 577]	[17,030; 68,119]
Production impact	2%	[50,000; 100,000]	[99; 198]	[4,486; 8,972]
Others impacts [12]	6%	[161,000; 451,000]	[99; 1897]	[11,688; 223,969]
Total cost				[143,027; 593,920]

5. Local benefits

5.1. Local perceptions of the FMTE's benefits

A large proportion of respondents give positive WTP for the conservation of FMTE (70%). Ranking as top priority, there appears a large predominance of bequest value, highlighted by 53% of positive WTP. Some respondents emphasize that, considering the current rate of disappearance of forests, they are afraid, that their descendants will never know the forest or benefit from its resources. Secondly, respondents cited the satisfaction of the future needs of their households as being of major importance (19%) alongside their present needs (15%).

Of those WTP respondents attributing zero value to their resource, we use follow-up questions as proposed in Terra (2005) to separate true zero values from protest responses. Therefore, 12% of responses are classified as legitimate zero bidders who did not value the proposed conservation scenario. Their motivation behind the "zero bid" was: *I don't have*

[12] Others impacts have been estimated at higher and lower value of details impacts. We also estimated others impacts at means of details impacts. We find a total annual cost of US$167,527- 473,607 in the second case.

enough money or *I believe FMTE conservation is not important*. We classify 18% of responses as protest responses. Their motivation behind the "zero bid" was: *I'm unable to indicate the maximum amount I can afford to pay; I don't think household contribution is the best way to conserve the FMTE; I don't have enough information;* or *It's not for me to pay anything*.

5.2. Estimation of local benefits: Willingness to Pay (WTP) estimation results

To assess the total benefit, we aggregate mean WTP over a relevant market (Stanley, 2005). We calculate total local benefit as to be equal to the aggregation to local household population of the mean WTP per household. Sample mean and medians are insufficient to explain behaviours of a group of households as econometric models can do (Desaigues and Ami, 2000). Furthermore, according to Terra (2005), econometric models are useful in addressing (1) the issue of zero reporting WTP in the data, (2) the issue of aggregation to get the average WTP of total population, and in (3) explaining respondents' choices while also (4) validating survey results.

Table IV-2. Summary statistics of variables used in econometric models

Variables	Description	Mean	Min	Max	N
WTP1	Declared WTP	695.8856	0	10000	232
WTP2	Declared WTP without protest zero	852.965	0	10000	185
WTP3	Declared positive WTP	999.4688	100	10000	151
REV	Income level (ranging from 1 to 6)	2.22	1	6	232
NCHILD	Number of children in household	4.54	0	19	232
ACCESSf	Dummy representing involvement in the project (no longer access =1; others=0)	0.24	0	1	232
FOREST	Dummy representing concerns about forest condition in the future (very concerned=1; not concerned at all =0)	0.88	0	1	232
Village	Selection variable; Dummy representing the proximity to FMTE (very close=1; far=0)	0.23	0	1	232

We estimate a series of models taking into consideration different issues. As the proportion of zero WTP is important, OLS estimator is excluded, as it would lead to biased and consistent parameter estimates (Cameron and Trivedi, 2009). We then estimate censored Tobit models.

Table IV-3. Tobit and Clad Models results

Survey Regression	TOBIT				CLAD	
Dependant variable	WTP1		WTP2		WTP1	WTP2
	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Coefficient
_cons	-686.273*		-486.263		77,88	42,1
REV					75,66***	114,47***
2.REV	670.762*	376.653*	500.434	331.785		
3.REV	527.181**	286.505**	411.263*	267.792*		
4.REV	-9.929	-4.712	-182.965	-103.749		
5.REV	809.155	468.233	432.164	282.611		
6.REV	2184.102*	1581.692	3429.669***	3038.619**		
NCHILD	-2.735	-1.603	18.292	12.835	2,65	1,31
ACCESSf	530.541*	310.900*	494.729*	347.150*	252,21*	127,63**
FOREST	546.495**	320.249**	682.355***	478.808***	123,89	176,31
sigma	1548.471***		1344.756***			
N	232		185		232	185
CM test (Prob>chi 2)	0.00		0.00			
LM test Stat	60		72			
Critical value at 1%	9.46		9.36			

t-statistics are in parentheses; * Indicates p-value less than 0.10; ** Indicates p-value less than 0.05; *** Indicates p-value less than 0.01
1.REV=< 200000,2.REV= 200000-400000,3.REV= 400000-600000, 4.REV=600000-800000, 5.REV=800000-1000000,6.REV= >1000000
CM test: conditional moment testing the null hypothesis that the disturbances in a Tobit model have a normal distribution. LM test: LM test for testing the Tobit specification, against the alternative of a model that is non-linear in the regressors and contains an error term that can be heteroskedastic and non-normally distributed; critical values are obtained using a parametric bootstrap: asymptotic critical values result in large size distortions for small to moderate samples.

We consider the issue of the treatment of protest zero in open-ended CVM and we estimate models with and without protest zero, as has been done in Cho et al. (2005). We test the null hypothesis that the disturbances in a Tobit model are homoskedastic and normally distributed using a LM test and a CM test (Drukker, 2002). We relax assumptions on the errors term estimating the Powell’s CLAD estimator (Powell, 1984), which is robust to heteroscedasticity and is consistent and asymptotically normal for a wide class of error distributions (Newey et al. 1990). The Tobit regression makes the strong assumption that the same probability mechanism generates both the zero and the positive values (Cameron and Trivedi, 2009). We relax this assumption with the Heckman procedure. We assume that according to the distance to the FMTE, household choose first to value the proposed good (FMTE conservation) or not. Those who value the proposed good state then their WTP. Table IV-2 provides summary statistics for variables in the models. The Tobit and Clad models results are presented in Table IV-3. Table IV-4 presents Heckman models.

Table IV-4. Heckman models results

		Heckman1	Heckman2	Heckman3
Dependant variable		WTP3	WTP3	WTP2
	2.REV	349,21	329,43	365,42
	3.REV	59,66	70,22	222,20
	4.REV	-135,05	-204,36	-33,62
	5.REV	451,49	304,41	345,90
	6.REV	3098,74**	3163,42***	3300,60***
	NCHILD	14,73	15,97	11,97
	ACCESSf	446,16	408,20	382,17
	FOREST	568,22***	620,52***	538,21***
	_cons	138,73	119,35	16,25
select	village	0,30	1,01***	0,99**
	2.REV	0,47**	0,58**	0,54**
	3.REV	0,60**	0,39	0,29
	4.REV	0,00	0,43	0,52
	5.REV	0,48	8,39***	8,23***
	6.REV	0,07	-0,25	-0,37
	NCHILD	-0,01	-0,03	-0,03
	ACCESSf	0,29	0,44	0,41
	FOREST	0,21	-0,05	-0,08
	_cons	0,01	0,52	0,68
N		232	198	232
rho		-0,22	-0,36	-0,30
[95% Conf. Interval]		[-0,47 ; 0,06]	[-0,63 ; -0,01]	[-0,53 ; -0,01]

t-statistics are in parentheses; * Indicates p-value less than 0.10; ** Indicates p-value less than 0.05; *** Indicates p-value less than 0.01. We use village (Dummy representing the proximity to FMTE (very close=1; far=0) as exclusion variable.

The income variable has an effect on the amount of the household's WTP in Tobit, Heckman, and Clad models. It seems that the greater the household income, the higher the declared WTP whatever the estimation method.The variable Accessf, that measures, precisely, the waiver of household's right to access the FMTE is also positive and significant in Tobit and Clad estimations. Awareness of forest conditions in future also affects the amount of WTP in Tobit and Heckman models. Large differences between Tobit and Clad estimates, suggest non-normal errors and heteroskedasticity of the errors. This is confirmed by the CM-test and LM-statistics and therefore suggest potential bias in the Tobit estimator of WTP.

We use the different models for obtaining predicted values of WTP per household, following Haab and McConnell (2002). Our valuation results show that people near the FMTE perceived benefits estimated from 270 to 1170. CFA francs per household per month, depending upon the estimation of mean WTP (Table IV-5). Per year, the WTP ranges from 3,245 to 14,047 CFA francs (US$7- 28), 2% to 3% of average annual income. With data on benefits/household/year and estimated number of households in the 9 villages near the FMTE, we estimate the total local benefit to be from 6,837,000 to 28,596,894 CFA francs (US$13,509 – 58,480).

Table IV-5. Estimate of expected WTP and total benefits

	Description	Mean WTP per household	Annual WTP per household	Total benefits (total population=2107 households)
		CFA francs	US dollars	US dollars
Empirical Means	WTP1	695,89	16,50	34 765
	WTP2	852,97	20,22	42 613
	WTP3	999,47	23,70	49 932
Estimated Means	Tobit 1	1006,20	23,86	50 268
	Tobit 2	1170,58	27,76	58 480
	Clad 1	270,41	6,41	13 509
	Clad 2	403,12	9,56	20 139
	Heckman 1	696,60	16,52	34 801
	Heckman 2	789,09	18,71	39 422
	Heckman 3	694,61	16,47	34 701

6. Discussion

The CVM applied in the study gives results that are consistent with previous findings regarding the significant relationship between WTP and income (Jacobsen and Hanley, 2008) and between awareness for the specific habitat (FMTE, here) and WTP (Christie et al. 2006). This corroborates the findings of Shyamsundar and Kramer (1996) that CVM can be successfully applied to rural households within a developing country context. We find as a main result that conservation can in some cases affect local villagers on both sides of the transaction, i.e. negatively as well as positively. Positive perception of biodiversity in rural communities is not only derived from direct use; local people in developing countries also attributed non-use values to PAs (Macdonald et al., 2011). This finding can qualify the story about the relation between people and parks in the sense that in some cases the issue is not that they don't want conservation, but, even if they want it, it is not affordable for them. This is important in the sense that it can explain why compensation measures can work in some cases and why it doesn't work in others.

Regarding the estimated cost and benefit for local people, it appears that the adverse effects of FMTE conservation are experienced by 21% of the local population, while 65% claimed they perceive benefits related to the conservation of the forest. Although "local winners" are larger in number than the "local losers," in monetary terms the local total costs are substantial compared with the actual total benefits associated with FMTE conservation. We find that the local benefit of FMTE for villagers is estimated for 2011 to be less than US$60,000. Comparatively, the total welfare loss lies between US$143.000 and US$594.000--2 to 10 times more than the benefits. As things stand then, benefits derived from the conservation of FMTE are quite inadequate to cover the local cost incurred by populations.

