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AERC COLLABORATIVE PhD PROGRAMME

AFRICAN ECONOMIC RESEARCH CONSORTIUM — CONSORTIUM POUR LA RECHERCHE ECONOMIQUE EN AFRIQUE

PAYMENTS FOR ENVIRONMENTAL SERVICES AND SUSTAINABLE WATERSHED MANAGEMENT: An Integrated Local Development Approach of Lake Barombi Mbo in the Mount Cameroon Region

A Thesis defended at the Faculty of Economics and Management of the University of Yaoundé II for the Award of the

Degree of *DOCTOR OF PHILOSOPHY* (Ph.D) in Economics

Option: Environmental Economics

By

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November 2018

DECLARATION

I declare that this Ph.D thesis is my original work. Where other people's work is used, acknowledgements have been made. I declare that it has not been previously submitted for the award of a degree at any university.

Claudiane Yanick Moukam

Claudiane Moukam

Signature

November 2018

Date

DEDICATION

To all those who have been parent to me, even for a while. Find here the expression of my deepest gratitude

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CAUTION

The University of Yaoundé II-Soa does not intend to give any approval or disapproval to the opinions stated in this thesis. They should be attributed to the author, who takes the full responsibility.

ABSTRACT

Most water policies (Decrees) in Cameroon have been focused on expanding infrastructures, in particular networks of 'safe' water supplies rather than sustainably manage water resources. Moreover, comparing the budget of water sector to those in social sectors, it occupied the last position with that of Social Affairs, with an average annual budget respectively of CFA 310 and 87.6 billion francs over the period 2004-2008, both being preceded by education and health sectors. As a result, there is increasing pressure on watershed services in general and water quality in particular, and therefore, the unsustainability of watersheds. To reconcile social welfare and the sustainable management of watersheds, this thesis builds a payment for watershed protection framework for the sustainability of Lake Barombi Mbo watershed in the Mount Cameroon zone. Using Contingent Valuation method (CVM) and Choice Experiment method (CE), two environmental valuation methods based on stated preferences, we assumed that a positive aggregate willingness to accept (WTA) compensation and willingness to pay (WTP) compensation express both supply and demand for watershed protection. In addition to these two methods and using a basic game theoretic approach within the framework of a Pricinpal-Agent model, we assumed that the coordination of upstream WTA and downstream WTP by the Municipality as intermediary reduces the transaction cost and makes the payment scheme effective and equitable. The results of the Tobit model estimation under the CVM give an aggregate WTA of FCFA 84.5million/year, which represents a total cost of reforestation by farmers to protect the watershed. Variables *age (-), sex (+), education (-), knowledge of bio-fertilizers (+)* are significant determinants of WTA. The aggregate WTP of downstream users is sensitive to the design option and the models used. The aggregate WTP varies from FCFA 69.7million with Binary Logit estimates under CVM to FCFA 185.7million with the Conditional Logit model, and to FCFA 293.2million/month with Random Parameter Logit (RPL) estimates under CE. Variable *age (+), education (+), availability of a tap-water at home (+)* significantly increase the probability to pay the proposed bid, while *water bill (-)* significantly decreases this probability. Moreover, the RPL model highlights heterogeneity in the preferences among respondents. The total benefits derived from these various watershed management attributes and the CVM reveal an estimated value of what could be the amount of payments by downstream households to upstream farmers for the provision of environmental services in the watershed. Per year, the ratio maxWTP/minWTA is about 41 (largely greater than 1) and underlines the fulfilment of the economic precondition for the payment scheme. The results of the basic game theory highlighted the role of the council as principal in reducing monitoring costs (inspection) if upstream farmers as agents decide not to shirk and cooperate. Therefore, the government should develop a genuine water policy in Cameroon based on a bottom up approach that takes into account households/farmers and councils contribution to watershed protection. Furthermore a revision of water, environmental, forestry and land tenure laws which incorporates PES mechanism would reduce watershed degradation in the country and increase the availability of the scarce financial resources required for their sustainable management.

RESUME

Les politiques (décrets) camerounaises de gestion de l'eau ont été davantage axées sur l'expansion des infrastructures, en particulier des réseaux d'approvisionnement en eau de qualité et moins sur la gestion durable des ressources en eau. En outre, en comparant le budget du secteur de l'eau à celui des autres secteurs sociaux, il a occupé la dernière place avec celui des affaires sociales, avec un budget annuel moyen respectivement de 310 et 87,6 milliards de francs CFA sur la période 2004-2008, tous deux précédés par les secteurs de l'éducation et de la santé. Ceci a entrainé une pression croissante sur les bassins versants en général et sur la qualité de l'eau en particulier, et ainsi à la non soutenabilité de ces bassins. Pour réconcilier le bien-être social et la gestion durable des bassins versants, cette thèse construit un cadre de paiements pour la protection du bassin versant du lac Barombi Mbo dans la zone du Mont-Cameroun. À l'aide de la méthode d'évaluation contingente (MEC) et de la méthode d'expérimentation des choix, deux méthodes d'évaluation environnementale basées sur les préférences déclarées, nous avons supposé qu'un consentement à recevoir (CAR) total et un consentement à payer (CAP) total tous positifs expriment à la fois l'offre et la demande de protection de ce bassin versant. En plus de ces deux méthodes, un simple jeu basé sur le modèle Principal-Agent a été développé. Dans ce cadre, nous avons supposé que la coordination du CAR en amont et du CAP en aval par la Mairie en tant qu'intermédiaire, réduit les coûts de transaction et rend le système de paiement efficace et équitable. Les résultats de l'estimation du modèle Tobit dans le cadre de la MEC donnent un CAR total de *84,5millions de FCFA / an*, qui représente un coût total de reboisement par les agriculteurs pour protéger le bassin versant. Les variables *âge (-), sexe (+), éducation (-), connaissance des biofertilisants (+)* sont des déterminants significatifs du CAR. Le CAP total des utilisateurs en aval est sensible à la méthode et aux modèles utilisés. Le CAP total varie de *69,7millions de FCFA* avec le logit binaire de la MEC à *185,7millions de FCFA* avec le logit conditionnel et à *293,2 de millions FCFA / mois* avec le logit à paramètres aléatoires (LPA) sous la méthode d'expérimentation de choix. *Les variables âge (+), éducation (+), disponibilité d'un robinet dans la maison (+)* augmentent significativement la probabilité de payer l'offre proposée, tandis que la variable *coût de la facture d'eau (-)* diminue significativement cette probabilité. De plus, le LPA met en évidence l'hétérogénéité des préférences parmi les répondants. Les bénéfices sociaux découlant des divers attributs de gestion du bassin et de la MEC révèlent une valeur estimée de ce que pourrait être, le montant des paiements effectués par les ménages localisés en aval, aux agriculteurs en amont pour la fourniture des services environnementaux dans ce bassin versant. Par an, le ratio CAPmaximun/CARminimum est de 41 (largement supérieur à 1) et vérifie la condition économique préalable du projet de paiement. Les résultats du jeu développé ont souligné le rôle de la Mairie en tant que *principal* dans la réduction des coûts de contrôle (surveillance) si les agriculteurs en amont (*agents*) décident de ne pas tricher et coopèrent. Ainsi, le gouvernement devrait développer une politique de l'eau basée sur une approche ascendante qui tienne compte de la contribution des ménages / agriculteurs et des communes dans la protection des bassins versants. En outre, une révision des lois sur l'eau, l'environnement, la foresterie et la propriété foncière qui intègre le mécanisme de paiements pour services environnementaux réduirait la dégradation des bassins versants et augmenterait la disponibilité des moyens financiers nécessaires pour leur gestion soutenable.

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ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
ASB	Alternatives to Slash and Burn
BV	Bequest Value
CAC	Command and Control
CAMWATER	Cameroon Water Utilities Corporation
CBD	Convention on the Biological Diversity
CDE	Camerounaise des Eaux
CDM	Clean Development Mechanism
CE	Choice Experiment
CED	Centre pour l'Environnement et le Développement
CL	Conditional Logit
COP	Conference of Parties
CPR	Common Pool Resources
CVM	Contingent Valuation Method
DSCE	Document de Stratégie pour la Croissance et l'Emploi
EPAT	Environmental Paper Assessment Tools
ES	Environmental Services
EU	European Union
EV	Existence Value
FAO	Food Agricultural Organization
FONAFIFO	National Forest Fund of Costa Rica
FTNS	Fondation pour le Tri-National de la Sangha
GEF	Global Environmental Facility
GWP	Global Water Partnership
ICDP	Integrated Conservation and Development Projects
IUCN	International Union for the Conservation of Nature
IWS	Investment in Watershed Services
LBMW	Lake Barombi Mbo Watershed
LBMFR	Lake Barombi Mbo Forest Reserve
MCNP	Mount-Cameroon National Park

MEA	Millennium Ecosystem Assessment
MINADER	Ministry of Agriculture and Rural Development
MINEE	Ministry of Water and Energy
MINEPAT	Ministry of Economy and Planning
MINEPDED	Ministry of Environment, Nature Protection and Sustainable Development
MINEPIA	Ministry of Fishing, Livestock and Animal Industry
MINFOF	Ministry of Forestry and Wildlife
NGO	Non Governmental Organization
NPS	Non Point Sources
NTFPs	Non-Timber Forest Products
NUV	Non Use values
OECD	Organization for Economic Cooperation and Development
OV	Option Value
PAWD	Partnership for African Water Development
PES	Payment for Environmental Services
PHES	Payment for Hydrological Environmental Services
PS	Point Sources
PSMNR-SWR	Programme for the Sustainable Management of Natural Resources in the South-West Region of Cameroon
PWS	Payment for Watershed Services
REDD+	Reduction of Emissions due to Deforestation and Forest Degradation, and sustainable forest management
RIS	Ramsar Information Sheet
RPL	Random Parameter Logit
TEEB	The Economics of Ecosystems and Biodiversity
UCS	Union of Concerned Scientists
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNREDD+	United Nations Reduction of Emissions from Deforestation and Forest Degradation programme
UN-SEEA	United Nations System of Integrated Economic and Environmental Accounting
UV	Use Values

WQT	Water Quatlity Trading
WRI	World Resource Institutte
WTA	Willingness To Accept
WTP	Willingness To Pay
WWF	World Wide Fund for Nature
ZIC	Community-based Hunting Zone
ZICGC	Commercial Hunting Zone

CHAPTER ONE

General Introduction

1.1 Background

Increasingly, ecological degradation has led to a deeper renewed focus on the links between economic growth and development. Healthy ecosystems provide society with a wide range of critical goods and services that contribute directly or indirectly to human well-being. A specific landscape such as forest and other woody vegetative cover in uplands and sloping lands not only provide timber and fuelwood, but also serve important environmental functions in land stabilization, erosion control, regulation of hydrologic flow, habitat for wildlife and climate stabilization. These services, namely "ecosystem services" provide both the conditions and processes that sustain human life.

Whereas ecosystems services, categorized in terms of p*rovisioning services, regulating services, cultural services* and *supporting services* are benefits people obtain from ecosystems (MEA, 2005), environmental services (ES) are positive externalities generated by human activities that sustain the provision of ecosystem services, and include *biodiversity conservation, carbon sequestration, watershed protection* and *landscape beauty*. Many of these services are important in production processes and climate stability (Pearce and Turner, 1990; Costanza and Daly, 1992; De Groot, 1992; Daily, 1997; Costanza et al., 1997; De Groot et al., 2002). However, despite their obvious importance to our well-being, their recognition and the roles they play rarely enters policy debates or public discussion. As a result, more than two third of them (including 70% of regulating and cultural services) are being used unsustainably (MEA, 2005; FAO, 2007; UNEP, 2011). Furthermore, the failure to account for their adequate valuation leads to their under provision (Cornes and Sandler, 1996; Salzman, 1997).

From an economic perspective, the market failure associated with the nature of ES being "positive externalities" or "public goods" cause ecosystems to degrade. These services lack markets or incentives for their provision that come with prices (Salzman, 1997; Swinton et al., 2007). As a result, local land managers do not receive a compensation for conserving them and thus, ignore them in their private decision-making, which often leads to socially sub-optimal land use decisions (Niesten and Rice, 2004; Hardin, 1968). In addition, incomplete information that includes ignorance and uncertainty regarding ecosystem functioning and land

use conservation practices, as well as lags in time and space between environmental disturbance and recognition of environmental problems also cause these ES to decline (Aylward et al, 1995; Wertz-Kanounninoff, 2006). Furthermore, the lack of attention paid on ecosystems as capital assets that can depreciate or degrade irreversibly if they are misused or overused results in ecosystems degradation (Dasgupta, 2008; Barbier, 2011). Therefore, the costs of the degradation of these services are high in rich and poor countries alike, while threatening sustainable development (Landell Mills and Porras, 2002; Ajonina, 2011).

Nevertheless, economic theory has long sought to identify favorable mechanisms to internalize these externalities (Pigou, 1920; 1932; Coase, 1960; Dales, 1968; Hardin, 1968). Moreover, managers and policymakers have promoted a wide array of institutional and technical approaches (Pearce and Turner, 1990; Ostrom, 1990; Baland and Platteau, 1996). Historically, regulations and fines were common approaches, along with subsidies to adopt improved technology or management practices. Nonetheless, challenges to implement these approaches include high transaction costs and lack of cheaply available information on the value of environmental services (Bulte et al., 2008; Pearce et al., 1989). Although attempting to value environment components and accounting for natural capital depreciation were further integrated into economic development policies and strategies (Asafu-Adjaye et al., 2005; El Serafy, 1997; World Bank, 1995), valuing ecosystem goods and services is not easy, yet it is fundamental to ensuring the sustainability of global economic development efforts (Costanza et al, 1997; Salzman, 1997; Pearce and Barbier, 2000; TEEB, 2008; 2010).

Recent innovations including green growth, green economy (FAO, 2010; UNEP 2011), blue economy (Ardakanian and Jaeger, 2012), and Payment for Environmental Services (PES) (Pagiola et al., 2002; Landell-Mills and Porras, 2002; Wunder, 2005, FAO, 2007) have received widespread attention. The economic recognition of environmental functions as valuable and scarce services for human wellbeing led to efforts to valorize environmental services through Payments for Environmental Services (PES). These approaches, developed earlier in the advanced world, are promoted across the developing world to support environmental stewardship in agricultural and forest-based landscapes and to address the existing imbalance between consumption and resource conservation (World Bank, 2006; WRI, 2005; FAO, 2007). PES primarily focuses on internalizing indirect externalities, for instance, indirect use values obtained from ecosystems that are outside the market. The ability of PES to internalize environmental services that present indirect use values is what some

perceive as the actual strength of PES schemes compared to other environmental policy instruments (Wertz-Kanounnikoff, 2006; FAO, 2007; Forest Trends, The Katoomba and UNEP, 2008). In this context, PES schemes are considered as an evolution from command and control (CAC) instruments and polluter pays principle (PPP). Their attractiveness is in part attributed to the interest of governments and civil organizations, especially conservation NGOs, to find new ways of promoting ecosystems conservation, while supporting the economic development of rural population.

The core idea behind the PES approaches is that external ES beneficiaries make direct, contractual and conditional payments to local landholders and users in return for adopting practices that secure ecosystems conservation and restoration[1] (Wunder, 2005). Furthermore, PES refer to voluntary transactions where a service provider is paid by, or on behalf of, service beneficiaries for agricultural land, forest, coastal or marine management practices that are expected to result in continued or improved service provision beyond what would have been provided without the 'payment', which payment may be monetary or in some other form (FAO, 2007). PES transactions may involve farmers, communities, taxpayers, consumers, trust funds, corporations and governments across a wide range of transaction types: from direct payments between downstream beneficiaries and upstream providers in a watershed to consumers paying for a cup of shade grown coffee beans produced on the other side of the world, that is, "user-financed programmes" (including eco-labeling product, information provision) (Engel et al., 2008; Ardakanian and Jaeger, 2012; Herbert et al., 2010). Payments may also be made by governments to service providers on behalf of society in "government-financed programmes" (Engel et al., 2008), together with other tools. Hence, there is recognition of financial incentives in influencing farmers, land managers and/or forest users' decisions concerning production practices that affect the provision of environmental services. However, considering the former approach of PES definitions, PES transactions can be sustained if, and only if, private demand supports them, while the latter approach depends in part on political criteria, which therefore can have significantly different implications for sustainability, efficiency and equity. Considered as alternative to CAC and Integrated Conservation and Development Projects (ICDP), that is, "Conservation by distraction" (Ferraro and Kiss, 2002; Niesten and Rice, 2004), the effectiveness of PES and their impact

[1] Hence, a variety of terms that describe them, including "*Market mechanisms for environmental services*" (Landell-Mills and Porras 2002) "*Compensations for environmental services* (Rosa et al., 2003*), Rewards for environmental services* (PRESA, 2009, 2011), and *Agri-environmental payments* (OECD, 2009).

on poverty and local development would be in line with the sustainable development (Locatelli et al., 2008; Wunder et al., 2008. Pagiola and Coll., 2003; Karsenty et al., 2010).

Nevertheless, while the concept of PES is fairly simple, their implementation can be challenging. Many of these services arise from complex processes, making it difficult to determine which actions affect their provision, to identify precisely who the providers and beneficiaries are and to agree on who holds the right to enjoy those services[2] (Barbier, 2011; Kindermann et al., 2008; Arriagada and Perring, 2009; Pagiola, 2005; Ajayi et al., 2012). Beneficiaries not used to paying for a service might show resistance to do so and suppliers may need to adopt new practices with some degree of uncertainty. Moreover, the extent to which the two objectives of environmental conservation and development can be achieved simultaneously through market-based mechanisms is not clear. Win-win outcomes are not easy to obtain and reactions to PES schemes in conservation and rural-development circles have been mixed (Kareiva et al., 2008; Wunder, 2007).