Concerning the distribution of costs and benefits, it appears that respondents who reported a high value for conservation are among the richest, while those negatively affected are mostly in the poorest group of the population. These results show that those who benefit are not necessarily those who bear the costs and the richest give more value to conservation than the poorest. In the specific case of FMTE, we can, however, establish some singularities. Indeed, some households (about 17%), despite the fact that they bear the costs of restricting access to FMTE, also perceived benefits from FMTE conservation. This highlights the potential trade-off that local people can face. Out of these households, 45% assign a bequest value to FMTE, 21% an option value, and 18% a use value. In this category, households have higher average income than "local loser" households who don't perceive any benefits. This may partly explain a bigger independence from FMTE resources and justify that the losses caused by the establishment of the voluntary natural reserve are not irreversible in this group. Among this specific category, about 55% live in villages closest to FMTE, which can also justify that these households are more attached to their heritage, despite the costs they incur.

A net positive impact on local people is achievable in the specific case of the FMTE conservation project. In fact, the FMTE has a huge potential for tourism, research, and carbon storage. The FMTE has the potential to avoid the emission of 318 tons of carbon per hectare into the atmosphere, a total of 3.816.000 tonnes for the 12.000 hectares of the FMTE (Adou Yao, 2007). At a price of US$16.82 per tonne in 2011 on the European market (http://www.cre.fr/en/markets/wholesale-market/the-co2-market), we can estimate that the benefit related to the FMTE carbon storage, is about US$64 million (32 billion FCFA[13]). The FMTE contributes to the conservation of two rare species of monkeys that are among the 25 most threatened primate species in the world. Tourism centred on endangered species can generate substantial income relative to conservation (Loomis and White, 1996). This was proven in many sites in Africa, such as in Uganda for Gorillas (Moyini and Uwimbabazi, 2000) and birds (Naidoo and Adamowicz, 2005) in Namibia and Kenya for wildlife viewing (Barnes et al., 1997; Navrud and Mungatana, 1994), and South Africa for lycaon (Lindsey et al., 2005). Scientific research activities in PAs are also an important source of fundraising. Since the beginning of the project, the FMTE has enabled much scientific research in areas such as primatology, botany, ecology, sociology, anthropology, and so forth. The application of innovative instruments, such as tradable permits of bio-prospecting (Palmer and Di Falco, 2012) and research as well as public/private partnerships with the pharmaceutical industry, for example, can capture the scientific value of FMTE. The valuation of these services could thus generate important sources of additional local income. Indeed, just 1% of the value from carbon storage could offset the total local cost borne in 2011.

7. Conclusion

In this paper we assess the local impact of a conservation project that aims to protect one "hot spot" for biodiversity, in the South-Eastern Ivory Coast. The goal of the project is that

[13] This part of local benefit should be qualified considering the downward trend in CO_2 prices.

National authorities decide to classify the forest of Marais Tanoé-Ehy as a Voluntary Nature Reserve. We used the market price method to estimate, on the one hand, the local costs associated with the project in terms of loss incurred due to changes of households' level of income, consumption, and production. On the other hand, we estimated locally valued benefits associated with conservation. The estimates reveal that costs incurred by local people as a consequence of the project are significant when compared to the current benefits they perceive. Balanced against the potential funding that forest management can generate, these costs are, relatively, very low. There is, therefore, a way to offset the current net negative impact of the project for local people by mobilizing these financial resources and making sure they actually reach local people. In order to obtain this, further work must first evaluate and measure the real potential of FMTE to raise funds to finance its conservation, and, second, focus on compensation and redistributive mechanisms adapted to the specific case of the FMTE.

Appendix IV-A. Survey details

Villages	Total numbers of household (N[14])	Numbers of household in survey (n)	n/N (%)
Atchimanou	27	0	0
Ehania-Tanoé	95	26	27,4
Dohouan	197	27	13,7
Yao-Akakro	178	42	23,6
Kadjakro	117	8	6,8
kongodjan-Tanoé	190	30	15,8
saykro	340	32	9,4
Nouamou	310	35	11,3
kotoagnuan	653	32	4,9
Total	2107	232	11,0

Appendix IV-B. Summary of survey

Socioeconomic profile and respondents characteristics

Gender
Age
Marital status
Number of children
Primary occupation (farmers; farm worker; hunter; fishermen; shopkeepers; others)
Secondary occupation
Education level (illiterate; Koranic; primary; secondary; university)
Annual income (0-200000 ; 200000-400000 ; 400000-600000 ; 600000- 800000 ; 800000-1000000 ; 1000000 and more)
Are you a native from the region? If yes, village name. if no, how long have your family been living in the region?
Village of residence

Part I: Cost valuation

Activities in FMTE

a) Do you need to access forest in general for your livelihoods?
b) Do you need to access FMTE for your livelihoods? (Every day; Several times a week; Few times a month; Few times a year; No longer; ever)
c) What kind of activities do you do (have you done) in FMTE?

[14]An estimation establishes the number of household in the 9 villages to be 2107 (Office for the Coordination of Humanitarian Affairs (OCHA) Ivory Coast, September 2011), the last national census was in 1998. ()

If the answer to b) is no longer

d) Why do you no longer go in the FMTE? (You find a new site for your need; FMTE project, Other(precise))?
e) Do you feel that the conservation project has impacted your livelihoods (Yes a lot, Yes a little, Not at all, Do not know)?
f) If the answer to e) is "Yes a lot" or "Yes a little"
g) Currently, do you earn more or less when compared to the period you had accessed to FMTE (I earn relatively more; I earn relatively less; My income is equivalent; Do not know;)
h) What are the expenses that you have given up because of the loss of income?
i) How much income is needed to ensure these expenses?
j) How much in general have you lost because of the project? (per month, per year)

Part II: Benefits valuation

FMTE conservation

k) What are the most important aspects of forest for you?
l) To what extent are you currently concerned about the state of forests in 20 years?
m) Do you notice increasing forest degradation in the region?
n) Do you think it is important to initiate measures to prevent the degradation and loss of forests?
o) Are you in favor of actions that were undertaken for the conservation of FMTE?
p) Are you in favor of installation of a village committee to ensure the conservation of FMTE?
q) Would you like that the action of the village committee continues, decreases, increases, or stops?

Hypothetical scenario: During the first phases of the project, local population will have to bear all costs related to the village committee. Your contribution or not will influence the work of the village committee in the conservation of the FMTE. Imagine that a voluntary contribution is introduced in your village for that purpose and, households that perceived *any benefits* from conservation of FMTE are asked to participate.

r) How much your household would be willing to pay monthly, given your budget, to participate in the project so that the village committee can complete its conservation mission? (0 ; less than 250 ; 250-500 ; 500 -750 ; 750-1000 ; 1000 and more)
s) In the interval you have choosen what is the maximum amount you would like to pay?

If the answer is different from 0

t) What are the most important reasons why you wish to participate in the conservation of FMTE? Prioritize (For the current needs of my household; For future needs of my household; For future generations; Conserve FMTE even if I never set foot; For rituals; We have a moral responsibility to maintain nature)

if 0, indicate why

u) Conservation FMTE does not seem important to me; Support village committee will not be effective to conserve FMTE; I'm unable to determine the amount that I would like to pay; I do not have enough information; it is not for me to pay; other (precise);

Appendix IV-C. Socio-economic characteristics of head of households in FMTE-adjacent villages

	Ehania Tanoé	Dohouan	Yao Akakro	Kongodjan Tanoé	Saykro	Nouamou	Kotoagnuan	TOTAL
Sexe(%)								
male	80,77	85,19	95,24	90	84,38	100	96,88	91,46
female	19,23	14,81	4,76	10	15,63	0	3,13	8,54
Origine(%)								
native	65,38	77,78	26,19	26,67	40,63	17,14	12,50	31,67
not native	34,62	22,22	73,81	73,33	59,38	82,86	87,50	68,33
Years in the region (%)								
<5	0,00	14,81	14,29	3,33	18,75	20,00	0,00	9,68
5-20	19,23	3,70	11,90	6,67	12,50	22,86	25,00	17,56
> 20	80,77	81,48	73,81	90,00	68,75	57,14	75,00	72,76
Years old (%)								
20-39	42,31	33,33	40,48	26,67	28,13	60	53,13	44,02
40-59	34,62	44,44	45,24	53,33	40,63	22,86	34,38	38,18
60-79	7,69	14,81	14,29	10	25	5,71	9,38	11,77
> 79	3,85	7,41	0	6,67	3,13	5,71	0	2,85
Child numbers (Mean)	4,38	4,37	5,62	5,23	5,19	3,94	3,72	4,54
Educational attainment (%)								
illiterate	61,54	11,11	50,00	63,33	50,00	42,86	56,25	50,36
koranic education	3,85	7,41	9,52	10,00	3,12	22,86	6,25	8,49
primary education	15,38	33,33	28,57	20,00	15,62	14,29	21,88	19,68
secondary education	7,69	40,74	11,90	6,67	25,00	20,00	15,63	19,22
university education	7,69	7,41	0,00	0,00	6,25	0,00	0,00	2,07
Profesional activity (%)								
farmers	80,77	70,37	83,33	93,33	71,88	65,71	78,13	77,70
farm worker	7,69	11,11	9,52	0,00	3,13	8,57	3,13	4,99
hunter	0,00	0,00	2,38	0,00	0,00	0,00	0,00	0,20
fishermen	3,85	0,00	0,00	0,00	0,00	8,57	0,00	1,45
small trader	3,85	7,41	2,38	3,33	6,25	8,57	9,38	6,63
	3,85	11,11	2,38	3,33	18,75	5,71	9,38	8,60
Secondary professional activity (%)								

farmers	0,00	3,70	2,38	3,33	6,25	11,43	6,25	5,55
farm worker	0,00	0,00	0,00	0,00	0,00	5,71	0,00	0,85
hunter	0,00	0,00	0,00	0,00	0,00	3,13	0,00	1,33
fishermen	3,85	0,00	14,29	10,00	6,25	5,71	0,00	5,59
small trader	26,92	14,81	11,90	0,00	3,13	14,29	3,12	7,98
Income level								
< 200000	73,08	70,37	50,00	56,67	28,13	37,14	25,00	39,55
200000-400000	15,38	14,81	38,10	13,33	25,00	22,86	28,12	24,31
400000-600000	0,00	3,70	4,76	16,67	12,50	28,57	21,88	16,86
600000-800000	0,00	0,00	2,38	6,67	3,13	5,71	6,25	4,14
800000-1000000	0,00	3,70	4,76	3,33	12,50	0,00	6,25	5,07
>1000000	7,69	0,00	0,00	3,33	15,63	2,86	6,25	6,30

CHAPTER V

V. Factors affecting local people preferences for conserving biodiversity in protected areas: a case study in Ivory Coast[15]

Abstract

Conservation objectives and local demand for natural resources could be conflicting issues especially when local stakeholders are poor. Long term integrity and effectiveness of protected areas are therefore dependent on their support. The present study precisely assesses factors that govern the acceptability of protected areas in Ivory Coast with a field survey conducted in October 2012 on 303 households from 14 villages located in the humid belt of the Guinean forest. Data were collected through a choice scenario, where hypothetical changes in protected areas surfaces were balanced against provision of ecosystem services. The relation between people preferences and potential factors that affect preferences are analyzed through multinomial models. It is found that local people state a positive preference for protected areas which were presented in light of their impact on the provision of ecosystem services. The study gives also new empirical evidence for the role of protected areas management type and provisioning ecosystem services in local preferences for protected areas.

JEL codes: D01, C35, Q57

Keywords: Biodiversity, ecosystem services, multinomial choice models.

[15] This chapter draws on a research project which has received funding from "CSRS-UNDP2" research scholarships for partnerships between Swiss and Ivorian institutions, which has been entrusted to the "Centre Suisse de Recherches Scientifiques en Côte d'Ivoire (CSRS)" and hosted by the United Nations Development Program (UNDP), in collaboration with Pr Inza Koné, Dr Gudrun Schwilch, and Julie Zähringer. **The paper has passed the first round of submission in Natural Resources Forum and is in revision.**

1. Introduction

The world's most biodiversity-rich forest ecosystems are found in developing countries where they are surrounded by poor rural farming populations (Fisher and Christopher, 2007; Naughton-Treves et al., 2005). The demand for securing this exceptional biodiversity in natural forest ecosystems is however generated at the global level, as are some of the benefits of the resulting conservation efforts (e.g. carbon sequestration) whereas conservation costs are mostly borne at local level. Furthermore, decisions for biodiversity conservation are often taken through an approach that is overly standardized and disconnected from local realities (Kaul et al., 2003).

To date, the main instrument for protecting tropical forests, their species, as well as their ecosystem services remains the designation of protected areas (PAs) (Craigie et al., 2010; Deke, 2008; Dudley, 2008), whose impact on local people is still poorly understood. In fact, although it has been shown that areas with rich biodiversity have high potential for generating benefits for local people (Turner et al., 2012), reconciling conservation goals with local needs has always been a challenge (Brandon and Wells, 1992; Ezebilo, 2013; Salafsky and Wollenberg, 2000; Tallis et al., 2008). In some cases, local populations do perceive PAs as beneficial for ecosystem service provision (Abbot et al., 2001; Allendorf and Yang, 2013; Hartter and Goldman, 2011; Sodhi et al., 2010). At the same time, they feel the burden of protected area (PA) establishment, mainly through reduced access to provisioning ecosystem services[16] (Guerbois et al., 2012; Robertson and Lawes, 2005), displacement, and the curtailment of property rights (Brockington and Schmidt-Soltau, 2004; Colchester, 2004; Ferraro, 2002; Ghimire et al., 1997; Muhumuza and Balkwill, 2013).

Many studies have reported however that the long-term integrity of African PAs, which often coincide with high human population pressure (Balmford et al., 2001), depends on the support of local people (Ferraro, 2002; Kremen et al., 1999; Vodouhê et al., 2010). As evidence, a meta-study on African protected forest areas found that a positive attitude towards the PA by the surrounding communities was the strongest correlate of PA success (Struhsaker et al., 2005). In any developing country context, key questions relate to what it really means

[16] Provisioning ecosystem services are the products obtained from ecosystems, such as food, genetic resources, fiber, and energy

for local people to live near a land devoted to conservation and what the key factors are that determine people's attitudes towards PAs and their support for conservation.

A better knowledge regarding the importance of PAs and related ecosystem services for local people is important, given the arguments mentioned above, for conservation policy efficiency. This will help policy makers orient further conservation project development towards fulfilling local demands for ecosystem services and enhancing local people's awareness regarding conservation. The importance of local people's perspective is further reinforced by the principle of subsidiarity, which suggests in a simplified form that those affected by a good should have a say in its provision (Breton, 1965; Oates, 1972; Olson, 1971). The question of local preferences for PAs should therefore be important for scholars and practitioners in conservation.

In recent years, studies examining perceptions, attitudes, or preferences of people living in the vicinity of PAs in poor regions of the world, and more precisely in Sub-Saharan Africa (SSA), have greatly increased. However, the majority of studies have been conducted in savannah ecosystems in areas of low or moderate human population density (Hartter and Goldman, 2011). Preferences were found to be very mixed with negative perceptions often linked to crop raiding damage by wild animals (Anthony, 2007; De Boer and Baquete, 1998; Guerbois et al., 2012; Newmark et al., 1993) or restriction of access to forest products (Guerbois et al., 2012; Robertson and Lawes, 2005) or relation with park staff (Ezebilo, 2013; Ite, 1996) and positive perceptions related mainly to financial benefits (Anthony, 2007) and development programs (Infield and Namara, 2001). These positive or negative perceptions which affects preferences were found to be driven by socioeconomic factors in SSA context (Coulibaly-Lingani et al., 2011; Ezebilo, 2012; Kaltenborn et al., 2006; Kideghesho et al., 2007; Shibia, 2010; Tessema et al., 2010; Vodouhê et al., 2010).

This article seeks to add to this literature by presenting an example from the West African country of Ivory Coast, from where, so far, no published studies of local preferences for PAs are available. We seek to identify key factors that determine preferences for PAs. The paper proceeds as follows: In section 2 we discuss previous works that analyze local preferences for conservation in SSA. Section 3 presents the survey methods. Section 4 defines the data used in empirical analysis. In section 5 we present the theoretical background of the econometric model and the econometric procedure. Section 6 presents the main results and discusses them, while the final section concludes with a number of policy recommendations.

2. Biodiversity conservation preferences in sub-Saharan Africa

In recent years, a relatively substantial literature has developed that aims to examine key factors influencing perceptions, attitudes, or preferences of people living in the vicinity of PAs in poor regions of the world, and specifically in Sub-Saharan Africa (SSA). Several studies conducted in SSA have investigated local opinion about the importance they give to the presence of a protected area (Vodouhê et al., 2010); local perceptions and attitudes towards biodiversity conservation provided by PAs (Anthony, 2007; Holmes, 2003; Shibia, 2010; Tessema et al., 2010); local people's preferences for species (Assogbadjo et al., 2012; Kaltenborn et al., 2006) as well as people's engagement in sustainable forest management (Brännlund et al., 2009; Coulibaly-Lingani et al., 2011), etc. Recent studies (Ezebilo, 2012, 2011) have considered the assessment of passive use values in preferences which is not well documented in the literature. A passive value is a value arising from a change in environmental quality (or any other situational change) that is not reflected in any observable behavior (Adamowicz et al., 1998). Including passive values, would be for instance to check for local responses to a given change in conservation management approaches or species diversity, that is also important for conservation policy implications.

Most studies rely on the stated preferences (SP) approach to investigate preferences. It consists in collecting pieces of information about respondents' preferences for environmental amenities of interest by observing choices in situations presented in a survey (Carson and Czajkowski, 2014). There exists a vast array of approaches to preference elicitation. One can note the use of single multinomial choice questions (Brännlund et al., 2009; Ezebilo, 2013; Holmes, 2003; Tessema et al., 2010), where the participant is asked a choice question with different possible alternatives. There are also examples of multiple multinomial choice questions (Anthony, 2007; Coulibaly-Lingani et al., 2011), where the respondent is presented with a number of related multinomial questions of which answers are condensed to construct a single indicator measuring perception and/or preference. Ranking and/or rating exercises (Kaltenborn et al., 2006; Kideghesho et al., 2007) are also proposed to respondents, allowing for an ordering of preferences. One study used a participative ranking exercise (Assogbadjo et al., 2012). Survey participants were asked to first list the public goods to be valued and thereafter rank them according to their preferences. We do not have any elicitation method in this literature drawing on the discrete choice experiment approach, though it is increasingly implemented in the environmental field (Hoyos, 2010). In the choice experiment approach, respondents are presented with alternatives, differing in terms of characteristics (attributes) and their levels, and are asked to choose their most preferred (Moro et al., 2013). A considerable advantage of this approach is that it allows respondents to directly consider the implications and trade-offs associated with each choice.

Data analysis methods vary from cross-tabulation using Pearson chi-square (Shibia, 2010), principal component analysis (Assogbadjo et al., 2012), or simple linear models (Anthony, 2007; Coulibaly-Lingani et al., 2011; Kaltenborn et al., 2006; Kideghesho et al., 2007; Vodouhê et al., 2010) to more elaborate econometric models, such as logistic regressions (Holmes, 2003; Tessema et al., 2010), ordered logit models (Ezebilo, 2012), and multinomial logit models (Brännlund et al., 2009; Ezebilo, 2013, 2011). We note only in Coulibaly-Lingani et al (2011) different tests for no violation of simple linear regression assumption. The conditions for the application of an ordered logit model have been tested in Ezebilo (2012). Brännlund et al. (2009) mentioned the weaknesses of their model, as they failed to test assumptions on error terms imposed by the multinomial logit model. In other papers, the choice of an econometric specification is not discussed or not very clear in general, which can question the robustness of their results.

Regarding preference drivers, a person’s age has been identified as having a positive impact on her preference for conservation (Ezebilo, 2012; Tessema et al., 2010). Education is another important factor for local preferences in SSA (Ezebilo, 2012; Kaltenborn et al., 2006; Kideghesho et al., 2007; Shibia, 2010; Tessema et al., 2010; Vodouhê et al., 2010). The influence of income on people’s preference has also been confirmed as a key driver of preferences (Coulibaly-Lingani et al., 2011; Ezebilo, 2011). Some other specific factors are gender (Coulibaly-Lingani et al., 2011; Ezebilo, 2012) and household size (Coulibaly-Lingani et al., 2011). Land tenure status and security of land use rights have been found to be important in influencing the individual household's dedication to promote sustainable forest management (Brännlund et al., 2009; Coulibaly-Lingani et al., 2011). In contrast to socio-economic determinants for preferences that have been largely documented as described earlier, there is a lack of empirical evidence in this literature to link local preferences to PAs management type and provisioning ecosystem services. It is however widely recognized that access to most provisioning ecosystem services, restricted depending on PA management type, could influence people’s attitudes toward PAs (Coad et al., 2008; Guerbois et al., 2012).