The concept of ES is embedded in multi-actors and multi-level process of market regulation and-/-or public policies (Karsenty et al., 2010; Greiber and Schiele, 2011; Herbert et al., 2010); and also involves new forms of governance that are being built and are yet to be invented (Antona et al, 2012). While institutions are necessary in PES analysis (Muradian et al., 2009; 2010; Vatn, 2010; Alix-Garcia and Wolff, 2014), their emergence is seen as a social and institutional innovation resulting from collective learning process (Segura, 2003; Bennett, 2008). In a market regulation framework with PES contracts, an auction to allocate contracts create a temporary market where one otherwise does not exist (Ajayi et al., 2012). An incentive compatible mechanism (Vickrey, 1961) helps overcome information asymmetries by giving participants a direct incentive to tell the truth. The competition created in this auction environment gives participants, an incentive to reveal their private information about the lowest payment that would make them to accept an environmental services contract (Ferraro, 2008; Ajayi et al., 2012). For public policy decisions framework to take ES into consideration, the values of ES should be known as well as their supply and demand; and the estimation of their values, supply and demand requires non-market valuation techniques. A common approach is the total economic value concept, which encapsulates the full range of

[2] Establishing international payment schemes such as payment for carbon sequestration or REDD+ mechanism has raised several important concerns due to information asymmetries and the number of producer of benefits. Indeed, PES involves negotiation and focuses on the actors, the contracts (incentive or binding), the application scale (global, regional or local) and the transaction costs.

economic values that people attach to each type of land use and ecosystem (Pearce, 1990). Following the Total Economic Values (TEV) approach, ecosystem services can be classified into use values and non-use values, whereby use values includes direct and indirect use values as well as option values[3] (Pearce and Turner, 1990; Barbier et, 1997; Markandya et al., 2002). Thus, valuing ecosystem services can enable the use of market instruments such as PES to incentivize forest users and communities to sustainably use ecosystem resources (Salzman, 1997).

Although studies have tried to value these services using various methods ranging from travel cost, contingent valuation and choice experiment method (Mitchell and Carson, 1989; Louviere and Henscher, 1982; Adamowics et al, 1998; Bateman et al., 1996; Hanley, 2001), few have evaluated the effectiveness of existing incentives for conservation policies (Legrand et al., 2010; Chen et al., 2014). But there is none evaluating the ex-ante potential impact of these conservation incentives for local communities and their influence on local institutions for managing natural resources. Ex-ante evaluation could noticeably influence the design of the PES scheme to sustainably manage natural resources (Ajayi et al., 2012). Moreover, widely experimented in developed countries[4] (Europe, USA, Australia) PES appears less widespread in developing countries where natural resources depletion and deforestation have become major threats to their environment and economies (FAO, 2007a and b). Empirical evidences in Africa are very few and it represents only 7% of world market for ES, corresponding to less than one third of the market in Latin America (Randrianarison, 2010).

Cameroon is endowed with rich ecosystem services and natural resources. The rich volcanic soils in most of the South West and Littoral regions and the maritime influence account for luxuriant vegetation which harbor flora and fauna, and support considerable agricultural, forestry and fishing activities. In Africa, Cameroon ranks fourth in floral richness and fifth in faunal diversity (UNEP, 1997). There is a high degree of diversity of ecosystems and genetic resources (species breeds, varieties) which all relate to the nature of the environment with corresponding effects on human and animal life and on the national economy (MINEP, 2008; République du Cameroon, 2012; 2014). The country has very unique watersheds diversity from its very dense hydrological network, drained from the Adamawa and from Nyong-

[3] The values that current generation place on the resource as something useful for future generation, or that must be used by the same current generation later.

[4] Viettel bottling company payment to farmers through agri-environmental programme of the Common Agricultural Policy of OECD countries, the Conservation Reserve Programme in USA dating from 1980s. In Costa Rica the programme began in the 1990s with forest conservation initiatives.

Sanaga dorsal along the four drainage basins or watersheds: Atlantic, Congo, Niger and Chad (MINEP, 2008; MINEE/GWP, 2009). The Atlantic basin consists mainly of Sanaga and coastal rivers (Nyong, Ntem, Moungo, Wouri) with numerous lakes including many Crater lakes (Barombi, Oku, Nyos, Wum, among others) from volcanic activities along its highlands. The tropical rainforest covers about 60% of the country and also covers most of the watersheds.

However, throughout the country, deforestation[i] coupled with changes in farming systems and population growth have caused severe problems of soil erosion, soil fertility loss, watershed degradation, fisheries habitats destruction and pollution of water sources (République du Cameroun, 2012; 2014; MINEE/GWP 2010). As a result, the livelihoods and well-being of the majority of the households in rural area are affected as well as climate regulation process and the biological diversity (MINEPAT, 2007; Chifamba, 2011; Ajonina, 2011; Kometa and Ebot, 2012; MINEE/GWP, 2010; R-PP, 2012). The combination of these environmental costs and their socio-economic impacts has heightened farmers and households vulnerability. Driven by short-term profit motives and representing about 80% of rural population (République du Cameroun, 2014), the private agents forest users and land managers do not yet see the link between investment in maintaining welfare and sustainability of watershed resources on which their profit and well-being depend. Hence, without urgent investment in watershed management the costs of rehabilitation would be very large.

Furthermore, at the national level, no explicit current legal framework directly supports the establishment of payment schemes to handle watershed degradation, but the engagement of stakeholders is of fundamental importance (R-PP Cameroon, 2012; Nlom and Sonwa, 2013; République du Cameroun, 2014). The Environmental Framework Law, Forestry Law, Water Codes, Land tenure Law, and other environmental Laws contain provisions that relate to PES and which influence the need to carry out PES schemes mostly dealing with the conservation, preservation and sustainable use of natural resources. The Forestry Law categorizes forest in terms of ‘Permanent’ and ‘Non-permanent’ state forest representing respectively 30% and 70% of total forest areas, and foresees management plans for sustainable use of forest goods and services in protected areas (National Parks, Reserves, Zoos, among others) existing under the permanent state forests. However, although both water and forestry laws are of fundamental importance in the watershed, to date water policies management of the country have been more focused on expanding infrastructures in particular networks of safe water

supplies rather than sustainably manage water resources (DSCE, 2009; MINEE/GWP 2010; MINEE/GWP, 2009). Governance frameworks and law enforcement are still too weak and financial means too scarce to adequately prevent pollution and ensure sustainable watershed management as well as efficient and equitable use of existing resources (MINEE/GWP, 2010). Moreover, the very few watershed protection projects and programmes developed or conceived in the country have been more focused on assessing or describing the process, rather than on the outcome (MINEE/GWP, 2009; Kwenty, 2011). Their practical implementation has been greatly influenced by conflicts in the management of the watershed and political situation as well as the funding sustainability. None of these studies has been focused on empirically estimating the value of ES and assessing the sustainability of the funding sources in the watershed. Moreover, other studies have highlighted that the landscape and ecosystem services of Mount Cameroon zone, one of the most prominent ecosystems of the country, have changed significantly over the last decade (Ruitenbeek, 1990; Yaron, 2001; Agbor, 2008; Green Synergies and WWF, 2009; Ajonina, 2011; Mont Cameroon National Park management plan, 2014).

Lake Barombi Mbo watershed (LBMW) in the Mount Cameroon zone hosts the largest Crater Lake in Cameroon which represents the main source of drinking water for Kumba town and the surrounding villages. The Lake was designated a RAMSAR site in 2006 and is an important biodiversity hotspot famous for the occurrence of twelve (12) endemic fish-species, which renders Barombi Mbo one of the areas with the highest densities of endemic species per area in the World (Schliewen and Tanjong, 2006; Eyenga et al, 2004). With the presence of freshwater sponges, the lake harbors one of the few examples of habitats for endemic Crater Lake fish species-flock with a high ratio per hectare (Schliewen and Tanjong, 2006; Drawall et al, 2011). While representing a conservation, touristic, research and socio-cultural site, LBMW is also a source of foods, timber, fuel wood, fish and other useful non-timber forest products to the surrounding communities. However, LBMW is threatened due to sedimentation and pollution from “illegal” farming and unsustainable fishing activities coupled with deforestation and water abstraction. While some of the farms and cocoa plantations are located at the vicinity of the lake, the use of pesticides to spray cocoa within the catchment area harms water quality as well as the life cycle of the endemic fish diversity in the Lake (Agbor, 2008; Tchouto et al., 2015). The *stomatepia mongo* species has currently been considered critically endangered (IUCN Red List; Darwall et al., 2011).

Nevertheless, because of the steeply slopes nature of LBMW prone to suffer erosion and the existence of a mixture of limon, laterite, sandy, clay and volcanic soils (Schliewen and Tanjong, 2006), a Forest Reserve[5] was created in 1940 to protect the Lake. Until 2012, the Lake Barombi Mbo Forest Reserve (LBMFR) was then managed by the Ministry of Forestry and Wildlife (MINFOF). However, following the decentralization process in the country and in order to ensure the participative and sustainable management of LBMFR, the management was transferred to Kumba I Council in 2012 by Ministerial Decision *N°2002/D/MINFOF/SG/DF/CSRRVS* of 21st August 2012. Therefore, the Reserve is currently under a three-year provisional management convention signed between MINFOF and the Council in 2013. One main requirement of this convention was that Kumba I Council has to work in close collaboration with the local community concerned and with technical support of MINFOF to fight against illegal activities in the reserve, to protect the lake and ensure the sustainable management of the reserve. Yet LBMFR does not have an Environmental Management Plan. Moreover, realizing those activities in National Parks and Reserves usually faces resistance from communities and necessitates sustainable financial resources and /or technical expertise.

1.2 Problem statement

Watershed protection is an economic justification of conservation activities as soil and water conservation may yield benefits to land-owners and alleviate damage to downstream economic activities (Aylward et al., 1995). While constituting an area of land that drains into a common water source, watershed as common pool resources, is a natural asset that delivers a stream of goods and services to society (Postel and Thompson, 2005; Kerr et al., 2005; Smith et al., 2006). Watershed services are therefore important for rural households to maintain their agriculture and forests based livelihood and to adapt to climate change which affects both water quality and quantity (Rai et al, 2014). Considered as the process of guiding and coordinating use of land and water resources in a watershed, hence, watershed management should provide desired environmental services and goods without adversely affecting resources upstream or downstream, preserve the high economic return and enhance community resilience to climate change through sustainable land use and water resource management (EPAT, 1999). Any policy to achieve sustainable development requires adapting

[5] According to Law N° 94/01 of January 20th 1994 Forest Reserve is a permanent state forest under the sub-category of production forest.

watershed management to economic and social realities (Brooks et al, 1982; Pattanayak, 2004; Forest Trends, The Katoomba and UNEP, 2008). Furthermore, integrated watersheds management approaches are important for lake and reservoir basin governance. Lakes are intermediary lentic water bodies with longer water residence time than lotic waters (rivers, streams) (Lin and Nakamura, 2012). Individual lakes influence upstream and downstream lotic water flows in their watersheds and produce more local impacts that can sustain human consumption and production activities which ultimately depend on land uses. On the global scale, lakes collectively significantly affect the regulating functions of the hydrological cycle (Lin and Nakamura, 2012). Consequently, effective lake governance must consider both the elements of water bodies and human activities within their watersheds. Integrated watershed management seeks to increase the availability of ecosystem services by balancing ecological, economic and social dimensions of watershed management. The demand for these local services must be sufficient to allow villagers and local actors to manage watersheds for improved provision of these services and sustain any investments that may be required.

However, efforts to protect watersheds are jeopardized by the complex nature of the externalities involved (Lubell et al., 2002). The off-site nature of many conservation activities benefits makes both valuation and internalization of these externalities difficult, thereby preventing the development of sustainable watershed protection programs. This is also the case in areas where mountain forests provide downstream national benefits to hydroelectricity and irrigation schemes. Building incentive systems that solve market, policy and institutional failures impeding watershed protection remains then a challenge for policy-makers, scientists and communities in Cameroon. Typically, command-and-control institutions and policies may be effective in controlling pollution from well-defined point sources, such as factories or sewage treatment plants. However, they are less effective in regulating non-point sources of pollution, such as those occurring when downstream water pollution (or scarcity) is the result of the combination of individual actions carried out by geographically dispersed and heterogeneous upstream providers.

By means of market transactions between downstream and upstream economic agents, PES schemes may induce upstream stakeholders to take downstream effects into account when making decisions about their own land use, resulting to larger socio-economic efficiency. Moreover, direct payments may be more cost-effective in meeting environmental and development goals, as compared to indirect means of financing a better management of

natural resources (Ferraro and Kiss, 2002; Landell-Mills, 2002; Pagiola et al., 2005). PES scheme in a watershed are derived from the Coase's theorem. Namely, in a free market with clearly established property rights and zero transaction costs, the gains in efficiency due to the internalization of environmental externalities are independent from the initial endowment of property rights. Hence, the adoption of the polluter-pay principle is not a condition for achieving a Pareto situation when applying this kind of instruments. In fact, the polluter-pay principle for most water-related service payments does not hold, since upstream landholders are often compensated for avoiding/reducing negative environmental externalities. However, PES schemes should fulfill two conditions in order to be efficient. First, the compensation of upstream landholders should be at least equal to the opportunity cost of the promoted land use. Secondly the amount of the payment should be lower than the economic value of the environmental externality i.e., the abatement cost of improving water quality or the cost of water treatment (Kosoy et al., 2007).

In tropical watersheds such as that of Barombi Mbo, vulnerable groups tend to be located in upstream areas, where land is often less productive and more prone to suffer erosion. Nevertheless, these rural communities are often providers of environmental services benefiting other groups in better socioeconomic situation, often located in downstream urban areas such as Kumba Town. Hence, PES schemes are also expected to contribute to wealth redistribution and poverty alleviation. PES should work as multipurpose (win-win) instruments, improving the conditions of different types of natural resources in the watershed at the same time (forests and water), raising awareness about the economic worth of ecosystems, and contributing to economic development. Valuing watershed services or examining ex-ante the conditions for successful implementation of PES schemes is then more directed towards establishing effective incentive schemes to promote sustainable watershed management and improving social welfare. Hence, the following research objectives and questions.

1.3 Research Objectives

The main objective of this study is to ***analyze the conditions to be met ex-ante for an effective payment scheme for watershed protection in LBMW in the Mount-Cameroon zone.*** Specifically, the study seeks to:

- Estimate the upstream users' willingness to accept (WTA) compensation and factors that influence their WTA to participate in reforestation, conservation and agro-forestry activities;
- Estimate the downstream users' willingness to pay (WTP) for watershed protection activities by upstream users and to determine the factors that influence their WTP;
- Develop a fair and equitable payment scheme in the watershed.

1.4 Research Questions

What are the conditions required for implementing an effective payment for watershed protection in LBMW in Cameroon?

Given the environmental attributes, economic and social utility, and stakeholders of this watershed, the above research question can be grouped into three specific ones:

- What is the willingness to accept of upstream users (farmers, fishermen) to participate in conservation, reforestation and sustainable agricultural practices?
- What is the willingness to pay of downstream users (Kumba households, CAMWATER) for watershed protection upstream? and
- How can intermediaries (Kumba I council, and others) coordinate the upstream and downstream interests (WTA and WTP) for the payment scheme to be fair and equitable?

1.5 Significance of the study

The questions above underline at the same time scientific, environmental, socio-economic and policy interests. In scientific context, the wide gap between the global benefits from ecosystems and what we are willing to pay or receive to maintain and conserve them is a critical symptom of how oblivious we are to the risks arising from the excessive ecological deterioration caused by the current pattern of economic development (Phelps et al, 2011; Barbier, 2011; Njomgang, 2009, p11; Gomez-Baggethun et al., 2009; Wunder, 2007; Nordhaus, 2007; Pattanayak, 2004; Rojas et Aylward, 2003; Stern, 1997; Grossman and Grueger, 1995). Moreover, the most noticeable in PES literature is the effort to create the market and an equitable schemes. Indeed, although the right must be defined, the commodity be delineated, and the group of users and providers must be specified, the difficult task as exclusion is very demanding in PES scheme. Using Lake Barombi Mbo watershed as case study, the present study contributes to the literature on the internalization of environmental externalities, ecosystem services valuation, the integrated watershed resources management

and PES mechanisms. In addition, the study contribute to the analysis of the role of intermediaries in PES literature.

In an environmental and socioeconomic context, Wunder (2006) and Miranda et al. (2003) emphasize that farmers' participation in PES schemes is influenced by PES contribution to household income and land opportunity costs, and notes that PES incentives have contributed up to 30% of household income in a variety of experiences across Latin America. Notwithstanding, Wunder also acknowledges that the economic value of environmental services is often set by service users rather than providers, which indicates that these initiatives are governed by power asymmetries. Interest of local communities in PES schemes is also explained by the provision of non-monetary benefits, including an improvement in internal organization, an increased visibility of the farmers for buyers (Corbera et al., 2007; Mayrand and Paquin, 2004; Rosa et al., 2003) and increase in land-tenure security. This study completes the previous studies by analyzing the PES schemes where farmers lack power in a negotiation process and have rather user rights on the resources. The study also fills in the gap of previous studies by taking into consideration the WTP for another type of downstream users that are households to ensure the sustainability of the funding in a context of a private sector operator providing water services. Moreover, if payment for watershed protection in Barombi Mbo will generate new sources of conservation funding, additional incomes for local population and new negotiated solutions to environmental problems, its focus is first of all to solve problems affecting water resources in the watershed.

In policy context, to cope with the ongoing unsustainable management of the country's natural resources, Cameroon is committed to develop and implement a national Payment for Environmental Services (PES) program by 2020 and therefore, to impute PES in the national budget. This study therefore provides baseline information that could help the implementation of PES watershed at the national level and to develop the LBMFR management plan. The data collected fills the gap of the lack of data on the value for watershed services of the country and also contributes to further researches in the field.