In order to add to this literature, we first construct a hypothetical choice scenario to elicit preferences relating to changes in PAs development, and then we consider passive use value in our analysis. Second, our hypothetical choice scenario draws on the choice experiment approach with minimal difference. The alternatives of the choice scenario are described with characteristics (attributes) and their corresponding levels, such in a classic choice experiment approach. However, each respondent was presented the same choice set. In this way, we measure the impact of respondent-specific variables on the probability of choosing a particular alternative. By varying characteristics (attributes) by alternatives- that multiply choice sets for each respondent – we could estimate specifically people's preferences for alternatives' characteristics, which is not the purpose of the current work. Third, we adopt an econometric, step-by-step approach with statistical tests for a robust data analysis. Finally, to fill the gap in key drivers for local preference, we empirically test the effect on local people's preferences of different PAs management type and of dependence on provisioning ecosystems services. Besides improving preferences elicitation procedure and quantitative analysis in this literature, our research makes a novel contribution to literature by investigating empirically the link between preferences and the provision of ecosystems services

3. Survey method

3.1.Research sites

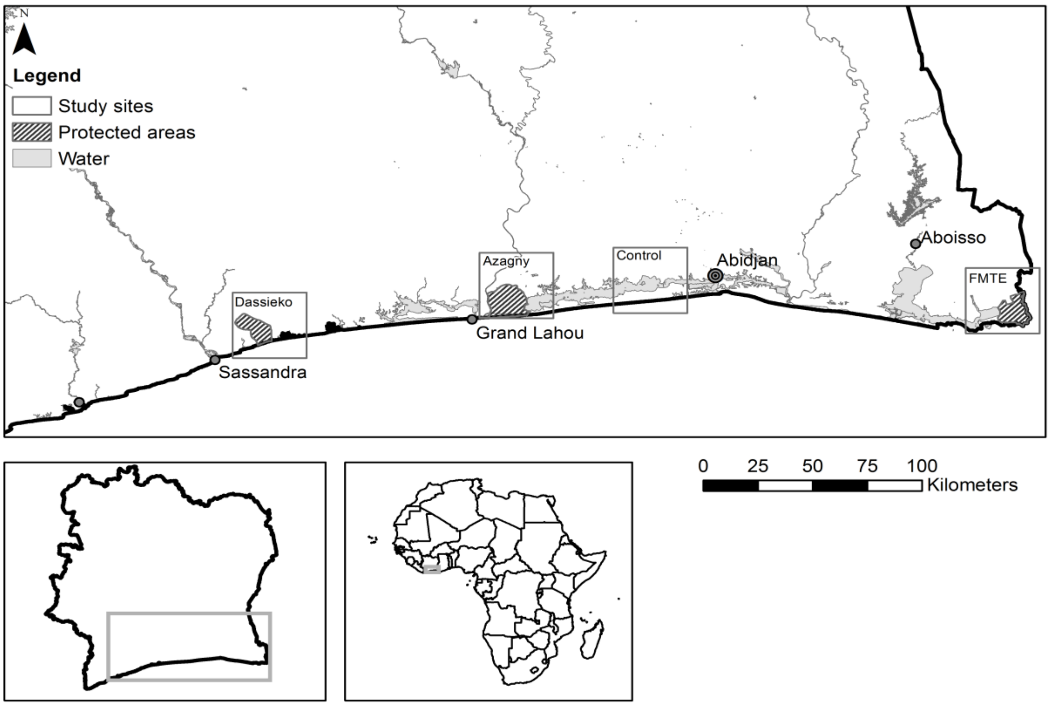
Three different protected forest areas were selected in the humid belt of the Guinean forest along the southern coast of Ivory Coast (cf. Figure V-1). The PAs differ regarding their governance types and their protection status according to IUCN categories (cf. Table V-1). Around each PA, four study villages were randomly selected, located on either side of the PA. Two villages located in the same agro-ecological zone but with no protected forest areas in their vicinity were included as control sites (cf. Appendix V-A for details on survey design). A mixed-method approach was applied, including (1) semi-structured, open-ended interviews and (2) a household survey using face-to-face interviews. In total, 27 semi-structured interviews were conducted with key informants and 303 households were surveyed in the 4 of villages. Fieldwork was conducted in October 2012 by two researchers at the doctoral level (of which one is a national of Ivory Coast and lead author) and five local research assistants, all at the master's or doctoral level.

Table V-1. Background information about the four study sites/characteristics of PAs

Name of PA/IUCN category	Governance types	Surface (ha)	Date of creation	Location (longitude latitude)
Community-based Forêt Marécageuse de Tanoe-Ehy (FMTE)/IUCN category VI	B. Shared governance (local communities/national agency/private actors in charge)	12,000	2006	latitude 5° 05‘ and 5° 15’ longitude 2° 45’ and 2° 53’
National Park of Azagny/ IUCN category II	A. Governance by government (national agency in charge)	19,400	1981	latitude 5° 09’ and 5° 16’ longitude 4° 48’ and 4° 58’
Classified forest of Dassieko/IUCN category VI	A. Governance by government (state enterprise in charge)	12,540	N/A	Latitude 5° 00’ 06’’ and 5° 07’23’’ longitude 5° 49’ 48’’ and 5° 56’ 57’’
control site without forest cover/Unprotected status	Open access			

Source: Author elaboration.

Figure V-1. Map of southern Ivory Coast, showing the location of the four study sites around the PAs of Forêt marécageuse de Tanoe-Ehy (FMTE), Parc National d’Azagny, Forêt classée de Dassieko, and the control site.



Source: Author’s elaboration

3.2.Household surveys among people living in the vicinity of PAs

Households were randomly selected in all villages, 14 in total. The questionnaire was intended for heads of households, whether male or female. We gathered information on household characteristics, their professional activities, and their level of income and expenditure. We obtained information about their use of provisioning ecosystem services and about their attitudes towards environmental issues. To get information on preferences for PAs, we proposed a hypothetical choice scenario to the respondents, drawing on the choice experiment approach.

As the study seeks to identify respondents' characteristics that affect their preferences, each respondent faced one multinomial choice question as described below.

"Imagine that we would like to get your opinion before the implementation of a project that aims to redevelop PAs in your region. The alternatives are completely degazette PAs, partially degazette PAs, expand PAs and status quo. Each alternative has the following characteristics (biodiversity, ecosystem services, forest industry employment and livelihood activities) and their corresponding levels:

(a) Completely degazette PAs. Levels of biodiversity and regulating/supporting ecosystem services would become very low. There would be a rise in forest industry employment and no restrictions on livelihood activities (provisioning ecosystem services) in the forest.

(b) Partially degazette PAs. Levels of biodiversity and regulating/supporting ecosystem services would be considerably reduced. There would be a small rise in forest industry employment. There would be less restrictions on livelihood activities (provisioning ecosystem services) in the forest.

(c) Expand PAs. Levels of biodiversity and regulating/supporting ecosystem services would increase considerably. There would be a decrease of forest industry employment. There would be restrictions on livelihood activities (provisioning ecosystem services) in the forest.

In others words, your choice will have an impact on biodiversity (number of animals as well as plant species), ecosystem services (crop pollination and water and flood regulation), forest industry employment and livelihood activities in the forest (hunting, firewood collection, and crop production). Which option would you choose?" The choice set was presented using pictures (cf. Appendix V-B.).

To minimize biases in the measurement of preferences and to elicit true preferences, we used follow-up questions after choices, allowing respondents to indicate why they made the choice they did. The choice of individuals who reject the status quo can be biased due to socially desirable responses, i.e., yea-saying or nay-saying acquiescence The yea-saying bias would occur in our case, when the respondent choose to expand PAs to please the interviewer (Couch and Keniston, 1960), to comply with a standard (Bradburn et al., 1978), or due to the warm glow effect, i.e., purchase of moral satisfaction (Andreoni, 1989; Nunes and Schokkaert, 2003). In the same vein, the nay-saying bias would occur when the respondent will choose to degazette PAs due to lack of involvement, excessive modesty or reserve, or antagonism to the interviewer (Tellis and Chandrasekaran, 2010). There also exists also a status quo bias that was first evidenced by Samuelson and Zeckhauser, (1988). In this context, the status quo bias would occur when the choice of status quo is due to aversion for change, or to a lack of sufficient information for decision-making, as well as to cognitive misperceptions.

4. Data

4.1.Dependent variable: Preferences measurement

We measured household preferences with a multinomial variable, y, which could take the values of 1, 2, or 3. To minimize the nay-saying acquiescence bias in negative preferences, we decided that a respondent has a negative preference (y=1) if the respondent chose alternative (a) or (b) and if he gave an answer different from "I don't know" to the question "*What is the main reason you want the partial or total degazetting of PAs?*" To minimize the yes-saying acquiescence bias in positive preferences, we decided that a household has a positive preference (y=2) if the respondent chose alternative (c) and if he had a positive willingness to pay (WTP) for the question, "*Are you aware that the implementation of your choice could demand a contribution on your part? In this case, what is the maximum amount you could afford in surplus of your household consumption expenses, given your income level?*" To minimize the status quo bias, we decided that a household's choice is status quo (y=3) if the respondent chose status quo and gave the answers, "I understood everything and it was my choice to do nothing," or "There are already enough PAs" to the question, "What is the main reason you want no action to be taken?"

4.2.Explanatory variables: factors affecting preferences

We defined three ranges of explanatory variables for the preference models. First, we examined whether PA management type influences households' choices. We defined a variable, "site," which took the values 1, 2, 3, or 4 for **community based** (IUCN category IV), **national park** (IUCN category II), **classified forest** (IUCN category V), and a **control site** (without forest cover), respectively. We included a control site to evaluate whether preferences for PAs in rural areas are different for people who *a priori* don't directly perceive the costs and benefits of conservation.

Second, we examined whether socio-economic variables influence households' decisions. We used respondent' age (**Age**). We define 4 classes for the level of education: illiterate (**Illiterate**), primary level (**Educ_prim**), lower secondary level (**Educ_sec1**), and upper secondary level (**Educ_sec2**). We used consumption expenses adjusted for household size (**Cons_exp**), given the fact that households are less uncertain about this information compared to other expense measures, thus making it more reliable. However, we used a household's total expenses (**House_exp**) and total income (**Income**) as other income variables.

Finally, we examined the influence of dependence on provisioning ecosystem services on household decisions. We considered that a household is dependent on firewood (**Fwd_dep**) if wood is the fuel source most often used by the household and if the main mode of supply is the collection and/or gathering of wood. Dependence on water (**Water_dep**) was observed if the household's drinking water supply comes from rivers, lakes or ponds, or wells with or without pumps. Households whose main supply of protein (**Proteins_dep**) is assured through fishing and/or bushmeat hunting were defined as being dependent on these provisioning services. Households who use medicinal plants (**Med_dep**), obtained mainly through collection and/or gathering, as their primary remedy were identified as being dependent on medicinal plants.

We introduced each category of factors—first independently and then as a whole—in order to identify the effects of each category of factors independently, as well as the cumulative effect of the factors on household choice.

In addition, in all models we use two control variables: a dummy variable (**Interwr**) to control for the degree of measurement noise due to the interviewer and a continuous variable (**Res_year**) to measure number of years of residence in the region to control for respondent involvement in community issues.

5. Model specification

5.1. Theoretical background

The utility theory states that a consumer is a rational individual who makes choices based on the expected outcomes of decisions. The process of decision making is then based on the ability to rank preferences over some set of goods and services and, thereafter, making the choice that maximizes utility.

Faced with a choice set of mutually exclusive alternatives for the provision of PAs, where options are (1) "*reduce surface of PAs*", (2) "*increase the surface of PAs*", and (3) "*doing nothing*", a rational consumer will choose alternative (1) when s/he perceives a higher level of utility if there is less PAs, alternative (2) when s/he perceives a higher level of utility with more PAs, and alternative (3) when s/he perceives a higher level of utility by "doing nothing".

The decision-making process described here is not a deterministic choice. It is then impossible to predict exactly the alternative that an individual will chose among the choice set of alternatives. A probability P_j can however be determined, which is the probability that alternative j is selected, conditional on the choice set of alternatives.

In our case, we can thus define the probability that an individual i chooses alternative (2), as:

$$\Pr(y_i = 2) = Pr(U_i^2 > U_i^1;\ U_i^2 > U_i^3).$$

The perceived utility U_i^j associated with the alternative j for an individual i is not easily observable. It depends on an array of observable and non-observable factors, related to choice conditions and to individual characteristics. After Manski (1977) and McFadden (1974), the perceived utility U_i^j is be decomposed into deterministic and random components:

$$U_i^j = V_i^j + \varepsilon_i^j.$$

The deterministic component represents the mean (expected value) utility perceived by all decision makers having the same choice context as individual i. The deterministic component is estimated as $V_i^j = X_i\beta^j$, where X_i is the row vector of observed values of independent variables for the i^{th} observation and β^j is the coefficient vector for alternative j. The random residual is the deviation (unknown) from this mean value of the utility perceived by individual i.

The probability that an individual i chooses alternative (2) can be rewritten as:

$\Pr(y_i = 2) = Pr\left[X_i\beta^2 + \varepsilon_i^2 \geq X_i\beta^j + \varepsilon_i^j \quad \forall j \in C_n\right]$, where C_n is the set of alternatives.

5.2.Econometric procedure

Since the dependent variable is not continuous and there is, *a priori*, no clear ordering[17] of the three outcome variables, unordered multinomial models look appropriate for estimating the model. We estimate then multinomial Logit (MNL) models, as explanatory variables describe characteristics of each decision-making unit. With N alternatives, the probability that the response for the i^{th} observation is equal to the j^{th} alternative is:

$$\Pr(y_i = j) = \left\{\frac{\exp(X_i\beta^j)}{\sum_{m=1}^{N}\exp(X_i\beta^m)}\right\}. \qquad [1]$$

In order to identify the model, we have to set one β^j to 0, though it does not matter which one (Cameron and Trivedi, 2005). Let the base outcome be status quo, then $\beta^3 = 0$. Remaining coefficients will measure the change relative to status quo. The relative probability of $y_i = j$ is then:

$$\frac{\Pr(y_i=j)}{\Pr(y_i=3)} = \exp\left(X_i\beta^j\right). \qquad [2]$$

The MNL specification assume independence of irrelevant alternatives (IIA), that implies in our case the probability to choose alternative (1) given alternative (1) or alternative (2) to

[17] One might think that there is a possible ordering of choices, which would justify the estimation of an ordered multinomial model. For example, we can state that the second best choice for those who prefer to degazette the PAs is the status quo and their last choice would be the extension of the PA. Even if a ranking is potentially possible for those who express a positive or negative preference, no assumptions can be made for those who choose the status quo as first choice. Indeed, there is no indication for their second or last choice. An unordered multinomial model is then appropriate.

be independent of whether alternative (3) is an option. A Hausman test, along with the LR test proposed by (McFadden et al., 1978) and improved by (Small and Hsiao, 1985) is implemented to test the independence of irrelevant alternatives (IIA). A corollary of the IIA hypothesis is that errors terms are assumed to be independently and identically (IID) distributed across individuals and alternatives using the type 1 extreme value distribution. An alternative to introduce correlation across choices in the unobserved component is to work with normally distributed errors (Cameron and Trivedi, 2005). We can do this by estimating a multinomial probit (MNP) model where the errors are jointly normally distributed.

The homoscedasticity hypothesis is tested using the Lagrange multiplier test, the Lagrange multiplier test based on OPG matrix (LMOPG), and the Lagrange multiplier test based on robust covariance matrix (LMR). We use different matrices, as the LM tests are based on covariance estimators. Moreover, while the tests are asymptotically equivalent, they can give different results in finite samples (Hole, 2006). Heteroscedasticity causes the coefficient estimates in discrete choice models to be inconsistent (Yatchew and Griliches, 1985). An alternative is to estimate a heteroscedastic logit model (DeShazo and Fermo, 2002).

6. Results

6.1. Summary statistics

Table V-2 presents an overview of the distribution of respondents' choices. Overall, we note that the proportion of respondents preferring expansion of PAs (39.91%) is greater than the proportion of respondents either preferring that no action be taken (35.09%) or preferring to degazzete PAs totally or partially (25.00%).

Looking at the columns of Table V-2, we see that the distribution of respondents between positive, negative, and status quo is basically the same for all types of PAs, except for the classified forest and the control site around which fewer people choose status quo. In addition, we find the lowest proportion of negative preferences to be among households that live near a PA under community-based management (18.63%) and the highest proportion of positive preference to be among rural households living near the control site (50%).

On average, respondents with a positive preference are older (51.12) compared to those who stated a negative preference (50.77); however, the difference in age is not significant (pvalue=0.8877 for H0: diff=0). The age gap is very pronounced, with those who choose status quo being much younger (43.79) (positive vs status quo, pvalue=0.0007 for H0: diff=0; negative vs status quo, pvalue=0.0037 for H0: diff=0).

Table V-2. PA management option multinomial choice: Data summary

Discrete variables	Sub-sample number of respondents (proportions in brackets in %)			
	Negative Preferences *y=1*	Positive Preferences *y=2*	Status Quo *y=3*	Overall all *y*
Community based	11 (18.33)	23 (38.33)	26 (43.33)	60 (100)
National Park	16 (22.54)	24 (33.80)	31 (43.66)	71 (100)
Classified Forest	18 (30.51)	25 (42.37)	16 (27.12)	59 (100)
Control site	12 (31.58)	19 (50.00)	7 (18.42)	38 (100)
Illiterate (%)	32 (29.63)	39 (36.11)	37 (34.26)	108 (100)
educ_prim (%)	13 (21.31)	25 (40.98)	23 (37.70)	61 (100)
educ_sec1(%)	6 (18.18)	15 (45.45)	12 (36.36)	33 (100)
educ_sec2(%)	6 (23.08)	12 (46.15)	8 (30.77)	26 (100)
Fwd_dep (%)	45 (25.42)	69 (38.98)	63 (35.59)	177 (100)
Water_dep (%)	29 (22.14)	48 (36.64)	54 (41.22)	131 (100)
Protein_dep (%)	18 (35.29)	16 (31.37)	17 (33.33)	51 (100)
Med_dep (%)	20 (27.03)	36 (48.65)	18 (24.32)	74 (100)
Continuous variables	Sub-sample averages (standard error in brackets)			
	Negative Preferences *y=1*	Positive Preferences *y=2*	Status Quo *y=3*	Overall all *y*
Age	50.77 (1.93)	51.12 (1.53)	43.79 (1.44)	48.47 (0.95)
House_exp (CFA franc)	153296 (23699.87)	124164 (10711.73)	151927 (18754.12)	141210 (9831.856)
Income (CFA franc)	312837 (70039.22)	300084 (98011.36)	208521 (54053.33)	270832 (46722.84)
Cons_exp (CFA franc)	86630 (18698.59)	76855 (6970.045)	93819 (12773.52)	85264 (6957.235)
Total respondents	57	91	80	228

The relationship between negative preference and level of education is not clear-cut when analyzing the proportions. We note, however, that the proportion of positive preferences is greater with higher levels of education. It grows from 41% for those with primary education to 46% for those with a secondary education.

Respondents stating a negative preference have, on average, a higher level of expenditure and income compared to those with a positive preference. Income is the lowest for respondents choosing status quo, while their consumption expenditure is the highest.

In terms of the relationship between preferences and dependence on provisioning ecosystem services, we note that the proportion of people with a positive preference remains higher than that of people with a negative preference, except for households who are dependent on fishing and hunting.

6.2.Empirical models results

At least one out of the three LM tests for heteroscedasticity confirms the presence of unobserved heterogeneity in all restricted models at the level of 5% (cf. Appendix V-C).We find that error variances are not identically distributed in restricted models and differs with level of education and the management mode of PA in the vicinity of the village. It is likely the case that the deviation of the utility from its mean value (for all decision makers) as perceived by respondents will vary if respondents can appreciate differently the changes predicted with the hypothetical scenario. This provides the rationale to take literacy skills and PA management types into account in a fully specified model. A direct result of this is that the three LM tests reject the assumption of heteroscedasticity in the fully specified model. What is more, the heteroscedastic Logit models for restricted models add little in explaining local preferences (cf. Appendix V-E). We retain then the full model in the rest of the paper.

The tests for IIA assumption are not conclusive for the fully specified model (cf. Appendix V-D). We cannot, then, discriminate between a multinomial Probit (MNP) model and a multinomial Logit model (MNL). Table V-3 therefore presents Probit and Logit estimates for households' choices for PAs' redevelopment mode. The coefficients are probabilities relative to the base outcome, "status quo" (cf. equation 2). They indicate how factors influence the likelihood of having a negative or positive preference rather than choosing status quo.