1.6 Scope of the study

Whereas Cameroon has important lakes or water sources, the largest and most threatened Crater Lake is the one located in Barombi Mbo watershed. This Lake watershed represents a conservation, research and education site compared to other Lakes in the country as well as a sociocultural and an attractive touristic site for the country. The watershed is also a source of

livelihoods to the surrounding communities. The unsustainable activities carried out there affect the economic activities as well as the well being of the local communities. Thus, a payment for watershed service scheme in LBMW will help improve the deficiency of water resources to Kumba households and the effects on their economic activities; reducing the cost of water treatment to the Water Utilities Company "la Camerounaise des Eaux (CDE)"; and improve social welfare of village communities through an increase in their income levels. Moreover, the study could be used by Kumba I Council to implement an effective reforestation programme in the reserve and around the Lake, which programme could generate benefits to the Council from REDD+ mechanism once implemented in the country.

1.7 Brief Outline of the methodology and presentation of data

The study uses at the same time primary and secondary data. Secondary sources of information were published and unpublished works in the study area and structured questionnaires administered to Divisional Delegation of Agriculture, Economy and Planning; Environment and Nature Protection and Sustainable Development; Forestry and Wildlife; Energy and Water Resources; Fisheries, Livestock and Animal Industries; Kumba I and City Councils, and others key informants. Primary data were collected from sampled farmers and households using structured questionnaire and face-to-face interviews; from CDE using administered questionnaire.

A total number of 384 farmers were surveyed in upstream from 05 villages: Barombi Mbo, Kake I, Njurky, Small Ekombe and New Town Barombi; and 383 households were surveyed in downstream Kumba Town of the watershed. The following formula[6]: $n = \frac{N}{1+Nd^2}$ was used to determine each sample size (n) and $N = 9562$ was the number of peoples older of more than 15 years old in upstream or N= 400,000 inhabitants downstream, and d= desired margin of error (0.05). Hence, a total of 767 individual farmers and households were surveyed. The proportionate stratified sample procedure based on villages was used to determine the number of farmers to be interviewed in 03 villages: Kake1; Small Ekombe; Njurky, after fixing the number in Barombi Mbo and New Town Barombi villages since most closed to the reserve and lake. In each village and Kumba town, farmers and households were randomly selected

[6] This formula is equivalent to $\frac{1.96^2\, p(1-p)}{\gamma^2}$, by *Sudman, S. and Bradburn, N. (1982). "Asking questions, a practical guides to questionnaire design; Jossey-Bass, San Francisco, California"*, where p is the proportion of the populations having the studies characteristics following a normal distribution, and γ is the desired margin error.

for interviews. Before starting data collection, enumerators were hired and trained on the content of the questionnaire, methods of data collection and on how to approach farmers and households. The questionnaires were pre-tested and modified with 30 upstream individual farmers and 10 household heads downstream. Moreover, given the use of Choice Experiment (CE) method in addition to the Contingent Valuation method (CVM), during the questionnaire test, focus groups discussions were organized with village representatives in order to identify the main attributes and their levels of the watershed to be valued, of which were added those identified from secondary sources. Indeed, Choice Experiment is a stated preferences approach to elicit WTP values based on the combination of the attributes and attribute levels of the good being valued. The different attributes of the watershed and their levels are presented in Table 3.1. Moreover, the villages and activities carried out upstream of the watershed are given in Annex 1.

Experimental Design: For the downstream part, besides the application of CVM, a total of **5** attributes were identified, of which 4 attributes with 2 levels each and 1 attribute with 4 levels. This then gave a total of 2^4x4 =64 combinations or profiles. By using the orthogonal plan design and the SPSS 20 Software, 8 profiles were successfully generated, which allowed us to get 4 choice cards per individual household, formed with 2 alternatives plus status quo. Thus, there was not need to block the design as the experiment design gave only four cards for each individual. An example of the choice card is presented in Table 3.1.

Furthermore, within the framework of the Coase theorem, the study uses a basic game theory with the Principal-Agent model to analyze the transaction costs, the efficient level of the ES protection to be adopted, and the efficient payment to be set in LBMW. Moreover, the ratio maximum WTP/minimum WTA is computed in order to verify the economic preconditions of the payment scheme.

1.8 Organization of the study

The study is organized in seven chapters: Chapter one focuses on *general introduction*. Chapter two presents the theoretical framework of the sustainability of watershed Management and Payment for Environmental Services. In this chapter, is included an overview of status, threats and management of watersheds and ecosystem services, and the framework of Payments for Environmental Services in Cameroon. Chapter three presents the conceptual framework and methodology of the valuation of ecosystem services in the

watersheds (CVM and CE). Chapter four focuses on the provision of environmental services through sustainable agriculture and fishing activities in the watershed by estimating a willingness to accept of upstream users. Chapter five determines the demand of the downstream' households for improved watershed management by estimating their willingness to pay. Then Chapter six analyses the role of intermediaries in linking upstream users' willingness to accept and downstream willingness to pay for an effective PES scheme. Finally, Chapter seven presents the general conclusion.

Chapter two that follows, explores the theoretical framework of the sustainability of watershed management and of the Payment for Environmental Services mechanism. The framework of Payments for Environmental Services in Cameroon is also presented. The chapter explores alternative governance arrangements that have been required to produce equitable and economically efficient outcomes for watershed ecosystem services management. This relied on the interface between two areas of scholars: the governance of common pool resources and the governance of externalities, which laid out detailed arguments in support of privatized vs. collective governance of the commons, and for free market or contract-based (autonomous) vs. state regulatory (Hierarchical) governance of externalities. Moreover, looking at the environmental and sustainability challenges through the framework of ecosystem services, the chapter considers the optimal combination of free market and hierarchical governance needed for watershed ecosystem services utilization, which integrates the value of these services through PES schemes.

CHAPTER TWO

Watersheds Management, Sustainability and Payments for Environmental Services: A Theoretical Framework

What now remains of the formerly rich land is like the skeleton of a sick man with all the fat and soft earth having wasted away and only the bare framework remaining. Formerly, many of the mountains were arable. The plains that were full of rich soil are now marshes. Hills that were once covered with forests and produced pasture now produce only food for bees.

Once the land was enriched by the early rains, which were not lost, as they are now, by flowing from the bare land into the sea, the soil was deep, it absorbed and kept the water…, and the water that soaked into the hills fed springs and running streams everywhere. Now the abandoned shrines at spots where formerly there were springs attest that our description of the land is true.

----Plato (quoted in Hillel, P.104 and in Daily, 1997, Chapter 1)

Daily, G. (1997). Introduction: What are Ecosystem Services; Chapter 1.

2.1 Introduction

The recognizance of watershed management for ecosystem services dates back to Plato's descriptions of the effects of deforestation on soil erosion and the drying of springs in 400BC (Plato quoted in Daly, 1997). However, watershed as natural asset has been subject of attention in economic theories. In economic consideration, watershed gathers a diversified natural resources including, land, water, forest, fish, mines or energy, plants, and many other services which can be used for cultivating and processing and support human life.

Adding renewable resources to non-renewable resources considered by Hotelling's tradition in 1931, natural resource economists, including forest economists, land economists, mineral or energy economists and fisheries economists, internalize external effects by applying economic theory and quantitative methods to determine the optimum allocation and distribution of these natural resources. The prohibitions against oil and mineral development (Krutilla, 1967) and cutting timber on certain government lands (Fautsman, 1968), and the closed seasons for fish and total allowable of catching fishes (Gordon, 1954) have this justification. However, while resource economists continue to encourage economic growth from natural resources, Meadows et al. (1972) highlighted the fall in the ability of the natural environment to assimilate wastes arising from production and consumption as the level of pollution increases. As argued Dasman et al. (1973), *"all economic development takes place within natural systems… although development brings changes to varying degrees, it is still subject to environmental limitations of these natural systems."* Therefore, while resource economics evolve, natural systems are considered as a provider of raw materials inputs and a receptacle for waste products of producers and consumers. Controlling air and water pollution have been major challenges coupled with the recycling of waste from production activities (Pigou, 1920; Coase, 1960; Georgescu-Roegen, 1971; 1975; Ehrlich and Ehrlich, 1981; De Groot, 1987; Costanza and Daly, 1992; Perrings et al., 1992). Governing common pool resources and establishing property rights regimes (Hardin, 1968; Ostrom, 1990) have also been challenged and subject to intense debates, and still no consensus is made, when considering resources such as air, biodiversity, wildlife, ecosystem services, on which defining a set of private property rights is physically not feasible.

Hence, as the world's resource base is limited and contains a complex and interrelated set of ecosystems that are currently exhibiting signs of fragility, it is increasingly questioned whether the global economic system can continue to grow without undermining the natural systems which are its ultimate foundation (Grossman and Krueger, 1995). Balancing development while maintaining ecosystems integrity requires a concerted planning effort that is inclusive and transparent. An integrated management approach that guides overall planning in the watershed recognizes the importance of multi-stakeholder negotiations as a means of combining top-down policy implementation and bottom-up participatory processes. Better governance is about including all those who should have a say, either because of their official position or because they benefit or suffer from the consequences of decisions made. The search for adequate funding to undertake integrated watershed management is a core concern

among government agencies. A variety of economic and financial approaches for integrated watershed management are already applied, including novel ways of analyzing economic costs and benefits in decision making, introduction of new prices and markets for watershed goods and services and development of innovative financing mechanisms (Landell-Mill and Porras, 2002, Pagiola et al., 2002; Wunder, 2005). Over the past decade, there has been a progressive shift in the way watershed values have been calculated and presented to decision makers. The concept of total economic value has become one of the most widely used frameworks to identifying and categorizing watershed benefits (Bateman et al., 1996; Pattanayak, 2004).

This chapter defines and discusses in its two first sections the concept of watershed management as common pool resources, the externalities theory and approaches for integrated watershed management, the sustainability challenges and their theoretical evolution. Section three defines the concept of payments for environmental services while comparing it to other instruments for externalities internalization in the watershed, and presents their theoretical evolution. Section four discusses the status of watersheds in Cameroon and the mechanism for financing the environmental and ecosystem services protection in watersheds of the country. Finally, section five concludes the chapter.

2.2. Watershed Management: The Sustainability Challenge.

The importance of multiple economic, social and environmental benefits derived from land-based resources has increased in recent years. Sound management of these resources is therefore prerequisite to sustainable resource-based production systems. Watershed management, which in essence is the application of land resource management systems, is considered by many to be the most appropriate approach to ensuring the preservation, conservation and sustainability of all land based resources and improving the living conditions of people in the uplands and lowlands. Integrated watershed management with participation of all the relevant key actors has become widely accepted as the approach best suited for sustainable management of renewable and non-renewable natural resources in the upland areas. The starting point for watershed management is recognizing that watersheds are the fundamental hydrological units and thus a basic land unit where biodiversity and ecosystem functions can be sustained and where livelihood opportunities are provided.

2.2.1 Concept of Watershed Management.

Many watershed resources are characterized by high exclusion cost and rivalry, the two main attributes of common pool resources (Kerr, 2007). Many natural resources in a watershed are often held in common, such as pastures, forests, ponds (fish), and groundwater. Other resources tend to be managed individually, especially agricultural land, but also some patches of pasture, forest, and captured runoff water. A watershed is defined, however, by the hydrological linkages among all these resources (Kerr, 2007). Through these hydrological linkages, a watershed system is in fact a high exclusion cost, subtractable environmental resource, that is, a common pool resource that faces typical commons management problems.

2.2.1.1 Watershed Management: A Historic View.

Large scale removal of forest lands by humans in the nineteenth and early part of the twentieth centuries created significant changes in the hydrological function of watersheds. Downstream flooding occurred more frequently, with subsequent increases in loss of life and damage to infrastructure. Accelerated erosion, produced by changes in the biotic and hydrologic components of natural drainages (watersheds), created unprecedented large scale siltation of developed lowlands. At the time, the general consensus was that the removal of forest was causing these undesirable impacts, which joints the Plato's descriptions of the effects of deforestation on soil erosion and other ecosystem services in 400BC (Plato quoted in Daly, 1997). However, at that time, developing mechanisms for reversing the process through sound scientific management had not been a priority.

During the second quarter of the twentieth century, the discipline of forest hydrology evolved from the need for scientific management of the soil and water resources of headwater catchments in order to minimize the flooding and siltation of productive lands and infrastructure in the valleys and plains inhabited by humans. As the importance of rangelands and cultivated lands in the hydrologic cycle and the erosion-sedimentation processes of catchments became known, forest hydrology gave way to more comprehensive, present day watershed management. Over time and in response to changing needs, the scope of watershed management has broadened from the initial concept of technical management of water resource to an integrated discipline that applies biological, technical, social and economic principles to maintain the productivity of headwater and lowland areas through the scientific management of soil, plant and water resources. Moreover, in complex, multiple use commons

like watersheds, interests have been balanced both within and across diverse interest group to generate agreement on regulations about resources access, allocation, and control.

2.2.1.2 Common Property Rights Regimes and Watershed Management

"Commons-type" natural resource management problems persist despite widespread awareness and concern among resource users. However, in discussing common property resources including fisheries, wildlife, surface and groundwater, range, and forests, it is important to differentiate between the characteristics shared by these resources, and to distinguish between ownership of that resource and the property-rights regime[7] in which the resource is held (National Research Council, 1986; Feeny et al., 1990). The primary feature in the literature with regards to the resource itself is the property of the resource that shapes the likely effectiveness of different forms of ownership and governance (German and Keeler, 2010).

Common-property resources share two important characteristics. The first is *excludability* (or *control of access*), that is, exclusive for a group. The physical nature of the resource is such that controlling access by potential users may be costly and, in the extreme, virtually impossible. According to Feeny et al. (1990), migratory resources such as fish, wildlife and groundwater pose obvious problems for regulating access. Similarly, range and forest lands typically pose problems of exclusion. For large bodies of water, the global atmosphere, exclusion is even more problematic. The second basic characteristic is *subtractability (or rivalry)*, that is, each user is capable of subtracting from the welfare of other users, that is, the consumption of the good by one agent reduce the quantity available to other users. Even if users cooperate to enhance the productivity of their resource, for instance by replanting trees, the nature of the resource is such that the level of exploitation by one user adversely affects the ability of another user to exploit the resource. This is illustrated with aquifer water or catching fish with Gordon (1954) and Scott (1955), the two modern resource economists usually credited with the first statement of conventional theory of the commons. Indeed, if one user pumps more water from an aquifer, other users will experience an increase in pumping costs as aggregate use approaches or exceeds recharge capacity[8]. Moreover, if one

[7] That is the institutions governing resource use and management
[8] Thus, rivalry is a source of the potential divergence between individual and collective rationality.

user harvests fish, the cash per unit[9] ($\frac{q}{e} = \theta x$) of fishing effort of other fishermen declines, while effort (capital and labor) increases. Hence, according to Berkes et al. (1989), common property resources is a class of resources for which exclusion is difficult and joint use involves subtractability or rivalry. However, the definition here resembles that of Ostrom (1986) where Ostrom underlines the importance of the distinction between the intrinsic nature of the resource and the property rights regime under which it is held, by defining the class of these resources as "common-pool resources".

Furthermore, four categories of property rights within which common property resources are held are defined by Feeny et al. (1990), including *open access, private property, communal property,* and *state property*. However, these are ideal and analytical types. In practice, many resources are held in overlapping and conflicting combinations of these regimes, and there is variation within each. Nevertheless, it is important to distinguish these four basic property rights regimes (see Feeny et al., 1990, p.5; Ciriacy-Wantrup and Bishop, 1975; Bromley and Cernea, 1989, pp. 3-5; Berkes et al., 1989, p.91; Demsetz, 1967, p. 354).

Open access: this regime is the absence of well-defined property rights, and the access to the resource is unregulated and is free and open to everyone. Under this regimes, resources are characterized by their "public goods" nature i.e. non-rival (consumption of the good by one does not reduce the amount left for others) and non-excludable (individuals cannot be excluded from consuming the good). Therefore, resources under this regimes are loudly exposed to over-exploitation and degradation, especially when population density is increasing or the commercial value of the resource is important (Ciriacy-Wantrup and Bishop, 1975). This is generally the case of many offshore ocean fisheries before the twentieth century, the global atmosphere, and some protected area unmanaged where neighborhood population found reasonable to continue exploiting resources that are protected, as according to their thought, they hold rights too on the resources (Hardin, 1968[10]; Heltberg, 2002).

[9] In the specific functional form of the harvest rate $q(t) = e\theta x$ from where the catch per unit $\frac{q}{e} = \theta x$ is derived, q(t) is the harvesting rate of fish, e is the effort (capital and labor) required for q, x is the stock size and θ a parameter.

[10] Hardin (1968) presents National Parks as another instance of the working out of *the tragedy of the commons* as they are open to all, without limit. He suggested national parks to be sold off as private property or be kept as public property where the right to enter them are allocated likely on the basis of wealth, merit, lottery or a first come first served administered to long queues.

Private property: under this regime, the rights to exclude others from using the resource and to regulate the use of the resource are vested in an individual (or group of individuals such as a corporation); and are generally recognized and enforced by the state. Unlike rights under open access, private property rights are usually exclusive and transferable. Examples include forests or rangelands that are held privately or private beach. In developing world, poverty, population pressure, corruption, high transaction costs, property rights failures and lack of infrastructures can seriously limit the effectiveness of this regimes, especially when these rights do not benefit to the holder (Platteau, 1992).

Communal property: under this regime, the resource is held by an identifiable community of interdependent users. These users exclude outsiders while regulating use by members of the local community. Within the community, rights to the resource are unlikely to be either exclusive or transferable; there are often rights of equal access and use. Watersheds generally fall under this category. Some inshore fisheries, range lands, and forests have been managed as communal property. Similarly, water-user associations for many groundwater and irrigation systems can be included in this category (Feeny et al., 1990). The rights of the group may be legally recognized, but in other cases, the rights are *de facto* depending on the benign neglect of the state. Baland and Platteau (1996) distinguish between regulated communal properties where rights to manage the resources are defined, and unregulated communal property where there exist no rules governing the use of the resources; which absence is likely to lead to overexploitation. Most of the watersheds unmanaged such as the one of Barombi Mbo falls under this category. Some scholars have used the term "common property", "common goods", "common resources", "common property resources" or simply a "commons" to refer exclusively to the communal property (Ostrom, 1990; Bromley, 1991).