Table V-3. PAs' redevelopment Mode Multinomial Choice: multinomial Probit and Logit estimates

	Probit model		Logit model	
	Negative vs Status quo	Positive vs Status quo	Negative vs Status quo	Positive vs Status quo
community based	.	.	.	.
national park	-0.565	-0.864*	-0.703	-1.076*
	(-1.15)	(-1.90)	(-1.08)	(-1.89)
classified forest	0.727*	0.571	0.963*	0.749
	(1.68)	(1.43)	(1.68)	(1.52)
control site	0.633	0.202	0.843	0.319
	(0.98)	(0.34)	(0.98)	(0.42)
age	0.0359***	0.0377***	0.0464***	0.0485***
	(3.14)	(3.46)	(2.96)	(3.43)
Illiterate	.	.	.	.
educ_prim	0.0697	0.481	0.170	0.615
	(0.14)	(1.11)	(0.25)	(1.13)
educ_sec1	0.449	0.769	0.657	0.933
	(0.77)	(1.52)	(0.87)	(1.50)
educ_sec2	0.536	0.0742	0.673	0.0478
	(1.37)	(0.21)	(1.31)	(0.11)
cons_exp	-0.0254	0.0527	-0.0682	0.0700
	(-0.14)	(0.32)	(-0.28)	(0.33)
fwd_dep	-0.140	-0.488	-0.242	-0.615
	(-0.35)	(-1.32)	(-0.45)	(-1.31)
water_dep	-0.782*	-0.698*	-0.970*	-0.802
	(-1.87)	(-1.78)	(-1.76)	(-1.61)
protein_dep	0.590*	-0.0362	0.795*	-0.0871
	(1.65)	(-0.11)	(1.72)	(-0.20)
med_dep	0.668*	0.898***	0.828*	1.099***
	(1.92)	(2.86)	(1.79)	(2.79)
res_year	-0.506**	-0.198	-0.654**	-0.255
	(-2.48)	(-0.99)	(-2.46)	(-0.99)
interwr	-0.0598	0.173	-0.0708	0.208
	(-0.39)	(1.24)	(-0.34)	(1.20)
_cons	0.00392	-1.498	0.368	-1.961
	(0.00)	(-0.66)	(0.11)	(-0.67)
N	223		223	
ll	-210.4		-210.8	
chi2	49.67		58.04	

Dependent variable y=1, 2, or 3, depending on which of the three options is chosen; t statistics in parentheses, * $p<0.10$, ** $p<0.05$, *** $p<0.01$;

The null hypothesis—i.e. all slope coefficients in Probit and Logit model are null, tested with the likelihood ratio chi-square test for Logit models and with a Wald chi-square test for Probit models—is rejected at a the 10% significance level. The model as a whole fits significantly better than empty models (i.e., a model with no predictors). This means that probability estimates may be affected by the explanatory variable defined: management type of PAs, the socio-economic profile, and household dependence on natural resource. There are no significant differences between Logit and Probit estimates. Logit and Probit estimations exhibit the same significant coefficients, however, the coefficient are quite higher in the Logit estimations.

Table V-4 presents the predicted probabilities (cf. equation 1) for each factor, i.e., the likelihood of choosing positive/negative/status quo given a value of each independent variable, adjusting for other variables. They indicate how management types of PAs, the socio-economic profile of households, and dependence on provisioning services influence the preference for PAs.

Table V-5 presents marginal effects[18] that measure the impact of factor changes on the scale of probability of choosing positive, negative, or status quo.

6.2.1. Preferences and management type of PAs

Compared to "community based," the variables "classified forest" and "national park" are significant in table V-3. This indicates that, relative to status quo, living around "classified forest" instead of a "community-based" PA increases the likelihood of negative preference, and living around a "national park" instead of a "community based" PA reduces the likelihood of positive preference. The results suggest, then, that management rules of PAs matter in the likelihood for local people to state preferences for PAs. In others words, a given respondent states preferences for PAs depending on management rules of the PA around where he or she lives. What is more, PA management systems which are less socially inclusive (classified forest and national park) negatively influence local perception of the relationship between PAs and livelihoods. The findings highlight the importance of socially inclusive conservation strategies in order to enhance local people's involvement in conservation.

[18] For the MNL model, the marginal effect on the probability of choosing alternative j for a kth factor is given by $\frac{\partial p_{ij}}{\partial x_{ik}} = p_{ij}(\beta^{jk} - \sum_l p_{il}\beta^{lk})$. It follows that the sign of the response is not necessarily given by the sign of β^j, unless $\beta^j > \beta^l$ for all $l \neq j$, and it does not necessarily make any sense to test whether a particular coefficient is zero (Cameron and Trivedi, 2005).

Table V-4. PAs' redevelopment Mode Multinomial Choice: predictive probabilities

	Negative preference	Positive preference	Status quo
community based	0,162	0,398	0,441
national Park	0,200	0,345	0,455
classified Forest	0,298	0,441	0,261
control site	0,312	0,528	0,160
age (40 year old)	0,214	0,353	0,433
age (50 year old)	0,247	0,418	0,335
age (60 year old)	0,274	0,477	0,249
age(70 year old)	0,296	0,527	0,177
illiterate	0,194	0,437	0,368
educ_prim	0,165	0,490	0,346
educ_sec1	0,200	0,513	0,287
educ_sec2	0,296	0,375	0,328
cons_exp (50th percentile)	0,238	0,403	0,359
cons_exp (75th percentile)	0,229	0,414	0,357
cons_exp (90th percentile)	0,198	0,454	0,348
fwd_dep	0,234	0,416	0,350
water_dep	0,200	0,383	0,417
protein_dep	0,293	0,333	0,374
med_dep	0,238	0,531	0,230
All variables at means	0,231	0,429	0,340

The importance of both restrictions on access to forest resources and participation in PA management as relevant factors influencing local preferences in communities living around PAs is confirm by predictive probabilities for each management type (Table V-4). We note that positive preference for PAs is the lowest for people living in the vicinity of he national park while the probability of having a negative preference is lowest for those living near the community-based PA. Rural households seem to be more favorable towards PAs around the community-based PA and less favorable towards PAs around the national park. This can be explained by the fact that the emphasis of the community-based management scheme is on the sustainable use of environmental products and services and benefits are directly perceived by the local community. However, in the national park, the restriction of access to forest resources is more strict and local people are less involved in its management. Community-based management seems to be a favorable option for the acceptance of PAs for local communities bordering PAs in Ivory Coast. This PA management type is still almost nonexistent in Ivory Coast (Roe et al., 2009). Examining the marginal effect of changing PAs' management type in table V-5, we find that there is in fact a significant effect, namely, that a change from community based to National park will decrease the average probability of having positive preferences by 0.203. The overall probability of stating positive preference is 0.429, so the magnitude of the response to PAs management changes is rather substantial.

6.2.2. Socioeconomic variables and preferences

The coefficient for the variable "age" is positive and statistically significant in differentiating negative/status quo and positive/status quo in table V-3. The results suggest that the likelihood for local people to have preferences relative to status quo increases with age. The analysis of predictive probabilities at different ages in table V-4 confirms this. We analyze preferences according to age from 40 to 70 years old. We find that the probability of positive as well as negative preferences significantly increase with age. The effect is, however, more pronounced for positive preferences and less pronounced for negative preferences. It seems that awareness of conservation issues increases with age. Two channels can explain the two different impacts of age on preferences. First, the older respondents, with their past experience, are more likely to appreciate the local costs of the progressive loss of biodiversity and related ecosystem services due to deforestation. This can explain why positive preferences could increase with age. Secondly, the need for cultivable land is likely to increase with age, due to the growing size of the household. This can explain why negative preferences could also increase with age. Although these two divergent effects of age are plausible, it appears in our case that the positive effect of age on the perception of PAs is more significant than the negative one.

Table V-5. PAs' redevelopment Mode Multinomial Choice: marginal effects

	Negative preference	Positive preference	Status quo
community based			
national Park	-0,0330	-0,1980*	0,2310*
classified Forest	0,0840	0,0704	-0,1545*
control site	0,1219	-0,0192	-0,1027
age	0,0035	0,0072**	-0,0107***
illiterate			
educ_prim	-0,0263	0,1384	-0,1121
educ_sec1	0,0130	0,1678	-0,1808
educ_sec2	0,1178	-0,0509	-0,0670
cons_exp	-0,0192	0,0239	-0,0047
fwd_dep	0,0179	-0,1261	0,1082
water_dep	-0,0940	-0,0993	0,1934*
protein_dep	0,1515**	-0,1007**	-0,0508
med_dep	0,0389	0,1860*	-0,2250***

dy/dx for factor levels is the discrete change from the base level. Marginal effects are calculated from mlogit model

Literacy skills are not a differentiating factor for positive preference relative to status quo or negative preference relative to status quo. The education variables are not significant in table V-3. This suggests that those who choose status quo do not have significantly different levels of education than those having negative or positive preferences. Predictive probabilities in table V-4 at each level of education produce the same conclusion. The likelihood that a respondent with upper secondary level has a negative preference is 0.3, whereas the same probability is 0.37 for positive preference and 0.33 for those who choose the status quo. There is however a significant difference at lower secondary level, where the probability of having positive preference is 0.51. Regarding marginal effects in table V-5, there is no significant impact of changes from illiterate to other education levels on the probability of stating preferences.

Daily consumption expenses are also not a factor in differentiating positive preference relative to status quo from negative preference relative to status quo. The variable cons_exp is not significant in table V-3. The likelihood of stating preference is not affected by household categories in terms of consumption expenses. We analyze predictive probabilities for consumption expenses equal to the 50th, 75th, and 95th percentile. We note that there is not much difference regarding the likelihood of having negative or positive preferences between groups of households classified relative to expenditure percentiles (50th, 75th, and 95th). However, it seems that negative preferences are lower for households that spend more on consumption (i.e. the richer households) and that these households have the highest positive preferences.

6.2.3. Dependence on provisioning services and preferences

Dependence on provisioning ecosystem services had an influence on households' likelihood to state preferences. The coefficient for "Water_dep" was negative and significant in both "negative/status quo" and "positive/status quo" comparisons, while the coefficient for "Med_dep" was positive and significant in table V-3. It suggests that getting drinking water from rivers, lakes, ponds, or wells (with or without pump) reduces the likelihood of having preference relative to status quo, while using medicinal plants as a primary remedy lead to a greater likelihood of having preference relative to status quo. The coefficient for "protein_dep" was positive and significant in table V-3. It suggests that being dependent on bushmeat and fish increases the likelihood of negative preference relative to status quo.

Predictive probabilities in table V-4 reveal, overall, that the probability of having a positive preference for PAs decreases with increasing dependence on provisioning ecosystem services. It seems that the more dependent households are on firewood, collected proteins, and water, the less favorable they are towards PAs. However, the likelihood of having a positive preference is higher for households who depend on medicinal plants.

This result can be somewhat explained by the fact that medicinal plants are specific to some natural habitats and habitat degradation is more likely to threaten the existence of some of them. In regard to predictive probability, we found the highest probability of having a negative preference for households who are dependent on proteins. The mean expected probability of having a negative preference is the highest if the respondent's main supply of protein is assured by fishing and bushmeat hunting. For the mostly poor local people, free access to these proteins is vital for their wellbeing. The scarcity of bushmeat and fish is already intensifying with population growth, deforestation, and urbanization, and expanding PAs then means exacerbating this scarcity. Concerning the effect of changes in dependence on the probability of observing preferences, we find in table V-5 that changes in dependence on fish and bushmeat increase negative preferences by 0.15, which is 65% of the probability of having negative preferences (0.23). We also found also that changes in dependence on medicinal plants increase positive preferences by 0.19, which is 44% of the probability of having positive preferences (0.43).

Estimates excluding the observations of the control site yielded similar results as those obtained using the full sample. The major difference was that taking into account only people living near PAs, in the category of socio-economic factors in addition to age it was found that the level of primary education had a significant influence on the likelihood of having positive preferences relative to status quo. Change in education level from illiterate to primary level increased the likelihood of having positive preference for local people living near PAs.

7. Discussion and concluding remarks

This study provides quantitative evidence that local people living near PAs have widely differing perceptions regarding PAs. The majority states positive preference for expanding PAs, but others demand the same PA to be degazetted. This runs counter the large literature on the burden of PAs for local people in the context of developing countries (Adams et al., 2004; Ferraro, 2002; Guerbois et al., 2012; Shyamsundar and Kramer, 1996). While we have not made a comparative analysis of methods, our results can be potentially explained by the choice scenario that differs from previous works. Indeed, presenting PAs development balanced against the provision of ecosystem services upon which local people are dependent, induces each respondent to tackle the implications of his choice on his wellbeing..

The study evidences that people’s preferences for PAs in southern Ivory Coast depends on the PA’s management type. The community-based PA management approach that was applied for the protection of the FMTE influenced people’s perception of the link between PAs and wellbeing in a positive way. This can be attributed to the fact that, in this case, the opinions and needs of local people were integrated in the planning process from the very beginning. Outreach activities have been conducted by researchers and a local NGO (Zadou et al., 2011). In the Sub-Saharan Africa context the importance of involving local communities in conservation design has been also established in others papers (Ezebilo, 2013; Fritz-Vietta and Stoll-Kleemann, 2008; Persha et al., 2011). This does not mean that participatory approaches are more successful than other approaches in SSA. Indeed, effectiveness of community based approaches to meet both environmental and socio-economic goals is questioned by several authors(Agrawal and Gibson, 1999; Brooks et al., 2013; Dressler et al., 2010; Infield and Namara, 2001; Kellert et al., 2000; Naughton-Treves et al., 2005; Tole, 2010). Our results rather evidence that involving local people increase their support for conservation, that is essential for long-term conservation strategies (Struhsaker et al., 2005). Current as well as future conservation efforts in Ivory Coast should foster the participation of local communities in planning, implementing, and monitoring activities, as our study shows that this can positively influence people’s preference for PAs

In our study region—the coastal belt of Ivory Coast—large-scale monoculture plantations of palm oil and rubber have now replaced most of the natural ecosystems and the only forests left are included within PAs. Older people, who have experienced these landscape changes through the years, especially seem to be very much aware of the negative impacts of widespread deforestation on livelihoods. However, the need for monetary income through the cultivation of palm oil and rubber presents a major trade-off for land use, not only between forest conservation and commercial crop plantations but also between the latter and subsistence crop cultivation. The influence of age on people’s perception of PA benefits was confirmed by the findings of the analysis, that older age increases the likelihood of having a positive preference for PAs as in (Lykke, 2000). This is also in line with (Ezebilo, 2012) who states that older people are more likely to see how conservation projects could support their traditional way of living including access to forest products. (Shibia, 2010) finds however that the younger where more positive towards conservation. It is worth to notice that in his case study, most young respondents were elite and were well informed on both tangible and non-tangible benefits of conservation. Education and the knowledge of conservation benefits seem then to be transmission channels for age on conservation preferences. In our study, the effect of education is somewhat ambiguous. Having a primary level of education positively affects local preferences for conservation only within populations that are very close to PAs. At higher levels of education, there is no effect of education on the preferences of local people in general, as in (Gadd, 2005). Furthermore, the limited environmental education in school system in Ivory Coast doesn't guarantee that more educated people are more aware of conservation benefits. This would appear to confirm that older people's experiences of conservation benefits drive their positive attitude towards PAs. They should be encouraged to share their knowledge and experiences about the impacts of deforestation in order to raise awareness among the younger generation.

The importance of medicinal plants from PAs was demonstrated quantitatively by the analysis, as it showed that the more households depend on medicinal plants the more positive they are toward PAs. Other studies from PA benefits in an African context have yielded qualitative similar results (De Boer and Baquete, 1998; Hartter and Goldman, 2011; Parry and Campbell, 1992; Zadou et al., 2011). The analysis further shows that the more dependent households are on other provisioning services (e.g. firewood and bushmeat) for their livelihoods, the less favorable they are towards PAs. The importance of direct benefits such as access to bush meat in shaping their support for and commitment to conservation in the context of SSA has been highlighted in others works (Gillingham and Lee, 1999; Parry and Campbell, 1992; Scanlon and Kull, 2009), although the question of dependence has been rarely debated. Based on these results, we suggest that PAs in southern Ivory Coast should provide at least some (non-financial) benefits for local people. Conservation plans in the region must consider substitutes for, or regulated access to, provisioning ecosystem services as a response to local people's dependence on natural resources, thus moderating the induced negative perception toward PAs.

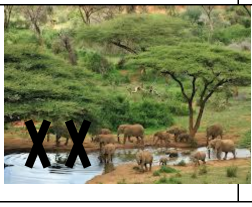
Appendix V-A. Survey details

Site	Village	Numbers of household in survey[19] (n)
Community-based Forêt Marécageuse de Tanoe-Ehy (FMTE)	DOHOUAN	20
	YAOAKAKRO	21
	KONGODJAN	21
	KOTOAGNUAN	20
Total site 1		82
National Park of Azagny	GBOYO	20
	IROBO	20
	NANDIBO2	22
	NZIDA	21
Total site 2		83
Classified forest of Dassieko	DAGBEGO2	20
	DASSIOKO	20
	KPATA ABIDOU	20
	LELEDOU	20
Total site 3		80
Control site	KPASS	28
	NGATY	30
Total site 4		58
Total		303

[19] We don't have information on the structure of the population in Ivory Coast for the last ten years. We decide then to select arbitrarily at least 10% of total household by village. We get an estimate of the number of households for some villages and we calculate a mean, which is around 200 household by villages. We designed then a sampling to capture a minimum of 20 households by village. We divided each village into two zones from a given starting point (north, south) and one interviewer was affected to each zone. Households were randomly selected in each zone during one full day, with a target of a minimum of 10 households by interviewer. For the control site, given the fact that we have only 2 villages, we affected two interviewers to each zone with a target of a minimum of 7 households a day.

Appendix V-B. Choice set

	Option 1	Option 2	Option 3	Statu quo
Aire protégée	Diminution	Suppression	Augmentation	Etat actuel

Biodiversité	Réduite	Très faible	Augmente	Etat actuel
Diversité et nombre d'espèces animales et végétales dans la forêt				

Services environnementaux	Réduite	Très faible	Augmente	Etat actuel
Pollinisation (productivité café, cacao, …)				
Rétention de l'eau (important pour les rivières, marigot, puits)				
Réduction des risques d'inondation (perte de récoltes, etc…)				

Emploi	Augmente un peu	Augmente beaucoup	Diminue	Etat actuel
lié à l'exploitation industrielle de la forêt				

Activités de forêt	Augmentation de la collecte	Aucune restriction	Restriction de la collecte	Etat actuel

Collecte bois de chauffe				
chasse				
agriculture				
Choix				

Appendix V-C. PAs' redevelopment Mode Multinomial Choice: Restricted models

	Preferences and management types[a]		Preferences and socio-economic variables[b]		Preferences and ecosytem services dependence[a]	
	Model 1		Model 2		Model 3	
	Negative vs Status quo	Positive vs Status quo	Negative vs Status quo	Positive vs Status quo	Negative vs Status quo	Positive vs Status quo
community based	0	0				
	(.)	(.)				
national Park	0.119	-0.148				
	(0.25)	(-0.37)				
classified Forest	0.924*	0.580				
	(1.84)	(1.34)				
control site	1.419**	1.126**				
	(2.37)	(2.13)				
age			0.0347***	0.0369***		
			(3.27)	(3.64)		
illiterate			0	0		
			(.)	(.)		
educ_prim			-0.160	0.148		
			(-0.45)	(0.46)		
educ_sec1			-0.186	0.472		
			(-0.42)	(1.20)		
educ_sec2			0.00970	0.693		
			(0.02)	(1.53)		
cons_exp			-0.0305	0.0107		
			(-0.18)	(0.07)		
fwd_dep					0.250	-0.290

	Preferences and management types[a]		Preferences and socio-economic variables[b]		Preferences and ecosytem services dependence[a]	
	Model 1		Model 2		Model 3	
					(0.54)	(-0.73)
water_dep					-0.856**	-0.635*
					(-2.30)	(-1.94)
pro_dep					0.396	-0.319
					(0.97)	(-0.79)
med_dep					0.762*	0.882**
					(1.88)	(2.49)
res_year	-0.306	0.0190	-0.372**	-0.0498	-0.346	0.00976
	(-1.38)	(0.09)	(-2.05)	(-0.27)	(-1.55)	(0.04)
interwr	-0.104	0.143	-0.0726	0.146	-0.218	0.0804
	(-0.61)	(0.97)	(-0.52)	(1.15)	(-1.20)	(0.52)
_cons	0.490	-0.523	-0.0817	-2.126	1.349	0.305
	(0.52)	(-0.56)	(-0.04)	(-1.12)	(1.42)	(0.33)
N	228		223		228	
Ll	-237.9		-226.7		-235.3	
chi2	16.97*		24.33**		22.27**	
Small Hsia (IIA test)	for H0		-		for H0	
Hausman (IIA test)	for H0		for H0		for H0	
LM robust	H1		H1		H1	
LM OPG	H0		H1		H0	
LM	H0		H1		H0	

Dependent variable y=1, 2, 3 depending on which of the three options is chosen; t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01;[a] multinomial Logit (MNL), [b] multinomial Probit (MNP) ; IIA test: H0 = Odds are independent of other alternatives; LM test: H0= homoscedasticity

Appendix V-D. Results of IIA test and homoscedasticity for the fully specified model

Results of IIA test

Hausman test of IIA assumption (N=223)

	chi2	df	P>chi2
Negative	-4.753	15	.
Positive	2.994	15	1.000
statu_qu	-0.322	14	.