State property or **state governance**, Finally, under this regime, rights to the resource are vested exclusively in government which in turn makes decisions access to the resource and the level and nature of exploitation. Examples include forests and rangelands held by the government and resources such as fish and wildlife that may be held in public trust for the citizenry (community or people). The category of state property may refer to property to which the general public has equal access and use rights. But the category also differs from other regimes in that, in general, the state, unlike private parties, has coercive powers. In many African countries, it is the colonial governments, then independent governments that have established rules for natural resources management. For example, in Barombi Mbo

Forest Reserve [11] (LBMFR), rules for the management were established by colonial government following Order No.17 of 1940 in accordance with Forestry Ordinance 38 of 1938, published in the supplement to Gazette No.20 of 25 April 1940. From its creation until 1970, the reserve was managed on the basis of its working plan. Then, in accordance with the 1994 Forestry Law, LBMFR become a permanent state forest for protection, where local communities living at the periphery are authorized to apply their user rights for consumption. Although the reality remains dominated by traditional rules governing natural resources management (Heltberg, 2002), nonetheless, formal legislation can transfer the management to local authorities and strengthening informal local institutions in managing them (Bromley, 1991). Since 2013, the management of LBMFR was transferred to Kumba I council who signed a three year provisional convention in 2013 with the Ministry of Forestry and Wildlife that was in charge of managing the reserve until 2012. Although the nature of the property-rights regime under which the resource is held is important, the information is not sufficient to draw valid conclusions concerning behavior and outcomes.

1. Hardin (1968) vs Ostrom (1990)

Hardin (1968) highlighted in his seminal paper, an important issue related to the commons, namely the *"The Tragedy of the Commons"*. Hardin relied upon a thought experiment. Considering the case of a pasture open to all, Hardin asked everyone to imagine what would happen to a metaphorical village common if each herdsman was to add a few animals to his herd. His thought highlighted the divergence between individual and collective rationality. Of course, as rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, *"What is the utility to me of adding one more animal to my herd"*. If each herdsman found it more profitable to graze more animals than the pasture could support, because each took all the profit from an extra animal but bore only a fraction of the cost of overgrazing, the result would be a tragic loss of the resource for the entire community of herdsmen. Thus Hardin concluded that *"freedom in the commons brings ruin to all"* (Hardin, 1968, p. 1244). To avoid the tragedy, Hardin recommended that the commons could be privatized or kept as public property to which rights to entry and use could be allocated. In other words, the open access and unrestricted demand for a finite good in common pool resources inevitably leads to overexploitation, requiring enclosure or privatization of the commons. This parable has had a remarkable impact on both policy debates and academic

[11]Forest reserve was established to protect the lake as well as its fauna and flora. At its creation, the Barombi Mbo and Kumba inhabitants were given the right to fish in lake.

enquiry into natural resource management (German and Keeler, 2010); it has been used in formulating resource management policy for Atlantic Canada fisheries (Feeny et al., 1990). Moreover, while the definition and description of the problem of managing the commons predates Hardin's story by many years, it remains the central story by which the problem has been examined. Furthermore, in an approximate way, Hardin (1968) highlights that the logic of the commons has been understood for a long time, perhaps since the discovery of agriculture or the intervention of private property in real estate. But it is understood mostly only in special cases which are not sufficiently generalized. He referred thus to overgrazing by cattlemen leasing national land to increasingly produces erosion and weed-dominance. Likewise, the oceans of the world continue to suffer from survival of the philosophy of the commons.

The assumption of the inevitability of resource degradation under common property regimes has been extensively critiqued by Elionor Ostrom and colleagues. Feeny et al. (1990)[12] conducting research to test Hardin's hypothesis, highlighted in contrary to Hardin's hypothesis under communal property that it is possible under certain forms of traditional or indigenous common property to manage resource sustainably. Their findings suggest that a surprising number of cases exist in which users have been able to restrict access to the resource and establish rules among themselves for its sustainable use. Overall, they come to conclude that private, state and communal property are all potentially viable resource management options, but that a more complete theory than Hardin should incorporate institutional arrangement and cultural factors to provide for better analysis and prediction.

The Ostrom tradition has clarified how groups of users can create institutions to fulfil a set of functions required for managing resources sustainably including exclusion, allocation among users, and conditions of transfer in situation where individual property rights fail to carry out these functions. By studying a large number of case studies from traditional common property regimes across the world, Ostrom has underlined a set of features common to institutions that have proved effective in ensuring the sustainable management of common property resources. These include *a clearly defined community of resource users; a clearly defined resource; the presence of clearly defined rules clarifying rights, responsibilities and sanction for non-*

[12] They used as their criterion for success, the concept of ecological sustainability with the definition of the World Commission on Environment and Development (WCED) of 1987, that is, whether the resource in question has been used "*without comprising the ability of the future generations to meet their own needs*". As predicted Hardin, Feeny et al. highlighted that under open access regimes, incentives for successful management are absent and weak.

compliance; effective monitoring systems; conflict resolution mechanisms that are cheap and easy to access (Ostrom, 1990). Each of these factors plays an important role in influencing levels of mutual trust as well as expectations of what may be gained through cooperation (German and Keeler, 2010). However, determining what makes collective management possible and effective both in terms of the nature of the resource and the nature of human institutions in watershed management has been highlighted by some authors.

2. Transaction costs and Common pool resources management

Factors contributing to undesirable but widespread natural resource management behaviors include the perceived or real costs associated with shifting to alternative management scenarios and the resulting outcomes in the control and use of resources; and the absence of effective enforcement mechanisms to support existing or new rules and regulations. Economic costs of shifting to more desirable or equitable watershed management may be in the form of transaction costs (Vatn and Bromley 1997; Vatn, 2010) or of economic losses associated with the shift to alternative arrangements (Coase, 1960). The reciprocal nature of "social cost" in the governance of externalities by Ronald Coase (1960) has been adopted as one way of addressing the perceived cost of improved governance in the watershed. Moreover, hybrid institutions that include elements of private property regimes also have the potential to facilitate comprise in the full or partial compensation for parties who may lose from a move to more fair or efficient outcomes (German and Keeler, 2010).

3. Trust and Cooperation in watershed management

The role of trust in facilitating cooperation in watershed management is a central question that spans the interdisciplinary literature on trust and society (Ostrom, 1998). Following Hardin Russell (1990), trust is defined as *"encapsulated self-interest, an account in which the truster's expectations of the trusted's behavior depends on the rational assessments of the trusted's motivations"*. Thus, trust is particularly important in interdependent exchange relationships where the utility of person A depends on the strategic choices of person B. Interdependence social exchange relationships entail risk because there is a probability of receiving a bad outcome if trust is misplaced and trusted individual does not engage in the expected behavior (Willianson, 1996).Trust facilitates exchange by allowing actors to make credible commitments to behave in a certain way, even without the monitoring and enforcement services of an outside agent, trust reduce the transaction costs of cooperation (Kreps, 1990; Lubell, 2000; 2003).

Following Ostrom (1990) and viewing watershed management institutions as governance institutions for solving collective action problems involving the use of common pool resources (CPR), authors such as Lubell (2003) pointed out that without effective governance institutions, watershed resources are overexploited and ecosystems are not maintained, leading to undesirable outcomes for both private and public actors. As a matter of fact, CPR appropriators have a choice between using natural resources at a sustainable level (cooperate), or taking as much as they can, as quickly as possible (defect), which results in a Prisoner's Dilemma game. Unfortunately, because defectors do not experience the social cost of unsustainable behavior, there are always incentives to free ride on the cooperation of others. If all actors defect, they reach the mutually undesirable outcome of overexploitation and possible destruction of the resource system (e.g., fisheries collapse). According to Lubell (2003), effectiveness of watershed management depends on cooperation from all types of involved stakeholders. Because each stakeholder has incentive to free ride on the watershed protection efforts of other actors, cooperation in watersheds captures the essence of a risky social exchange relationship in collective action dilemma. The most prominent national example is the US Environmental Protection Agency's National Estuary Programme (NEP), where Estuaries in the NEP conduct a collaborative planning process resulting in the completion of a nonbinding resource management plan, which requires voluntary cooperation for implementation (Lubell, 2000).

However, the environmental problems associated with agricultural runoff have a similar strategic structure. Farmers use the waste assimilation capacity of groundwater and surface water to absorb the excess nutrients (especially phosphorous and nitrogen) contained in field and pasture runoff. These excess nutrients generally come from animal wastes or fertilizer. Because groundwater and surface water basins are non-excludable, farmers do not experience all the social costs of their agricultural practices. Hence, watersheds often experience elevated nutrient levels that exceed federal or state water quality standards.

Excess nutrients not only harm fish and wildlife, but can also have direct effects on human health. Farmers have a common interest in preventing water quality deterioration, either because their health and economic welfare depends on clean water, or because polluted water often triggers costly regulations from state or federal authorities. Thus, the central question is how to encourage farmers to cooperate by installing best management practices (BMPs) that reduce the volume and nutrient content of agricultural runoff. Unfortunately, cooperation is

not guaranteed because BMP implementation is subject to the logic of collective action. BMP implementation entails increased production costs, which may injure the competitive position of a farm operation if other farms do not implement BMP. Furthermore, BMP implementation by one farmer would not have a large marginal impact because water quality is a function of the combined agricultural practices of all farmers in the basin. Improving water quality requires BMP implementation by most farmers, and each individual farmer has an incentive to free ride on the efforts of others. As with any CPR situation, free riding by all farmers leads to Hardin's (1968) tragic outcome. Hence, efforts to protect watershed could be jeopardized by the complex nature of externalities involved. For instance, the off-site nature of many conservation activities benefits that make internalization of these externalities difficult, thereby preventing the sustainable development of watershed.

2.2.1.3 Externalities Theories and Watershed Management

A way to see how environmental problems results from watershed management is through the framework of "negatives externalities". In making decisions in a market economy, businesses and individuals take private benefits and cost into account. However, where their actions result in cost or benefit to someone whom they cannot charge, they will not consider that externality in their decisions. Thus, negative externalities involve actions by one party that directly harm other parties, but for which the first party pays no cost. *Positive externalities* involve case where the actions of one party directly benefit other parties, but the first party receives no payment. Unless some type of corrective policy is undertaken to "internalize" the externality, too many negative externalities and too few positive externalities will occur in the watershed.

1. Pollution of water resources

In a reverse way, the tragedy of the commons reappears in problems of pollution; not in question of taking something out of the commons, but of putting something in sewage, or chemical, radioactive and heat wastes into water. Indeed, as underlined by Hardin (1968, p.1245), the rational individual finds that his share of the cost of the wastes he discharges into the commons is less than the cost of purifying his wastes before releasing them. However, both surface and groundwater are polluted by different sources of pollution namely point sources and non-point sources including precipitations. *Point sources* are identifiable and can be monitored. They include mining or industrial contamination such as a factory pipe. Mining is the major source of metal contamination, whereas other industries contribute to

acidification (Perman et al., 2003). A *non-point source* is one that cannot be identified accurately and degrades the environment in a diffuse, indirect way over a relatively broad area. Non-point sources are by definition, difficult to identify and thus difficult to control (Perman et al., 2003). Examples are farmland runoffs, landfills, spills, atmospheric deposition. Hence, the intensification of agricultural activities has led to the contamination of groundwater by fertilizers and others chemicals. In the United States, the US Geological Survey of 2001 has detected herbicides in 99% of urban stream samples and 50% of urban groundwater samples (Postel and Thompson, 2005). Lake Barombi in Cameroon also experiences such contamination. Moreover, irrigation projects often cause a rapid rise in the level of groundwater, which leads to waterlogging and soil salinity (Boutry, 2011, p.112; Mendieta, 2005; Perman et al., 2003). Thus, much water pollution derives from its use in industry, agriculture, or for domestic purposes.

Steps have been taken to controlling pollution of complex water resources with respect to either the pollution sources (point source and non-point sources), or end use of water. This latter implies that designated use of waters or "assets" to be protected may include: direct extraction for drinking-water supply, extraction into an impoundment prior for drinking-water supply, irrigation of crops, watering of livestock, bathing and water sports, amenities, fish and other aquatic organisms.

2. Controlling Point Sources

Policy makers and practitioners have long enjoyed a suite of tools for addressing environmental issues affecting water resources: command and control (CAC) or prescriptive regulation, market-based mechanisms (Pigouvian's tax), redefinition of property rights (Coase theorem), and other financial incentives (Salzman and Thompson, 2010).

1) Command and Control Instruments (CAC)

CACs are the oldest forms of pollution control policies in existence. 'Command' sets a standard (e.g. the maximum level of pollution allowable), and 'control' monitors and enforces the standard. Examples include (i) ***Ambient standards***: minimum desired level of air or water quality, or the maximum allowable level of a pollutant; (ii) ***Emission (or effluent or performance) standards:*** maximum level of permitted emissions; (iii) ***Technology-based standards*** that specify the technology, techniques or practices that a firm must adopt. This type of standard could be in the form of 'design standards' or 'engineering standards'; and (iv) ***Other types of standards***: *product standards*, *input standards*. A practical example is the

World Health Organization's Water Quality Standards *(see annex).* Often labeled "prescriptive regulation", CAC directly dictates what individuals and organizations can and cannot do, typically by restricting activities or actions that harm the environment (Salzmann and Thompson, 2010). The major way of controlling point sources (PS) is trough effluent standards (effluent limits). Effluent standards limit the amount of contaminants that may be released into surface waters by PS. Effluent limits vary by the type of polluting source, the age of the facility and sometimes by contaminant released. This control method prohibits direct discharges to surface water without a permit, which permit states precisely what the effluent limits are as well as the requirements for monitoring and reporting (Dales, 1968).

However, although there are different standards for different types of polluting sources such as steel mills, pesticides, and fertilizers, they have been shown to be difficult to define because limits must reflect technological differences across industry groups. *For example, the U.S Clean Water Act sets pollution-discharge standards based largely on available technology*. Moreover, standards are applied uniformly across dischargers within identified industry groups. This prevents cost-effectiveness since effectiveness requires abatement levels be set to achieve equal marginal abatement cost (MAC) levels across all polluters. Another problem highlighted with uniform standards is the lack of incentives for efficient abaters to reduce effluents beyond the legal limits. In fact it has be argued that the structure of the effluent limits acts as a market disincentive to technological innovation. If a discharger were to develop a new technology to remove effluents more efficiency, the limits will be tightened based on the innovative discovery. This response will impose a higher abatement cost on all dischargers including the innovator. Furthermore, penalties for violating standards tend to be too low and enforcement tends to be weak. To set an optimum standard and penalty, the government must know the demand (marginal social benefit) and the supply (marginal social cost) curves for pollution abatement. Since water quality is a non-market good, the demand curve is not directly observable; also, it is difficult for the government to know exactly the industry's marginal abatement (or external) cost curve, given the large number of polluters.

2) Market-Based Instruments

Market-based instruments (MBIs) use price or some other economic variables to provide incentives for economic agents to abate pollution. These include charges (or Pigouvian taxes), subsidies, marketable (tradeable) permits (Dales, 1968). Governments increasingly have sought ways to make CAC more flexible and reduce its costs. "**Cap and trade" systems** or

"**pollution rights**" has been one such approach, in which government sets the overall standards for pollution, then allows private entities to determine how to allocate the limited amount of permitted pollution through market trades (Dales, 1968). Market for water has been created in this case as the carbon market. Based on some success in the use of tradeable permits for PS pollution control for air (most notably SO_2 emissions), U.S and Australia experimented with water quality trading (State of Watershed Payments 2010, Ecosystem Marketplace). In general however, this experience has been limited, perhaps primarily due to the difficulty of marketable permits to operate when there are several pollutants in the area. With several pollutants, it is more difficult to measure aggregate emissions and to monitor compliance. Then, the non-perfectly competitive nature of the market for permits if the number of polluters is small. In this case, the bigger firms may be able to exert some market pressure on permit prices. Moreover, **"Wetlands Mitigation Banking"** or **"Offset Banking"** has been another mechanism commonly used to make regulations more flexible, by allowing people to engage in activities that are harmful to the environment only if they mitigate the injury through some form of compensatory behaviour. *For example, the U.S sometimes allows wetlands to be modified or destroyed if the action is mitigated by restoring, enhancing or creating wetlands elsewhere* (Ruhl and Salzman, 2006).

Charges are based on the ***'Polluter-Pays Principle (PPP)'*** which asserts that the polluter should bear the cost of any abatement taken to maintain an acceptable level of environmental quality (OECD, 1989). According to Pigou (1932), marginal private cost (MPC) diverge from marginal social cost (MSC) (pollutants resulting in uncompensated damage), but that MPCs and MSCs can be aligned by imposing tax on output sourced to pollutant. Unlike standards, which are applied uniformly to all polluters, charges enable firms to adopt a cost-effective solution to pollution abatement, and induce firms to lower their emissions to the point where their MAC = the charge (see figure 2.1 below, where MEC is the marginal external cost). Baumol and Oates (1971) argue that suitable taxes are more efficient to reach environmental standard than quantitative restrictions; compared to standards, there is a stronger incentive for firms to adopt new technology in order to lower the charges they have to pay.