Ho: Odds(Outcome-J vs Outcome-K) are independent of other alternatives

Small-Hsiao test of IIA assumption (N=223)

	lnL(full)	lnL(omit)	chi2	df	P>chi2
Negative	-56.274	-49.421	13.705	15	0.548
Positive	-39.833	-29.047	21.573	15	0.120
statu_quo	-40.822	-35.709	10.227	15	0.805

Ho: Odds(Outcome-J vs Outcome-K) are independent of other alternatives

Results of homoscedasticity test

	chi2(1)	Prob > chi2
LM test for heteroscedasticity	2.23	0.1354
OPG based LM test for heteroscedasticity	2.74	0.0976
Robust LM test for heteroscedasticity	3.54	0.0599

Appendix V-E. PAs redevelopment Mode Multinomial Choice: heteroscedastic Logit models

	Preferences and management types		Preferences and basic human capabilities		Preferences and Ecosytem services dependance	
Dependant variables						
ASC1	0.119	(0.70)	5.901	(0.50)	0.359	(1.03)
ASC2	0.00640	(0.11)	-5.397	(-0.64)	0.0220	(0.12)
Natural Park*ASC1	0.0156	(0.36)				
Natural Park*ASC2	-0.0135	(-0.42)				
Classified Forest*ASC1	0.0453	(0.37)				
Classified Forest*ASC2	0.0650	(0.68)				
Control site*ASC1	0.127	(0.71)				
Control site*ASC2	0.0484	(0.59)				
age*ASC1			0.145**	(1.97)		
age*ASC2			0.152**	(1.98)		
educ_prim*ASC1			-1.933	(-0.83)		
educ_prim*ASC2			0.520	(0.38)		
educ_sec1*ASC1			-0.863	(-0.41)		
educ_sec1*ASC2			2.220	(1.24)		
educ_sec2*ASC1			-1.318	(-0.47)		
educ_sec2*ASC2			1.781	(0.86)		
cons_exp*ASC1			-0.522	(-0.57)		
cons_exp*ASC2			-0.299	(-0.46)		
fwd_dep*ASC1					0.0679	(0.56)
fwd_dep*ASC2					-0.0508	(-0.48)
w_dep*ASC1					-0.247	(-1.24)
w_dep*ASC2					-0.0571	(-0.53)
pro_dep*ASC1					0.159	(1.20)
pro_dep*ASC2					-0.120	(-0.79)
med_dep*ASC1					0.104	(0.65)
med_dep*ASC2					0.0899	(0.53)
idres*ASC1	-0.0455	(-0.70)	-1.906	(-1.55)	-0.0939	(-1.02)
idres*ASC2	-0.00446	(-0.29)	-0.166	(-0.19)	0.0222	(0.48)
ienqutr*ASC1	-0.0211	(-0.78)	-0.844	(-0.90)	-0.0685	(-1.06)
ienqutr*ASC2	0.00372	(0.32)	0.507	(0.87)	0.000189	(0.01)

	Preferences and management types		Preferences and basic human capabilities		Preferences and Ecosytem services dependance	
Het (independent variables to model the variance)						
ideduc	0.948**	(2.22)			0.595**	(1.98)
site			-0.673**	(-2.16)		
N	684		669		684	
ll	-233.6		-222.7		-233.1	
chi2	8.574***		8.313**		4.312**	

Data have been restructured in long format, where alternatives (possible choices) were indexed 1, 2 or 3. The dependant variable is a dichotomous variable as coded 0/1, 1 for the chosen alternative, and 0 otherwise; ASC (Alternative specific variables) are “fixed effects” for each alternative. t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01

CHAPTER VI

VI. Conclusion générale

1. Implications des résultats et recommandations

Pour les pays en développement, la conservation de la biodiversité tout comme les autres défis environnementaux, représente un challenge. Deux points de vue s'opposent, « se développer sans contrainte environnementale» justifié par des principes d'équité et l'évolution technologique, ou se « développer en intégrant les contraintes environnementales », justifié par les principes de responsabilité collective et de précaution. Selon le premier point de vue, les pays devraient avoir le droit de polluer (dégrader l'environnement) tout comme les pays développés l'ont fait dans le passé. S'attaquer aux questions environnementales pourrait compromettre leurs efforts de développement et rendre plus difficile l'atteinte d'objectifs jugés plus urgents tels que la réduction de la pauvreté ou plus généralement ceux identifiés dans les Objectifs du Millénaire pour le Développement. Les limites de ce point de vue renvoient notamment aux questions d'irréversibilité, et au caractère global de la perte. En effet, les incertitudes sur les seuils d'irréversibilité des systèmes naturels requièrent que le principe de précaution guide les choix des politiques même dans les pays en développement. Dans cette thèse, les résultats de nos études macroéconomiques permettent de contribuer à ce débat et d'apporter quelques réponses pour les pays d'Afrique Subsaharienne.

Dans le chapitre II, nous montrons que l'impact du développement économique sur l'érosion de la biodiversité ne peut être perçu de façon globale. Dit autrement, ces résultats ne permettent pas de soutenir l'idée que les efforts de développement menaceraient la diversité biologique dans sa globalité. En effet, quand un lien statistiquement significatif entre le PIB par tête et les espèces menacées d'oiseaux est trouvé, il n'existe pas de relation statistiquement significative entre le PIB par tête et les espèces de mammifères. Nos résultats révèlent également qu'une vision totalement pessimiste n'est pas entièrement justifiée pour les pays en développement de l'Afrique Subsaharienne. On trouve en effet, qu'une évolution du PIB par tête dans la région entrainerait une pression plus faible sur les espèces d'oiseaux. Ces résultats vont quelque peu dans le sens du premier point de vue. Cependant, ces résultats quoique moins pessimistes n'intègrent pas des seuils d'irréversibilité (qui sont à l'heure actuelle méconnus) et également la soutenabilité des activités économiques à la base de l'évolution du PIB par tête. Pour ces raisons il serait plus rationnel pour les pays de l'Afrique Subsaharienne de se pencher sur des approches de développement intégrées, qui limite les impacts sur l'érosion de la biodiversité. En outre, ces pays sont parmi ceux qui sont les plus vulnérables aux changements dans la diversité biologique et également ceux qui ont le moins de moyens financiers et technologiques pour faire face à ces changements. Il est donc encore plus rationnel pour ces pays, d'opter pour des approches de développement moins risquées en termes de changements dans la diversité biologique. Les contraintes financières de ces pays sont cependant réelles. Le caractère global tant des bénéfices que des conséquences de l'érosion de la biodiversité, renforcé par le principe d'équité recommande donc que ces pays soient assistés dans leur efforts de conservation.

Dans le chapitre III, nous mettons en évidence que les transferts financiers directs sont un moyen efficace pour accroitre l'effort de conservation des pays en Afrique Subsaharienne. Bien que les transferts directs en tant que moyen de financement de la biodiversité arrivent à créer des incitations positives pour la conservation au niveau des pays de l'ASS, il est important de se poser la question de la pérennité de ce système et de la dépendance de ces pays à l'aide extérieure. L'idée que des incitations internes existent émerge donc comme une nécessité pour renforcer et peut-être se substituer à terme à ces financements extérieurs. Nos résultats ne mettent cependant pas en évidence un lien significatif entre un potentiel incitatif local comme l'écotourisme et l'effort de conservation des pays. Diverses explications peuvent être avancées : (i) les bénéfices nationaux du tourisme ne sont pas encore importants comparativement aux bénéfices d'autres activités économiques, (ii) l'évolution du secteur d'activités n'est pas aussi importante dans l'ensemble des pays pour saisir un effet global à l'échelle de la région, (iii) l'expansion du secteur de l'écotourisme est récente, les effets sur la conservation ne se feront qu'à long terme. Pour clarifier toutes ces hypothèses, des indicateurs plus précis sur l'écotourisme dans la région peuvent s'avérer nécessaires. Nos résultats montrent aussi qu'une voie tout aussi valable pour renforcer les politiques de conservation dans les pays en ASS serait de motiver leur participation aux accords environnementaux (participation à la CITES dans le cas de notre étude) qui affecte positivement les efforts de conservation de la biodiversité. Enfin, un résultat important à nos yeux pour l'Afrique Subsaharienne est l'importance des effets de « spill-over » tant dans l'érosion que dans la conservation de la biodiversité. En effet nous avons trouvé des effets de débordement de la pression sur les espèces d'un pays à l'autre. Aussi, nous avons trouvé que la participation d'un pays aux accords environnementaux induit des effets positifs sur la conservation dans les pays voisins. Cela implique donc de considérer des approches régionales pour les problématiques liées à la biodiversité en ASS.

L'approche de conservation la plus répandue est l'établissement d'aires protégées. Cette approche s'est longtemps faite sans l'appui des populations locales. La raison étant due à la présence d'asymétries entre demande locale et offre de services environnementaux. L'intégrité de ces zones de conservation est pourtant nécessaire pour la conservation de la diversité biologique ainsi que les bénéfices liés. Les implications des résultats de nos études microéconomiques (Chapitres IV et V) permettent de discuter et de nuancer cette hypothèse. Nos résultats montrent que la conservation affecte les populations rurales locales tant positivement que négativement. Les bénéfices de la conservation pour ces populations pauvres incluent également des bénéfices de non-usage, à laquelle elles attribuent une valeur monétaire. Nos résultats montrent qu'il y a une demande locale, dans le monde rural, pour la biodiversité en Côte d'Ivoire. Une barrière à l'expression de cette demande est la non-participation des populations locales aux stratégies de conservation de la biodiversité, qui influent sur la préférence négative pour les aires protégées. Une autre barrière est le manque d'alternatives pour la provision de services de prélèvement qui remplissent des fonctions de base vitale pour les populations rurales. La conclusion qu'on peut tirer de ces études est que, les populations rurales pauvres ne sont pas ignorantes des bénéfices que leur procurent la nature, elles prennent les décisions qui sont pour elles économiquement rationnelles. Il faut donc pour renforcer l'intégrité des aires protégées en Côte d'Ivoire, valoriser les bénéfices nationaux et globaux de la biodiversité et (i) s'assurer que les populations locales en bénéficient, (ii) proposer des alternatives aux services de prélèvement ou réguler l'accès aux produits de la forêt, (iii) mieux intégrer les populations dans les stratégies de conservation.

2. Extensions

Une extension de notre étude de l'impact du développement sur l'érosion de la biodiversité serait d'analyser cet impact pour d'autres régions tropicales riches en biodiversité où le décollage économique est déjà amorcé (telles que l'Amérique latine par exemple), pour en apprécier les effets sur l'érosion de la biodiversité. Aussi regarder si cette expansion économique a des effets perceptibles sur l'offre de conservation de la biodiversité.

Dans la continuité de l'étude sur l'offre de conservation dans les pays pauvres, il serait également intéressant d'explorer à partir d'un modèle théorique les potentielles interactions entre pays du fait du développement des incitations économiques liées à la conservation. Cela permettrait d'identifier les conditions de coopération entre pays qui conduisent à des choix optimaux pour la conservation.

Au cours de nos enquêtes, nous avons pu constater sur le terrain en Côte d'Ivoire, l'impact des prix des produits d'exportation (l'hévéa en l'occurrence) sur les décisions d'allocation des terres cultivables. Vu la demande grandissante de terre, le risque pour l'intégrité des aires protégées est grand. Une extension pour nos études de terrain serait de pouvoir analyser l'impact de la volatilité des prix des produits d'exportation sur les décisions de conservation au niveau des décideurs tant individuels que nationaux.

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