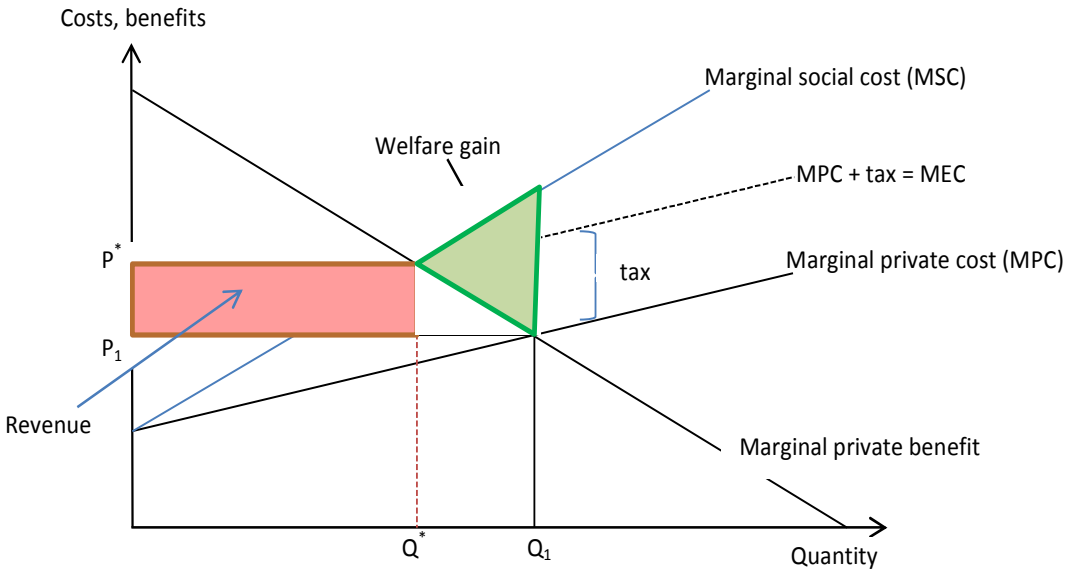


Figure 2. 1: An example of a Pigouvian tax. Adapted from Asafu-Adjaye, 2000

Hence, a factory pipe nearby a stream or a lake could be taxed per unit of emission for its polluting activity or for discharging chemical substance into the surface water that harms neighborhood community or fauna (fish) of the lake or stream. However, under monopoly conditions, the taxed industry has ability to create artificial scarcity and pursue anti-social behaviour, where with output still below socially optimal level, output restrictions could worsen social position. Moreover, firms could pass on a portion of the tax to consumers in the form of higher product prices, and imposing a tax could lead to job losses as firms minimize their costs in order to increase pollution abatement. Furthermore, setting an optimum tax is problematic for the government, due to uncertainty about the demand and supply curves i.e uncertainty about marginal abatement benefit (MAB) and marginal abatement cost (MAC) (Weitzman, 1974).

An alternative to taxes is for the government to subsidize the polluter**. Subsidy** can be a direct repayment of abatement costs (e.g. purchase of pollution abatement equipment or technology) or a fixed payment per unit of emissions reduction. The subsidy may also apply to payment of certain "services", e.g. *"Payment for Environmental Services* (PES*), which has been proposed for sustainable management of tropical humid forests in developing countries"*. In theory, both taxes and subsidies should result in the same optimum level of pollution abatement, but their properties with respect to the number of firms in an industry are different. Differences stem from the fixed subsidy, which lowers the total and average cost to the firm, making it lower under subsidies than under taxes. Consequently, the whole industry tend to

have too many firms and produce too much output. Therefore, in the long run, aggregate pollution could increase under subsidies but decrease under charges. Moreover, subsidizing pollution abatement may be seen as socially 'unjust' because what it effectively does is to redistribute income away from society to polluters. The tendency for subsidies to attract entry of firms could be avoided if the subsidy only covers abatement costs (Asafu-Adjaye, 2000). Though difficult to monitor, the government could also require some benign behaviors in return from firm, as it is the case with farmers under PES in internalizing "positive externalities".

3) Redefinition of Property Rights or Bargaining Solution (Coase, 1960)

Ronald Coase, in his 1960 article *The Problem of Social Cost*, argues that the Pigouvian approach in correcting externalities ignores the "reciprocal nature" of the problem. His main concern is in regards to the presumptive entitlement of the party being harmed. Coase argues that avoiding harm to party B would also inflict harm on party A, and that the real problem is to avoid the more serious harm. In devising and choosing between social arrangements, Coase argues that one should have regard for the *total effect*. Coase is convinced that government is likely to do a poor job of correcting externalities due to limited information about the valuation that heterogeneous individuals place on the resource, and a resulting inability to correctly impose incentive-driven or regulatory solutions. Hence, the ***Coase Theorem*** (Coase, 1960) states that *negotiation or bargaining between two parties involved in an externality will eliminate Pareto-relevant externalities and result in an efficient solution if property rights are well specified. The final allocation does not depend on the initial assignment of property rights and the only effect is the distribution of costs and benefits.*

Considering two parties, a factory which is polluting a nearby river with industrial effluent, and a community which utilizes the river water for drinking purposes, the Coasian solution could be achieved where the property rights to the river is held either by the factory or the community. - ***Coase Theorem with two parties located near a river:*** In figure 2.2 below, the community has a downward-sloping demand curve for pollution abatement. This refers to the marginal benefit (MB) curve because it indicates the consumer's benefits from consuming an additional unit of clean water. The factory has an upward-sloping supply curve for pollution abatement, which curve is also the marginal external cost (MEC) curve. In the absence of legal requirement to abate pollution, the factory has an incentive to supply zero pollution abatement (q=0%) because at that level, the profit is maximized.

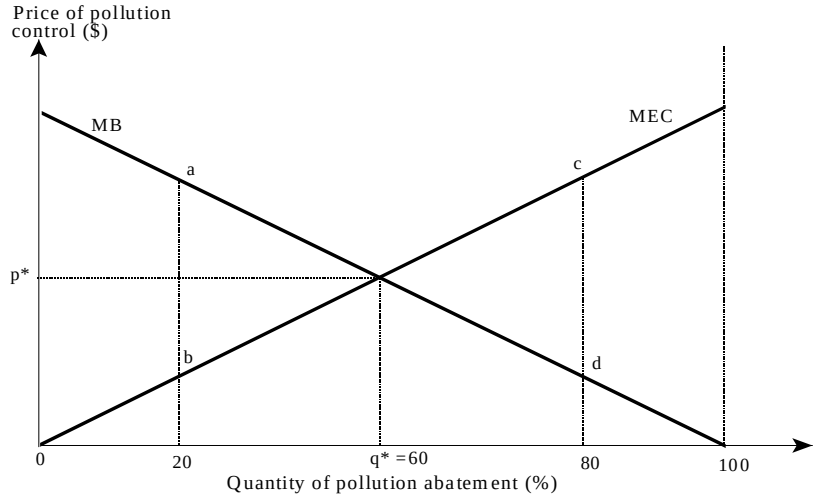


Figure 2. 2: Coasian solution in internalizing industrial effluent polluting a river. Adapted from Asafu-Adjaye, 2000

According to the Coase theorem, the socially optimal level of pollution abatement will be q*=60%. To see this, let us first consider the two cases of property rights to the river.

Case 1: Community has the property rights

The entitlement to the community of the property rights to the river leads to the starting point of q=100%, since the community would like to have zero pollution or 100% pollution abatement (PA). The downward-sloping demand curve for PA implies that at 0% PA, the community's *willingness to pay* (WTP) for PA is initially high. However, as the units of PA increase the community's WTP for PA is lower than the polluter MEC. There is therefore a possibility for trade. At 80% level for example, the maximum amount the polluter is willing to pay to supply an additional unit of pollution is *c*, which is higher than the minimum compensation, *d*, that the community will demand per unit of PA. In this particular case, the factory would be willing to offer compensation of up to *cd* per unit to the community to induce them to accept less PA. The community would be *willing to accept* this amount because even though it suffers a welfare loss from having less PA, this is offset by the *compensation* which exceeds their minimum demand price of *d*. Thus, the move from q=100% to q=80% is a Pareto improvement because at least one party is better off and no one is worse off. The factory could then negotiate less and less PA. But it would not offer a level of PA less than q*=60% because below this level, the minimum compensation demanded by the community exceeds the marginal cost of suppling PA (MEC). Therefore, the factory will choose to supply PA.

Case 2: the factory has the property rights

When the factory has the property rights to the river, the starting point is q=0% because it has the right to pollute. However, there is potential for trade because the community's WTP for PA exceeds the factory's marginal cost of PA. If for example the community wishes to increase pollution abatement to q=20%, it could offer a 'bribe' of *ab* per unit to the factory to induce it to supply more PA. The factory would be willing to accept this amount because it exceeds the MEC at that level. However, the factory has no incentive to provide PA beyond q*=60% because MEC exceeds the maximum unit bribe the community is willing to offer.

From the previous two cases, it can then be seen that, irrespective of who has the property rights, equilibrium is achieved at a quantity of q* and price of p*. The outcome of this market solution is an efficient allocation of resources and the removal of the Pareto-relevant externality. However, *the distribution of costs and benefits in each case is that, when the offending party has the property rights, it is the affected party who makes the payment, and vice versa* (Asafu-Adjaye, 2000). Although the Coasian theorem has been based on some key assumptions including *zero transaction cost, well defined property rights, no free rider* that may not apply in the real world, the merit of Coase theorem is that it recognized the "reciprocal nature" of the externality. Hence, in the context of a real world with positive transaction costs, this theorem has been effectively analyzed and applied under certain conditions in internalizing positive externalities in the watershed, where upstream actions of farmers or fishermen damage economic activities or welfare of downstream users (Kosoy et al., 2007; Pagiola et al., 2002; Vatn, 2010).

3. Controlling Non-Point Sources

Traditional approaches such as CAC and MBIs have been mostly used for point sources. When it comes to NPS, their uses are problematic because NPS are difficult to control due to non-concentrated diffusion, and difficult to monitor because of weather related issues. A uniform national programme cannot address diverse NPS such as agricultural runoff, activities related to land clearance and building construction, as they significantly differ in MACs and marginal damages across each rural/urban area. Nevertheless, governments have made efforts to address NPS by setting standards for specific end used of water including irrigation, livestock watering, recreational use and drinking water. Criteria have been published by FAO as well as a number of countries, which criteria may differ from one countries to another. Water quality criteria for irrigation water generally take into account

amongst other factors, characteristics such as crop tolerance, sodium concentration and phytotoxic trace elements. Criteria for livestock watering usually take into account the type of livestock, the daily water requirements of each species, the chemical added to the feed of the livestock to enhance the growth and to reduce the risk of disease, as well as information on the toxicity of specific substances to the different species. Recreational water quality criteria are used to assess the safety of water to be used for swimming and other water-sport activities. The primary concern is to protect human health by preventing water pollution from faecal material or from contamination by micro-organisms that could cause gastro-intestinal illness, ear, eyes or skin infections. Criteria are usually set for indicators of faecal pollution, such as faecal coliforms, pathogens and viruses that could affect swimmers.

Drinking water criteria are set to assure that water supply systems serving public meet minimum national standards for protection of public health. Its aim is to define, monitor and enforce whatever standards are needed to ensure that tap water is safe for human consumption. The standards for drinking water are generally more stringent than those for other water uses. As with many other uses, targets for drinking water are often set at two levels, namely, the Maximum Contamination Level Goal (MCLG) and the Maximum Contamination Level (MCL). The MCLG defines the level of a pollutant at which no known or expected adverse health effects occur, allowing for an adequate margin of safety. Once the target or MCLG is established, the MCL is set. The MCL gives the maximum contaminant level allowed in the drinking water. It is set as close to the MCLG as feasible, where feasibility is defined through the best available technology (see appendix WHO standards).

2.2.1.4 Top down Approach and Bottom up Approach of watershed management

1. **Top down approach**

Top down approach assumes comprehensive scope and strictly follows a formal process to give priority to the biophysical framework of watershed in the early periods of watershed management programmes (Douglass and Lawrence, 1997). Although called integrated watershed management, the government fixes the target plan and implementes it directly by a contractor or their own staff without consulting the local people (Ohler et al., 2000; Tiwari et al., 2008). Since the early 1970s up to 1980s, this has been the approach to watershed

management in Nepal[13] and India. Nonetheless, although this approach has strengths, it was not very successful for watershed management. Experience has shown that many watershed management projects throughout the world have failed because they have been top-down, fixed or rigid technology solutions geared to replace, instead of complement local conservation practices; with centralized top down conservation effective if large expenditures allocated for enforcement or under autocratic governance (Tiwari et al., 2008). The negative feelings of local people towards an alien effort of management, which community has failed to understand and accept highlights this failure. Examples of such sentiment include acts like arson fires and illegal grazing in forest plantations, lack of maintenance in conservation work and other materials intended for protection of resources (Tiwari et al., 2008). Top-down approach was then ineffective due to neglect of the local knowledge, traditional practices, socioeconomic conditions and available resources (Pretty and Shah, 2000).

2. Bottom up approach

The bottom-up approach involving decentralization of planning and policy formulation has become popular in developing countries over the last two decade. It is built-up on the principle of devolution of power and authority to local communities for management, utilization and conservation of the resources (WRI, 2003). It includes the democratic process of participation of the local people for planning, implementing and decision making for community development at the local level. Bottom-up approach is practical for managing natural resources, however, drawback of the approach includes delay in release of funds from the central government and still target oriented, government focused and decision making employed by local leader. The dangers of decentralization is often to simply empower the local elites and perpetuate existing poverty and inequality (Johnson et al., 2001). In Cameroon, although decentralized process is ongoing, watershed management decision is still planned and implemented by the government accompanied by contractors CAMWATER and CDE. The involvement of local authorities, private operators, and citizens remains very low. The responsibility of municipalities is too low. Yet, they are positioning themselves as main or true development actors at local level.

[13] The approach to resource management in Nepal consisted of top-down planning, implementing and monitoring of activities. Available maps and aerial photos were used to assess land and forest resources. Targets were fixed based on available budgets. Terrace improvement programs were administrated as individual farm activities, and other activities were planned for public land based on project quotas (Ohler et al., 2000).

However, although integrated watershed management is a holistic area-based planning process that extends the government's policy on sustainable natural resources management and development activities, there is confusion as to why watersheds should be considered natural resources conservation and development planning units, and confusion on which level of watershed should be considered as a management planning unit.

3. Level of watershed management as Management Planning Unit (MPU)

Watersheds could be classified into a number of groups depending upon the mode of classification. The common modes of categorization are the size, drainage, shape and land use pattern (see Table 2.1).

Table 2. 1: Category of watershed based on area

Category	**Size Range (ha)**	**Examples in Cameroon (see doc MINEE,2010)**
Water Resource Region	27,000,000-113,000,000	
Basins or sub-catchments	200,000-27,000,000	Lake Chad Basin
Macro Watersheds	9,000-200,000	Sanaga Watershed
Meso Watersheds	1,500-9,000	Sangha Watershed
Micro Watersheds	500-1,500	Lake Barombi Mbo Watershed

Source: author, Adapted from Saharkar et al., 2015

However, distinction is made between a macro watershed, micro watershed and meso watershed (Saharkar et al., 2015). According to Thapa (year not mentioned) *Macro-watershed* is a large area comprising watersheds of several tributaries of a main river. However, considering this level of watershed as a MPU leads to the ineffectiveness of management in addressing the location-specific problems and potentials. As consequence, active public participation is constrained. A *micro-watershed* comprising the catchment of a stream is the most appropriate MPU. Though it requires large investments in necessary institutional arrangements, it addresses the macro-level planning related problems effectively. A *meso-watershed* approach represents the catchment of a tributary. Considering it a MPU would address issues with both macro and micro level watershed management planning problems. Therefore, watershed management as MPU studies the relevant characteristics of watershed and aims at the sustainable distribution of its resources and the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal and human communities within a watershed boundary. Thus, landowners, land use agencies, management experts, environmental specialists, water users and communities all play an integral part in sustaining watershed management.

4. Objectives of Integrated watershed management

Watersheds are sustainably managed to provide a range of ecosystem goods and services including *water supplies for agricultural, industrial and urban-domestic uses; water filtration or purification; flow regulation and flood control; erosion and sedimentation control; fisheries, timber and other forest products; recreation or tourism; habitat for biodiversity preservation; climate stabilization; and cultural, religious, inspirational values and aesthetic enjoyment* (FAO, 1999; Aylward et al.,1995; Postel and Thompson, 2005). Thus, watershed management calls for an interdisciplinary approach and must consider the social, economic, environmental and institutional factors operating inside and outside the watershed. As argued EPAT (1999), watershed management guides and coordinates use of land and water resources in a watershed, which process should provide desired environmental goods and services without adversely affecting resources upstream and downstream. Hence, taking a watershed management approach allows for the explicit accounting of certain environmental benefits and cost associated with agriculture, forestry, water resources and other development projects, and helps identify the linkages between environmental improvement and productivity increases over the long term. Sustainably manage watersheds for sustaining ecosystem as a whole, has been showed to increase ecosystem services and welfare of inhabitants (Ruitenbeek, 1990; FAO, 1999; Yaron, 2001). However, considering the sustainability condition, the meaning of sustainability has been subject of intense debate in economic, and still no consensus is made on which approach of sustainability to consider for management.

2.2.2 Concept of Sustainability

This subsection presents the various concepts related to the sustainability as used in the study. It includes definition and measurement issues among others.

2.2.2.1 Definition of Sustainability: Weak versus Strong Sustainability

Most interpretation of sustainability take as their starting point the consensus reached by the World Commission on Environment and Development (WCED), which in 1987 defined sustainable development as *"development that meets the needs of the present generation without compromising the ability of future generations to meet their own need"*. However, while Pearce et al. (1989), readily interpret sustainable development as *a non-declining human welfare over time, that is, a lower "standing of living" is not "sustainable"*, Pezzey (1989) interprets it as *"per capita welfare should not be declining over time"*. Thus, along

with these two views, Pearce and Barbier (2000) consider the total stock of capital employed by the economic system including natural capital to determine the full range of economic opportunities, and thus well-being, available to both present and future generations. However, surprisingly, it is not simply the aggregate stock of capital in the economy that may matter but also its composition, in particular whether present generations are using up one form of capital to meet the needs of today. By depleting the world's stock of natural wealth irreversibly, the development path chosen today will have detrimental implications for the well-being of future generations. The sustainability debate currently focuses on the ability of the economy to substitute human created infrastructure for the services of the environment, which led to the neoclassical concept called "weak sustainability" and the ecological concept called "strong sustainability" (Gowdy, 2000).

The motivation for weak sustainability (WS) is preserving an economy's capital stock *consisting of human-made (manufactured capital), the services of the environment (natural capital) and the level of technology and training (human capital)*, which produces economic output. WS assumes that these kinds of capital are substitutable for one another, and for proponents of WS such as Hartwick (1977); Weitzman (1976); Solow (1986), there is essentially no inherent difference between natural and other forms of capital, and hence the same compensation rules out to apply to both. As long as the natural capital that is being depleted is replaced with even more valuable physical and human capital, physical and the remaining natural capital is increasing over time. Maintaining and enhancing the total stock of all capital alone is sufficient to attain sustainable development. This reasoning derives from the consideration of the economy as a closed system, where energy is exchange with the surrounding environment but not matter. However, an alternative representation of the economic system is an open system where there is interaction with a distinct environmental system, both the economy and environment being open sub-systems of a larger system namely ecosystem (Figure 2.3).

In contrast then to WS, the motivation for strong sustainability (SS) is recognizing that substitution possibilities among these different kind of capital are very limited. Proponents of SS such as Pearce et al. (1989, 1991); Costanza and Daly (1992); Faucheux and O'Connor (1995); Stern (1997); Dasgupta (2008) and Barbier (2011) argue that physical or human capital cannot substitute for all the environmental resources that comprise natural capital stock, or all of the ecological services performed by nature. Moreover, Hall et al. (1986)

underlines that SS condition violates the Second Law of Thermodynamics, as a minimum quantity of energy is required to transform matter into economically useful products, and energy cannot be produced inside the economy (Georgescu-Roegen, 1971; 1975). According to Common and Perrings (1992), ecological principles concerning the importance of diversity in system resilience imply that minimum quantities of a large number of different capital stocks are required to maintain life-support services. Thus, SS view suggests that environmental resources and ecological goods and services that are essential for human welfare and that cannot be easily substituted by manufactured capital should be protected and not depleted. Thus, the only satisfactory rule for protecting the welfare of future generations is to keep essential natural capital intact, i.e., maintaining or increasing the value of the total capital stock over time, in turn, requires keeping the non-substitutable and essential components of natural capital constant over time. Moreover, for some environmental assets, which Stern (1997) termed "critical capital", there is no question of acceptable trade-off because once eliminated, their effects are irreversible. However, according to Mäler (1995), the critical issue of debate is not whether natural capital is being irreversibly depleted, but whether individuals today can compensate future generations for the current loss of natural capital. This follows Pearce et al. (1989) argument for which, there is a strong case for a precautionary approach in which the bias is toward conserving the natural capital.

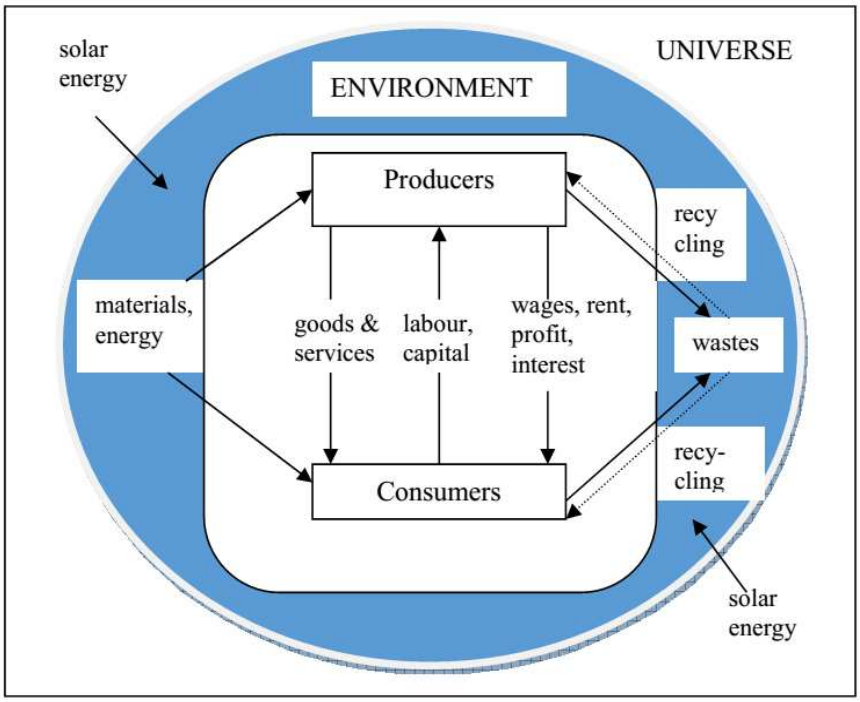


Figure 2.3: An economy-environment system, adapted from Asafu-Adjaye (2000)

2.2.2.2 Measurement of Sustainability

The meaning of sustainability remains uncertain, despite an overwhelming number of efforts to define it. There are broadly acceptable definitions, such as the idea of a triple bottom line used in discussions of sustainability and Business (Elkington, 1999) or the concepts of 'weak' and 'strong' sustainability that emerge in economic analysis. Yet, there is no broad consensus on measures that allow to assess the sustainability of a nation or region (Dietz et al., 2009). Question of how to measure sustainability seems of great policy importance because answering it allow addressing effectiveness of alternative strategies for achieving sustainability in watershed management. Empirical implementation of sustainability tends to focus on the measurement of sustainable income (Hartwick, 1977; Solow, 1989; El Serafy, 1989) or net capital accumulation (Pearce and Atkinson, 1993) rather than on direct estimation of the capital stock. The other major conceptualization of sustainability measurement is "green accounting" where adjustments for externalities are made to national measure of economic activity such as gross domestic product (GDP) or savings rates (Genuine Saving), to reflect the environmental and social concerns not captured in the traditional measures (UN-SEEA, 1993). However, they were limited in their ability to account for transboundary pollutants i.e. how or whether one should account for the polluting effects external to country for which the Eco Domestic Product (EDP) is being computed. In addition, EDP2 could not indicate the effects on human welfare of a deteriorating environment i.e. could not give early warning signal. Thus, Stern (1997) argues that any sustainability indices that attempt to make a first approximation to the reality must take into account population growth and technical change as well as change in human capital. Also, the other major limitation of adjusted national account as a measure of sustainability is that data requirements for calculating estimates are substantial so they may not be available for many nations, region and time periods (Dietz et al., 2009).

Combining these arguments suggests that it may be fruitful to investigate how environmental valuation can be a way to achieve sustainability. However, from a human point of view, what matter about the environment is the ability of capital stock as a whole to be able to continue to perform. Hence, Ekins et al. (2003) defines ***Environmental Sustainability*** as the maintenance of important environmental functions or Services and therefore, the maintenance of the capacity of the capital stock to provide those functions. English Nature (1994) cited in Ekins et al. (2003) considers that "*Environmental sustainability* means maintaining the

environment's natural qualities and characteristics and its capacity to fulfill its full range of functions, including the maintenance of biodiversity. De Groot (1992) has identified nine different types of values of environmental functions grouped under the three dimensions of sustainable development namely: *Ecological* (conservation and existence values); *Social* (human health, personal, community and option values); *Economic* (consumptive, productive and employment values). However, De Groot's four categories of environmental functions relate to very different aspects of the natural capital providing them: ***for regulation functions***, criteria such as maximum carrying capacity, conservation of biodiversity and integrated life support process are involved; ***for habitat functions*** a special dimension is added such as minimum critical ecosystem size; ***for production functions***, the maximum sustainable yield level is an important criterion; ***for information functions***, criteria are more driven by and derived from social science such as perception of valuable landscapes; cultural and historic value. Therefore, criteria for their importance, or criticality, and sustainable use need to be addressed in very different ways, bearing in mind also that each of the criteria need to be interpreted in a way that reflect the essential dynamic nature of ecosystems. Sustainable development thus recognizes that ecosystem services are fragile, and these services are considered to be the cornerstone of this latter. Because nature provides services that are central to human well-being and productive activity, any society that tries to develop at the expense of its natural environment will not be sustainable in the long run (Salzman, 1997 2009; Barton and Thompson, 2012). Hence, although awareness of ecosystem services dates back to Plato, ecologists and economists have begun systematically examining their contribution to social welfare.

2.2.2.3 The New Economics of Ecosystems: From Functions to Services.

During the last three decades, sustainability sciences have witnessed the underpinning of a utilitarian line of argumentation that stresses societal dependence on natural ecosystems, sometimes referred to as ecosystem services sciences.

Between 1960s and 1980s, the concept of ecosystem services introduced in 1981 by Ehrlich and Ehrlich (1981), builds on earlier literature highlighting the societal value of nature's functions. In ecology, the term ecosystem function has traditionally been used to refer to the set of ecosystem processes operating within an ecological system (Hector et al., 2007), irrespective of whether or not such process are useful for humans. However, in the late 1960s and 1970s, a series of contributions started referring to the way particular *functions of nature*

served human societies (King, 1966; Odum and Odum, 1972). In the 1970s and 1980s, a growing number of authors started to frame ecological concerns in economic terms in order to stress societal dependence on natural ecosystems and raise public interest on biodiversity conservation. Schumacher (1973) was probably the first author that used the concept of natural capital and shortly after, several authors including Westman (1977), Ehrlich and Ehrlich (1981) and De Groot (1987) started referring to "ecosystem" or "ecological", or "environmental", or "nature's" services. The rationale behind the use of the ecosystem service concept was mainly pedagogic, and it aimed to demonstrate how the disappearance of biodiversity directly affects ecosystem functions that underpin critical services for human well-being.

The development of ecosystem services as a serious part of the research agenda was stimulated by the Beijer Institute's Biodiversity Program in the early 1990s (Perrings et al., 1992). Research priorities that this program identified were addressed in a number of publications that appeared in next years (Daily, 1992; 1997). The paper by Costanza et al. (1997) on the value of the global natural capital and ecosystem services was a landmark in the mainstreaming of ecosystem services. The monetary figures presented resulted in a high impact in both science and policy making, manifested both in terms of criticism and in the further increase in the development and use of monetary valuation studies.

1. Ecosystem Services into the Policy Agenda

In the late 1990s and the early 2000s, the concept of ecosystem services slowly found its way into the policy ground through the *Ecosystem Approach* adopted by the UNEP-CBD of 2000, and the *Global Biodiversity Assessment* (Heywood and Watson, 1995). The *Millenium Ecosystem Assessment* (MEA, 2003; 2005) constitute a critical milestone that firmly placed the ecosystem services concept in the policy agenda. Since the MEA, the literature on ecosystem services and international projects working with the concept have multiplied (Fisher et al., 2009). In the last few years, several initiatives have framed global environmental problems in economic terms and conducted global cost-benefits analysis. Some relevant examples are the *Stern Review on the Economics of Climate Change* (Stern, 2006), the *Postdam Initiative Biological Diversity 2010* and the *Conference of Parties (COP21)* of the UNFCCC. The project *Economics of Ecosystems and Biodiversity* (TEEB, 2008), stemming from this initiative, aims to estimate the costs of ecosystem services decline from inaction to halt global biological diversity loss. Nevertheless, while emphasizing an

anthropocentric approach, the MEA framework stressed human dependency not only on ecosystem services, but also on the underlying ecosystem functioning, contributing to make visible the role of biodiversity and ecological processes in human well-being. Table 2.2 below summarizes MEA conclusions about the status of twenty-four different ecosystem goods and services, as well as their trend-lines (increasing ▲, decreasing ▼, or stable +/-) (Millennium Ecosystem Assessment 2005).

Table 2. 2: The state of ecosystem services (Millennium Ecosystem Assessment 2005)

Service	Sub-category	Status	Notes
Provisioning services			
Food	Crops	▲	Substantial production increase
	Livestock	▲	Substantial production increase
	Capture fisheries	▼	Declining production due to overharvest
	Aquaculture	▲	Substantial production increase
	Wild foods	▼	Declining production
Fiber	Timber	+/-	Forest loss in some regions, growth in others
	Cotton, hemp, silk	+/-	Declining production of some fibers, growth in others
	Wood fuel	▼	Declining production
Genetic resources		▼	Loss through extinction and crop genetic resource loss
Biochemicals, natural medicines, pharmaceuticals		▼	Lost through extinction, overharvest
Fresh water		▼	Unsustainable use for drinking, industry, and irrigation; Amount of hydro energy unchanged, but dams increase Ability to use that energy
Regulatory services			
Air quality regulation	Global, regional, local	▼	Decline in ability of atmosphere to cleanse itself
Climate regulation	Global	▲	Net source of carbon sequestration since mid-century
	Regional and local	▼	Preponderance of negative impacts
Water regulation		+/-	Varies depending on ecosystem change and location
Erosion regulation		▼	Increased soil degradation
Water purification and waste treatment		▼	Declining water quality
Disease regulation		+/-	Varies depending on ecosystem change
Pest regulation		▼	Natural control degraded through pesticide use
Pollination		▼[a]	Apparent global decline in abundance of pollinators
Natural hazard regulation		▼	Loss of natural buffers (wetlands, mangroves)
Cultural services			
Spiritual and religious values		▼	Rapid decline in sacred groves and species
Aesthetic values		▼	Decline in quantity and quality of natural lands
Recreation and ecotourism		+/-	More areas accessible but many degraded

2. Cause of the Degradation of Ecosystem Services in the watershed

Given the obvious importance of ecosystem services to human well-being, one might assume that ecosystem services would be prized by markets and explicitly protected by the law. Despite their economic value and central role in provision of important public benefits, however, ecosystem services are only rarely considered or protected by the law (Salzman, 1997; 2009). Nor, in the past, have significant markets arisen that capitalize on the commercial value of these services. The main reason for this relative neglect according to Salzman (1997; 2009) and Tietenberg, (2006) is threefold: ignorance, institutions and markets failure.

Ignorance: Perhaps the most basic reason why we do not pay more attention to the provision of ecosystem services is that they are taken for granted. We are ignorant of the sources of goods and services we depend on and take them for granted. Most environmental laws around the globe were not designed with ecosystem services in mind, and legal protection of ecosystems and the services they provide simply were not primary objectives when the relevant laws were drafted. Generally speaking, laws addressing air pollution and water pollution rely primarily on technological or human health-based standards. Conservation laws protecting endangered species are species-specific; and planning under resource management laws are written to accommodate multiple and conflicting uses. Because these laws were not primarily intended to provide legal standards for conservation of natural capital and the services that flow from it and, as many authors have pointed out, in practice they usually do not (Salzman, 1997; 2009).

Institutional failures: A second obstacle to the protection of services is institutional. Political jurisdictions are rarely aligned with ecologically significant areas such as watersheds; instead, they exercise authority over areas defined by state, provincial, or municipal borders. Not surprisingly, environmental problems do not track political boundaries and it is difficult for multiple political actors to agree on the same course of action. More challenging, the costs and benefits of conserving ecosystem services may be separated across jurisdictions. Thus, for example, upstream and downstream jurisdictions will have very different views about the value of upstream forest conservation when it comes to water quality. As a result, consistent efforts to manage landscapes that ensure service provision are easily confounded by collective action problems (free rider problem). Seeking to overcome this obstacle, New Zealand and a number of Australian states in the last decade have created

catchment management bodies that exercise land use planning authority throughout an entire watershed, but these remain a rare exception (Salzman and Ruhl, 2001).

Market failures: The last reason services are difficult to protect according to Salzman (1997; 2009) lies in market failures. While some services are clearly valuable to social welfare, they may have little or even no market value. We have no shortage of markets, for example, for many ecosystem goods (such as timber or fish). People pay money for fruits every day at the grocery store without a second's thought. But the ecosystem services underpinning these goods (such as renewal of soil fertility and pollination) are free. This does not mean that they have no value. Rather, the services have no market value for the simple reason that no markets exist in which they can be bought or sold. As a result, there are no direct price mechanisms to signal the scarcity or degradation until they fail (at which point their nonmarket value becomes obvious because of the costs to restore or replace them) (Heal *et al*., 2001). Indeed, many ecosystem services may be described as "public goods", that is non-rival (consumption of the good by one does not reduce the amount left for others) and non-excludable (individuals cannot be excluded from consuming the good). Unlike fruits that can be bought and consumed by one person, all those who live in a country with secure borders and low crime rates benefit from these public goods, whether they pay taxes or not. Similarly, those who live downstream from watersheds benefit from the role watershed services play in slowing floodwaters, whether they paid to conserve the watersheds or not. Therefore, the public or quasi-public good feature of watershed services implies that it is difficult, if not impossible, to exclude an individual from using watershed services such as drought control, and several individuals can use the services simultaneous without diminishing each other's use values. Their externality feature means that the effect on economic profit and utility of users of these services (e.g. soil conservation) will not necessarily enter the decision calculus of the supplier of the services. Typically, these services are characterized by economies of scale in production and consumption, and by transaction costs in the form of incomplete information about the nature and magnitude of their value (Pattanayak, 2004).

Population Growth: Besides the main reasons of ecosystem services degradation highlighted by Salzman et al. (1997; 2009), it is generally believed that the need to feed and clothe a rapidly growing population is the major cause of ecosystem services and environmental degradation. Although concern for the environment has heightened within the

last three decades, the debate over population growth and the environment has raged over the past two centuries[ii] (Malthus, 1798; Ricardo, 1820; Mills, 1857 all cited in Gomez-Baggethun et al., 2009). According to Hardin (1968), *the cause of the tragedy of the commons is the freedom to breed without any sort of control, and as a finite world can support only a finite population, "population growth must eventually equal zero"*…… and he further states "*the most rapidly growing population on earth today are (in general) the most miserable"*. Obviously it is the argument of Paul Ehrlich in his book, *The Population Bomb*, which states "*population is not merely an important problem but is the problem in ensuring the long term survival of the human race"* (Ehrlich, 1970). However, one simple fact proves that there is no prosperous population in the world today that has, and has had for sometimes, a growth rate of zero. Thus, population growth increases the demand for goods and services which, in turn, puts additional pressure on environmental resources. The more people there are, the greater is the amount of waste production, and the implications for the environment's assimilative capacity.

Poverty: Population growth, poverty and ecosystem services degradation are closely interrelated. Increasing population leads to more intensive use of land, shorter fallow periods and lower soil productivity. It also leads to more clearing of forest cover and hillsides. The net results of these effects is that there is increased ecosystem services degradation (e.g., soil erosion, landslides, etc), reduced soil productivity, and hence, lower yields. This results in fall in per capita income and an increase in poverty. The poverty creates a vicious cycle in that it leads to further land degradation as the poor desperately try to draw out a living on the marginal land. However, to borrow Simon (1981) proposition[iii], population growth may have a positive feedback: farmers may be encouraged to adopt technological innovations in agriculture (e.g Green Revolution). However, the positive effects are likely to be offset by the negative effects, resulting in a net negative effect (Asafu-Adjaye, 2000, p225). Furthermore, rapid population growth in many developing countries has often resulted in conflicts involving indigenous communities and state-managed natural resources such as mineral resources, national parks, etc. Gradually, some indigenous communities are being pushed from their traditional hunting, fishing and farming areas due to expanding resource exploitation or conversion to other uses. With regard to protected areas, suggestions have been made that, for example, some national parks could be made available for low-intensity use by local communities to alleviate resource use pressure and reduce the potential for

conflict. This is based on the idea that there can be harmonious co-existence between, say, wildlife and livestock so that opening up national parks will not be harmful to wildlife. But, Prins (1992) views that such a harmonious existence is not possible[14]. His solution is that *Rich Western Nations should make "in absentia" payments that can be used to develop programmes to: limit population growth; provide alternative income for the rural poor; and encourage settle of people outside the protected areas.*

3. From Ecosystem Services to Environmental Services

While benefiting from ecosystem services, human activities therefore could provide environmental services with the support of ecosystems. However, these benefits are uncompensated, and they are, in economic terms, "positive externalities" provided by the landowner. Because landowners generally are not paid for the services their land provides others, it should come as no surprise that they see few incentives to conserve or enhance the services they provide, nor are there obvious reasons they should take service provision into account when making land use decisions. This might not be critically important if most lands providing services were public property that could be set aside for conservation, but they are not. Private lands, including many lands used for agricultural production, are vital not only for biodiversity conservation but also for provision of many other services (Farrier 1995). As a final point, it is worth noting that ignorance and public goods, the barriers to market creation, are related. Markets create knowledge. We have a very advanced understanding of how to manage farmland to maximize production of cash crops for the simple reason that they are cash crops. It pays to manage land efficiently for crop production. We have a much poorer understanding of how to manage land for ecosystem service provision, not because services have no value but because land owners cannot capture the value of the services their landscape provides. Agricultural markets provide very clear signals to farmers of the value of clearing watersheds or wetlands to grow more crops; but there are no markets for biodiversity, water quality, or flood control to reflect the loss in benefits once the land is cleared. Nevertheless, the recognition that the preservation of forested lands will generate valuable environmental services leads a growing number of national and local governments to set up programmes that pay landowners to protect and manage lands; this is the case of payments for environmental services (Jack et al., 2008).

[14] Example given is that even if the Serengeti National Park is handed over to the Masai, it can only absorb the growth of the Masai population for only about 40 years.

2.3 Payments for Environmental Services: A Promising Tool for Watershed Management

Payment for Environmental Services (PES) has attracted increasing interest as a mechanism to translate external, non-market values of the environment into real financial incentives for local actors to provide such services (Engel et al., 2008). Examples include national-scale PES programmes in Costa Rica and Mexico (Pagiola et al., 2002; Mayrand and Paquin, 2004), Agri-Environmental schemes in Europe and USA (Dupraz et al., 2003; Dobbs and Pretty, 2008), Conservation Concessions and Easements (Hardner and Rice, 2002), and Forest-carbon Plantations (Smith and Scherr, 2002).

2.3.1 Concept of Payment for Environmental Services (PES)

The "Payment for Environmental Services" (PES) is part of economic instruments based on market mechanisms in the context of pollution prevention and ecosystem conservation. These are new approaches that promote "positive environmental externalities" through the transfer of financial resources among the beneficiaries of Environmental Services (ES) and their suppliers or managers of environmental resources. The PES is based on the "***Beneficiary Pays Principle"*** (Pagiola, 2005; Legrand, 2013). In PES systems, the beneficiaries of ES pay ecosystem managers in exchange for adopting some practices necessary to provide these services. Usually close to ecosystems or wetland habitats and watersheds, these ecosystem managers are rewarded for maintaining healthy ecosystems through good land or water management practices that enhance ecosystem service flows especially those that produce positive externalities (environmental services). Though in theory, encouraging positive externalities of production or consumption for private goods leads to small quantity produced compared to what is socially optimal, this is not the case in ecosystems management, where many side effects exist. Considering the case of forest being converted to pastures for cattle ranching in watershed helps understand this logic. While forests provide an important range of ES to society, it may be more profitable for owners to convert their forest into pastures; however, this may not be best from a social point of view. Thus, ES beneficiaries may decide to pay for these services in order to make forest conservation a more profitable option for forest owners, which increase water quality, carbon stock and protect wildlife habitat (Figure 2.4).

Definition of PES: A wide range of PES approaches and, not surprisingly, a variety of terms that describe them have been used, including "*Market mechanisms for environmental services*" (Landell-Mills and Porras 2002) "*Compensations for Environmental Services* (Rosa et al., 2003*), Rewards for Environmental Services* (PRESA, 2009, 2011), *Agri-environmental payments* (OECD, 2009); and *International Payments for Environmental Services* (UNEP et al., 2006). However, PES remains the most widely used and recognized term. Wunder (2005) defines PES as *"a voluntary transaction in which a well-defined ES (or land use likely to secure this service) is being 'bought' by at least one ES buyer from at least one ES provider if, and only if, the ES provider secures ES provision during a specified period of time (conditionality)"*.

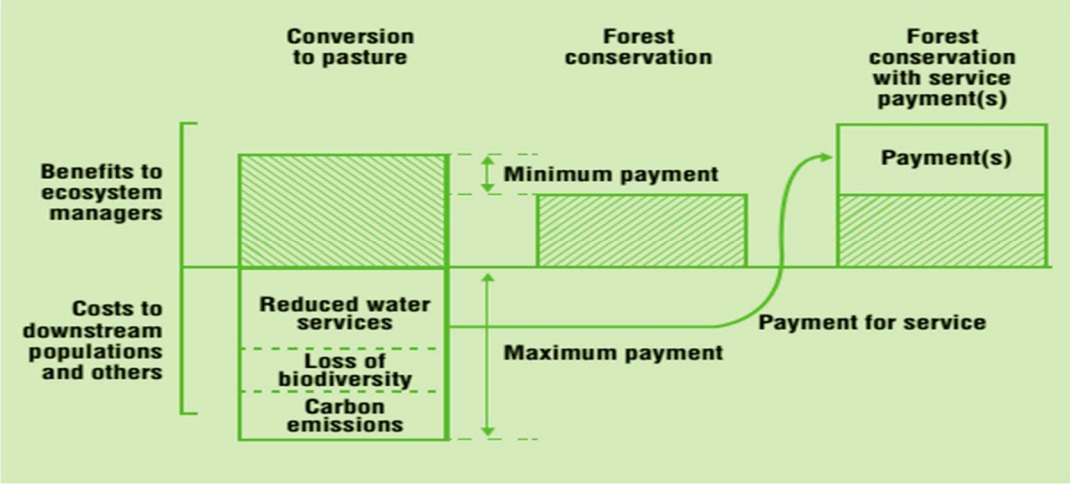


Figure 2. 4: The logic of PES in watershed. Adapted from Engel et al., 2008

However, Wunder[15] (2007) recognizes that most of PES schemes do not fit within this definition. The services that PES deal with are often environmental public goods (both local and global). Their provision entails a collective action problem insofar as it requires the coordination of various actors to avoid undesirable outcomes from a social point of view. The main goal of PES ought to be the creation of incentives for the provision of such goods, thereby changing individual or collective behavior that otherwise would lead to excessive deterioration of ecosystems and natural resources. Therefore, Muradian et al. (2010) propose a larger definition of PES as *"a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources"*. Such transfers (monetary or non-monetary)

[15] Wunder (2007, pp.50) points out that 'many initiatives were either loosely monitored or not monitored at all, payments were up front instead of continuous, and payments were made in good faith rather than being truly contingent on service provision'.

are embedded in social relations, values and perceptions, which are decisive in conditioning PES design and outcomes. The transfers may thus take place through a market (or something close to one), as well as through other mechanisms like incentives or public subsidies defined by regulatory means. Herbert et al. (2010) identified a set of PES systems including *public payment schemes for private land owners, formal market with open trading between buyers and sellers, self-organized private deals, tax incentives, and certification programmes (see Table 2.3).*

Table 2. 3: Systems of PES

Public payment schemes for private land owners to maintain or enhance ecosystem services	These types of PES agreements are country-specific, where governments have established focused programmes. They commonly involve a government agency, or another public institution providing direct payments to rural landowners to steward their land in ways that will generate environmental services. Payments may be standardized or negotiated individually. This form of PES is the most common. The Conservation Reserve Program in the United States, for instance, paid out over US$1.7 billion to farmers in 2008 in exchange for their protection of endangered wildlife habitat, open space and/or wetlands *(Conservation reserve Program, Summary and Enrollment Statistics) (also see Green Payments and American Agriculture).* China has a similar multi-billion dollar program in place to fund erosion control (*see Grain for Green*), while Mexico and South Africa target their payments toward stewards of watershed services (*see Mexico Forest Fund; Ecosystem Farming the precursor of markets in South Africa?; Betting On Markets*)
Formal markets with open trading between buyers and sellers, either: (1) under a regulatory cap or floor on the level of ES to be provided**, or** **(2) voluntarily**	**Regulatory ecosystem service markets** are established through legislation that creates demand for a particular ecosystem service by setting a 'cap' on the damage to, or investment focused on, an ecosystem service. The users of the service, or at least the people who are responsible for diminishing that service, respond either by complying directly or by trading with others who are able to meet the regulation at lower cost. Buyers are defined by the legislation, but are usually private-sector companies or other institutions. Sellers may also be companies or other entities that the legislation allows to be sellers and who are going beyond regulatory requirements. One example of this is the *European Union Emissions Trading Scheme* under which large emitters of carbon dioxide (a greenhouse gas) within the European Union must be under a specific level carbon dioxide emission per year **Voluntary markets** also exist and primarily serve companies or organizations seeking to reduce their carbon footprints to enhance their brands, anticipate emerging regulation, or in response to stakeholder or shareholder pressure, or other motivations. Voluntary exchanges are also a category of private payments. (e.g., *Hitting the Target in New South Wales; Sustainable Fisheries: Can Market Mechanisms Help Get Us There?; Natsource Creates Carbon Credit Pool; Hunter River Salinity Trading Scheme; Profile of a Company and an Industry; Emissions Trading is Not the Mother of Invention*).
Self-organized private deals in which individual beneficiaries of ES	**Voluntary markets**, as outlined above, are a category of private PES. *(see Voluntary Carbon Market - Climate Wedge ; A Drive to Offset Emissions*) Other **private PES** deals also exist in contexts where there

contract directly with providers of those services	are no formal regulatory markets (or none are anticipated in the near term) and where there is little (if any) government involvement. In these instances, buyers of ES may be private companies or conservationists who pay landowners to change management practices in order to improve the quality of the services on which the buyer wishes to maintain or is dependent. The motivations for engaging in these transactions can be as diverse as the buyers. This will be explored further in next sections.
Tax Incentives: Tax incentives are a form of indirect government compensation for landowners protecting ecosystem services.	In exchange for committing resources to stewarding ecosystem services, individuals receive tax breaks from the government. Tax incentives are used, for instance, to encourage landowners in the United States to put their land under conservation easements (*see Spotlight on Conservation Easements*).
Certification Programs: Certification programs designed to reward producers who protect ecosystem services have been developed for a variety of products, including wood, paper, coffee and food, among others	When consumers buy certified products, they are paying not just for the product itself, but also for the manner in which it was produced and brought to market. Since such production and transport means are often expensive, price premiums associated with certified products can be considerable. When consumers choose to pay the price-premiums associated with products that have been labeled as ecologically friendly, they are choosing, in a sense, to pay for the protection of ecosystem services. (*See Pesticide Free but Pricey and Transforming Markets & Supply Chains; the Forest Stewardship Council (FSC)*).
Persuasion or moral suasion (education fees)	Relies on an information approach, educating landholders of the consequences of their management practices on the landscape and informing them of alternate approaches. This is a common approach in many countries in the agricultural sector, where extension services including NGOs provide counseling and technical support to farmers. The goal of this approach being self-regulation.

Source, Author, adapted from Herbert et al. (2010).

2.3.1.1 PES and other Policy Instruments: Choosing "Payments" or a "Combination"?

Governments traditionally have not relied strongly on payments to ensure environmental protection. When choosing which instrument to use in changing the behavior of landholders, the government could choose from a toolkit of strategies (Baumol and Oates, 1988; Salzman and Thompson, 2007). Moreover, Environmental Economic theory tells us that a right policy instrument should be considered *economically efficiency* (it does not impose cost on the society, or there is no loss for the society), *effective or dependable* (it achieves the target), *adaptable or flexible* (it can be changed when circumstances require), *equitable or fair* (it treats people equally or regards its impacts on wealth and income distribution), and *politically acceptable*. In addition, although the academic discussion of PES and other instruments is often framed of "either-or", the discipline also tells us that in a second best world where several sources of market failure coexist, a combination of instruments is needed. Thus Landell-Mills and Porras (2002, p.2) in the case of forest sector have put it: "*the key question*

is, thus, not whether we should promote markets instead of government intervention, but what is the optimal combination of market, hierarchical and cooperative systems for governing forest sector utilization and management". Moreover, Engel et al. (2008) argued that the more policy relevant question concerns how different instruments should be combined to achieve conservation objectives. According to Pagiola and Platais (2007), World Bank-supported projects that apply the PES approach have moved away from standalone PES projects to projects that implement PES as part of broader policy approaches. Hence, PES has then received a great deal of attention as a promising approach to natural resources management (FAO, 2007; TEEB, 2010). Regulatory policies have often appeared to be disconnected from local contexts and difficult to apply (Laurans et al., 2011). This was particularly true in Costa Rica in the mid-1990s when the national PES programme was elaborated (Legrand, 2013). In line with this, Pagiola et al. (2005) and Grieg-Gran et al. (2006) underlined that, whereas the CAC approach to conservation deprived people from their property or user rights, PES starts by recognizing these property rights. Thus, it appears more respectful of local communities' interests and more able to provide them with economic and social benefits, in a context of sustainable development. PES therefore complements rather than substitutes existing tools for environmental conservation (Ferraro, 2011), including regulatory (law, norm), economic (tax, subsidy).

The use of these contractual arrangements and/or these beneficiaries-pay concept have proved appealing at the global level in fostering conservation efficiency, poverty reduction and sustainable finance for conservation. As argued by Pattanayak et al. (2010), many of the services supplied by nature are externalities, and if the poor own resources that give them a comparative advantage in the supply of ES, then PES can improve environmental and poverty outcomes. These opportunities associated with PES also seems valid in the African context, where PES seems to have the potential to increase conservation efficiency and poverty reduction (AfDB, 2015). Even though in developing countries institutions are weak, Barbier and Tesfaw (2013) show that landowners with customary tenure in Africa can be efficient providers of carbon forestry if tree planting helps secure their permanent claims to the land. Indeed, if farmer's tree planting can reduce the threat of eviction, the amount of land allocated to carbon forestry may be greater or lesser than under private ownership, but it is always more than if tenure security is completely absent. Their results support the view that carbon forestry schemes should accommodate traditional African customary tenure systems, and if designed successfully, can both promote carbon forestry and benefit the poor. Moreover, critics of

ICDP have point out their relative inefficiency and incapacity to limit land-use changes deriving from their indirect character and the underlying assumptions of conservation and development as natural converging goals. They have proposed direct payments for conservation as a more cost-effective approach (Ferraro and Kiss, 2002; Ferraro and Simpson, 2002; Karsenty, 2011).

PES is also viewed as a promising tool for mobilizing new sources of sustainable funding for conservation in Africa (R-PP, 2012). It could not only attract international resources, but also help countries mobilize domestic financial support to biodiversity conservation in accordance with their commitments under the Conservation of Biological Diversity or the RAMSAR Convention (AfDB, 2015; Ajonina et al., 2014). This also especially includes the private sector, which is taking an increasing share of conservation finance in some countries across the world. Business that rely on a regular flow of ES, such as hydroelectric plants or water infrastructure, may provide new sources of finance through PES to secure these services. Besides, businesses dependent on agricultural or other land-based supply chain may also use PES to enhance the sustainability of their supply chains in order to mitigate the risks associated with decreasing flow of ecosystem services and gain competitive advantages[16].

Although PES as economic incentives could thus appear as a pragmatic alternative, especially in Africa where environmental law enforcement is very problematic, it will be important to ensure that PES do not undermine intrinsic motivation to conserve and law compliance by dispersing utilitarian attitude and making people reluctant to comply with regulations in the absence of any financial compensation.

2.3.1.2 Characteristics of PES

PES programmes differ with respect to various design characteristics. Some reflect differences in the specific ES they are trying to generate or in the social, economic, or political context in which they operate, while others are deliberate design choices. While Wunder (2005) distinguished typology of PES by three criteria: *areas or products, funding*

[16] A cocoa or coffee company for instance, may incentivize small producers to plant trees on their agricultural lands in order to mitigate the risk of lower production (in case of water scarcity for example), develop ecosystem-friendly products and eventually get carbon credits as well. AfDB is in the process of financing a forest plantation project with carbon sequestration certification in Mozambique, as an effective approach to building climate resilience (the pilot program for Climate Resilience of the Climate Investment Funds (CIF)).

sources, and level of activity, the typology from Laurans et al. (2011) is based on the *modalities for financing* the PES schemes.

1. **Criteria in distinguishing the typology of PES**

PES based on areas or products: a PES can focus on the management of a specific land area or rely on the sale of products certified as environmentally friendly. Corporations may be motivated by indirect market concerns. Pressure from environmentally-conscious consumers, for example, may cause a company to source its products or raw materials from supplies that have been certified as sustainably harvested. They may pay for service provision because of pressure from shareholders or consumers demanding improved corporate social responsibility. In both cases, the company seeks to improve its image. This include the international Organization for Standardization (ISO) norms ISO 14000 (environmental management), ISO 9000 (quality management), that are voluntary guidelines that include "zero discharge of pollutants", "adoption of pollution abatement technology", "submission of mitigation plans", and ISO 26000 which provides information and decision-making tools for businesses to identify ways they can improve their impacts on people and places they work and live in, and thereby become more valuable and valued members of society (Henriques, 2011). A green premium paid by consumer is then considered as PES according to Wunder (2005).

PES based on specific ES: Looking at the PES systems operating around the world, payments gather around four broad types of ES:

Watershed protection. This includes the ecosystem services of water purification, enhancing/ensuring water quality and quantity, flood control, erosion control, and others. In general, downstream beneficiaries pay upstream land owners either for adopting particular land uses or maintaining current land uses. Payments for water services benefit from the advantages that it is relatively easy to identify both the providers and the users of these services and, equally important, the users are generally discrete private operations such as hydroelectric facilities and industrial users or institutions that represent groups of users such as municipal water authorities (who act on behalf of the public) or irrigation districts (who act on behalf of the irrigation farmers). All of these parties have an obvious and direct interest in service provision. Moreover, the beneficiaries, particularly water users, are used to paying for water, already.

Water services are the most common PES scheme around the globe (Landell-Mills and Porras 2002). The most cited successful case is that of Nestlé group in France that has compensated since the late 1980s farmers for the opportunity cost of abandoning practices that could pollute the source of its Vittel mineral water (URS, 2013). In Latin America, mostly in countries such as Costa Rica and Mexico, Payment for watershed services (PWS) have emerged from national policy programmes where State-based public institutions reward resource managers in exchange for a single or a bundle of ES. In Mexico, the Payment for Hydrological Environmental Services (PHES) programme was founded in 2003 to pay for upstream forest conservation that would protect water services using revenue from downstream water charges (Kerr et al., 2005). In Equator, the "Socio Bosque" national programme constitutes an investment in PES. Globally, there are a number of initiatives for payment for watershed protection around the world and the value of their transactions was estimated at USD 8-10 billion in 2011 and the figure is still growing fast (Rodríguez de Francisco and Boelens, 2014; Benett et al., 2013). Although watershed protection is a specific ES, it is important to note that many positive side effects exist in protecting watersheds. Through sustainable land-uses, watershed protection enhances the local carbon stock through carbon sequestration, wildlife habitat and landscape aesthetics. Therefore, paying for watershed protection is to pay for a bundle of services.

Carbon sequestration. Depending on how the climate negotiations conclude, the sequestration of carbon by reforestation, afforestation, and land use may end up dominating all the other PES schemes combined in terms of total value. The classic example of such a PES scheme is a large emitter of carbon dioxide in a country that regulates greenhouse gas emissions paying a land owner to plant additional trees (Annex: figure on carbon sequestration by tree). In exchange for the additional carbon now sequestered, the company obtains credits it can use to offset its greenhouse gas emissions. In contrast to watershed services, it can operate at the regional, national or global scale, though the trend seems to be increasingly toward national and global markets (Ecosystem Marketplace, 2015; 2016).

Biodiversity conservation. Because biodiversity is such a classic public good, the PES here are smaller and more discrete. While there are isolated examples of species habitat banks, biodiversity payments can take a wide range of forms, including purchase of conservation easements, payment for bio-prospecting rights or research permits, hunting and fishing

licenses with Safari Companies, and management contracts to conserve and restore habitat. Not surprisingly, most of these payments operate at the local or perhaps regional level.

Landscape beauty. The most obvious example of this is eco-tourism, where tourism operators pay a local land owner or community not to hunt in certain areas or to engage in particular land management activities. Examples include community hunting zones (ZICGC) in Cameroon. This approach has run into criticism that few meaningful payments from eco-tourism actually end up in the hands of locals. Nonetheless, as development pressures increase, the value of natural and beautiful places will increase, as well, raising at least the potential for greater revenue flows toward eco-tourism.

PES based on funding sources: A critical issue of PES concerns with ***"Who the Buyers of the ES are"***. In particular, there is an important distinction between cases in which the buyers are the actual users of the ES, and the cases in which the buyers are others (typically the government, an NGO, or an international agency) acting on behalf of the users of the ES. Hence, PES funding can comes from a public or private source. Engel et al. (2008) distinguish PES in terms of "*government-financed*" or "*user-financed*" schemes.

In a **"user-financed" PES**, the buyers are the actual users of the ES. For instance, a hydroelectricity power producer that pays upstream land users to conserve the watershed above its plant. Pagiola and Platais (2007) referred to kind of PES scheme as "Coasian" and argued that the scheme is particularly likely to be efficient, as the actors with the most information about the value of the service are directly involved, have a clear incentive to ensure that the mechanism functioning well, can observe directly whether the service is being delivered, and have the ability to re-negotiate (or terminate) the agreement if needed. Thus, user-financed PES are often implemented in situation with local monopsonies or oligopsonies. However, as the number of ES buyers increases, transaction costs and incentives for free riding increase as well. Moreover, when the ES are public goods, such as biodiversity or a bundle of ES, then it is often difficult to identify and delimit the users, and non-excludability implies that users have strong incentives to free ride. Hence, when appropriate conditions for user-financed PES to emerge do not hold, government involvement may be the only way that PES can be implemented. Government can overcome the free-riding problem by charging compulsory user fees. Furthermore, government, NGOs, or international organizations can take an important role in facilitating a Coasian outcome by reducing transaction costs. This

has been the case of Costa Rica PSA[17] programme that provides a forum for voluntary contributors to channel their contribution through an already existing administrative structure (Engel et al., 2008).

In **"government-financed" PES**, the buyers are a third party acting on behalf of service users. This is typically a government agency, but could also be an international financial institution or conservation in the case of global externalities. For example, the Global Environment Facility (GEF), the UNEP, and the Forest Carbon Partnerships Facility (CFPF) of the World Bank were established by the international community to preserve global benefits such as biodiversity and carbon sequestration, and their financing for PES programmes that protect global ES are considered a payment by the users' representative. However, as the buyers in this case are not the direct user of the ES, they have no first-hand information on its value, and generally cannot observe directly whether it is being provided. They also do not have a direct incentive to ensure that the programme is working efficiently, on the contrary, they are often likely to be subject to variety of political pressures (Engel et al., 2008; Ferraro, 2008). Because of these factors, Pagiola and Platais (2007) argue that such programmes are less likely to be efficient.

Nevertheless, such programmes may be more cost-effective than user-financed ones because of economies of scale in transaction costs or funding modalities. Indeed, in some cases, governments finance PES through compulsory fees charged to service users rather than from general revenue. As a matter of fact, Laurans et al. (2011) identified PES funded by a voluntary grants, a fee or tax to consumers of that particular ES, or through the national budget. Considering the case of the Mexico's programme of payment for hydrological environmental services (PHES) that aims to preserve water supplies funded from a portion of the revenue generated from water use fees, Engel et al. (2008) believe that PES are properly considered to be government-financed. Indeed, PHES could also be seen as user-financed; but water users make none of the decisions in this programme. Indeed, although many stakeholders were consulted in the process, all program design decision were made by the government, and, water users were notably absent from the table, and water users have any option to withhold payments if they do not receive the water services they seeks. Thus, according to Engel et al. this program, and others that rely on compulsory fees should be considered as government-financed. Moreover, distinguish between these two financed PES

[17] Pagos pos Servicios Ambientales

schemes, then, is not just who is paying the bills, but who has the authority to make decision about paying the bills. However, considering the case of PES programmes financed directly by users, and where the users are in the public sector (e.g. public sector hydroelectricity power producers), Engel et al. argue that they should be considered user-financed if they rely on their own budgets and have ultimate decision-making authority over whether to enter into, or continue participating in a PES programme. For instance, PES programme in which a municipal water utility such as that of Pimampiro in Ecuador pays for watershed protection is according to Engel et al. most appropriately considered a user-financed PES programme.

Furthermore, an intermediate case is the case where an NGO or another agency financed by voluntary contributions takes on the role of the ES buyer. Examples include the *Forest Carbon Partnership Facility (FCPF)* of the World Banlk, an NGO such as the N*ational Forest Fund of Costa Rica (FONAFIFO*[iv]*),* or an environmental funds or trust funds[v] such as *the Sangha Tri-national Trust Fund for environment in Central Africa (FTNS)* paying for an existence value like biodiversity conservation. In Madagascar, payments have been implemented in small watersheds by NGOs to ensure the functioning of micro hydro powers. These are government-financed in the sense that a third party is taking the decision on how to spend funds; but they are also somewhat like a user-financed programme since users' contributions are voluntary, and, thus, users could in principle withdraw future funding if they do not feel that the agency is investing funds appropriately. Although there are good reason highlighted to expect user-financed PES to be more efficient than government-financed ones, there are many instances in which government-financed PES may be the only option.

PES focused on ES providers: Another critical issue concerns with "***Who the Sellers of ES are"***. According to Engel et al. (2008), the potential "sellers" of an ES are those actors who are in a position to safeguard the delivery of the ES. Land-use practices affect downstream water services, for example, through their effect on filtration, evaporation, erosion, and other processes (Figure 2.5). In general, this means that the potential sellers are landowners or forest users located upstream of the watershed.

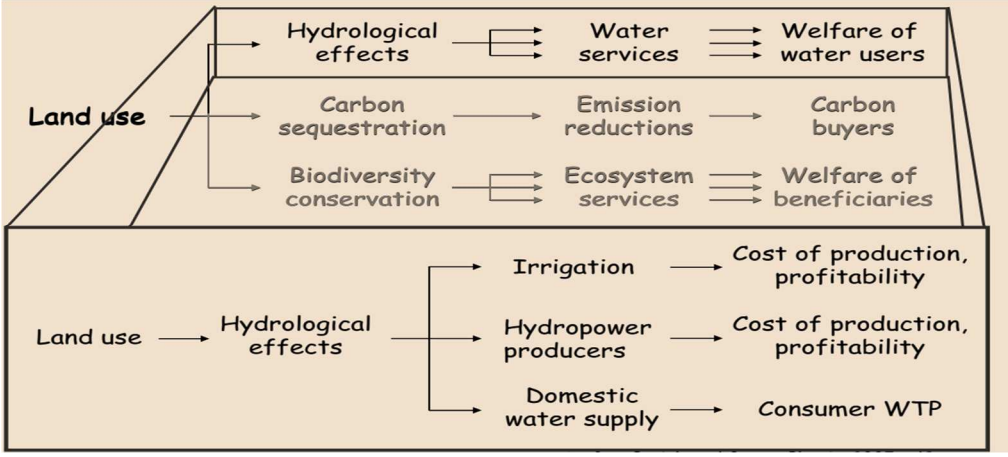


Figure 2. 5: Understanding ES provision in the watershed. Adapted from Pagiola and Platais (2005)

The vast majority of PES programmes are aimed at private landowners. However, governments are also landholders, and so PES programmes can aim, wholly or partially, at public lands such as protected areas. Examples include the Reduction of Emissions from Deforestation and Forests Degradation (REDD+) mechanism derived from the Kyoto Protocol of the UNFCCC in developing countries, where governments are the main services sellers (carbon sequestration, etc), through restriction of land-use for forest conservation and sustainable forest management, or building assets such as reforestation and some practices of agroforestry or silvopastoral farming (R-PP, 2012; République du Cameroun, 2014). In other cases, local communities have joint property rights or at least use and management rights to land and may act as collective ES providers, raising issues of intracommunity distribution of PES (Engel et al., 2008). These include community payments for environmental services such as the ones developed in the South and East regions of Cameroon by the *Centre pour l'Environnement et le Développement* (CED) with two community forests and EU-WWF in Ngoyla Mintom with four community forests.

Whoever the sellers may be as presented in Table 2.4, PES seeks to take advantage of their knowledge of the cost of ES provision and to seek out the low cost providers. As long as participation is voluntary, ES sellers are unlikely to accept a payment lower than their cost of providing the ES, while conditionality ensures that they actually comply with their contracts (Ferraro, 2008; Ajayi et al., 2012).

Table 2. 4: Potential buyers and sellers of ES

Category of actors	Description and examples
Potential buyers of Environmental Services	
Government bodies	• When services are public goods or diffuse beneficiaries, government may step in and act on behalf of those benefiting from the services. • Level of government intervention depends on the scale of service provision. For example: government payments to landowners for the services of water quality (local government), flood control (regional government), or carbon sequestration and biodiversity conservation (national government).
Corporations	• When services are provided to discrete beneficiaries, private PES buyers may be willing to pay providers to ensure continuous provision. o Thus a hydroelectric company may be willing to pay upper watershed landowners to keep their forests intact in order to maintain the service of erosion control (so the lake behind the dam does not silt up). o Similarly, ecotourism operators may pay a local community to ensure conservation of attractive biodiversity in the surrounding areas. • o A company engaged in land development may voluntarily offset its harm to local biodiversity by voluntarily restoring and enhancing habitat elsewhere. o Corporations may pay for services because of regulatory requirements for offsets. o The same offsite mitigation requirement may be true for a company that drains and fills a wetland.
Consumers/ urban citizens/ households (water services consumers)	• A category of consumers may wish to direct its purchases toward companies and products that act in what they view as an environmentally responsible manner. • Eco-labels and certification programs can provide information to guide the purchasing behavior of these "green consumers." • If enough consumers wish to buy certified products, then suppliers and retailers will respond to this market demand. • Households may be willing to pay for water quality preservation in order to reduce the cost of the treatment of water for drinking purpose or home activities, or to reduce the risks of diseases caused by poor water quality.
Nonprofits (environmental groups, philanthropies)	Not all buyers of services are motivated by profit: • Conservation groups and land trusts may routinely pay land owners to conserve biodiversity as part of their groups' central mission. • Similarly, philanthropies may fund service providers in order to ensure continued provision of an undervalued public good.
Potential providers or sellers of environmental services	
Private Landowners	• In many countries, most ES are provided by private lands. These are often agricultural lands, including crops, grazing and silviculture. While one-to-one exchanges between buyers and private landowners are possible, collective action problems are significant. There are high transaction costs to single negotiations and gathering together enough sellers to achieve a significant level of service provision may be difficult. This is particularly challenging for small scale and low-income land owners in many rural areas (particularly in developing countries) who face an information constraint and may lack clear legal title to the land. • To overcome some of these problems, landowners may organize into a private association so they can negotiate with a single voice, better protect their interests, and increase the overall level of service provision for sale. Such collective organization also allows sellers to "bundle" different services together.
Public Landowners	• Public bodies control large amounts of land in some countries, and may negotiate for service payments. • A community group may sell services from communally held land or from land where community members have specific property rights (such as grazing or

	cropping). • In some countries, the payment to public bodies for service provision has been controversial. Critics argue that these lands are public; therefore they already belong to the people. If so, then it is improper to charge the public for services provided by their own lands.
Mitigation Providers	• In countries with offset requirements for development, private parties may create mitigation banks and sell "credits." This happens in the United States with wetlands mitigation and in some states with endangered species habitat.
Certification Organizations	• Those who are directly paid may not be the provider of services. For example, in certification systems, the certifying body is often paid a licensing fee by the supplier for use of its eco-label. The certification indicates that the seller is operating in a sustainable manner (e.g., shade-grown coffee) and this, in turn, signals consumers that they should buy this product rather than others that are not labeled.
Intermediaries or brokers of environmental services	
NGOs	• Local NGOs often receive payments and then directed to landowners or may facilitate such payment flows through sensitization and capacity building initiatives.
Government or municipalities	• Government may use the legal instrument to mandate private companies or other beneficiaries to make payments to government agencies as trust fund that operates through a defined mechanism to compensate landowners.

Source, Author, Adapted from Salzman (2009) and Salzman and Thompson (2007)

From the foregoing, although PES programmes involve contracts between consumers of ES and the supplier of these services, the majority of the PES is funded by governments and involved intermediaries, such as NGO. Moreover, in general, the party suppling the ES normally holds the property rights over the environmental goods that provides a flow of benefits to the demanding party in return for compensation. However, the supplier of ES could be in a situation of a common pool resources[18] (CPR) such as watershed, governed by communal or common property regimes. In this case, bargaining between the parties involved based on Coasian theorem is likely to lead to efficient outcome, if transaction costs are reduced by government or its representation (Kosoy et al., 2007; Vatn, 2010). PES schemes are designed to support the delivery of ES from CPRs, so the considerations relevant for managing CPRs sustainably could also help the design and the implementation of PES schemes.

2. Common Pool Resources and PES

To explore the similarities between PES schemes and CPRs, Fisher et al. (2010) analyzed six characteristics for successful CPR management from previous research and applied these to existing PES activities. Three of CPR characteristics focus on the resource size, the user community, and the user-resource relationship. CPR studies found that smaller resources with

[18] Ecosystems are described as Common Pool Resources when it is hard to stop people using them, and when one person's use reduces the resource available for others. The environmental systems that provide ecosystem services, such as forests, catchments or fisheries, are often CPRs.

well-defined boundaries are easier to manage, as are smaller user groups. The same applies to PES: PES applied to very large river catchments (50,000 km^2 and 175,000km^2) and diverse user groups spread over a large geographic area are difficult to manage. However, suggestions have been made that PES in this large area could be managed better at a sub-catchment scale (Fisher et al., 2010). CPR management also works well when the users are close to the resource, and are highly dependent upon it. For PES, when users are not distant from the service provider, as it is the case for lake watersheds, users can understand the benefits they receive from the resource. The next two characteristics explore institutional arrangements and interactions between these and the resource. Any governance arrangements for CPRs must be clear and seen as fair by users. This suggests contracts for PES should be awarded transparently, and any rules should be agreed collectively with user communities to ensure social acceptance. The relationship between institutional arrangements and the resource are also important. Institutions governing PES schemes need to understand the system in question and demonstrate to policy makers and users of the resource the effectiveness of the scheme through successful monitoring. Thus, the institutional links between downstream water use and upstream catchment management need to be greatly strengthened. Finally, the external environment can also play a role in CPR management. For instance, changing global resource demand, new technologies, and political shift can all affect the effectiveness of both CPR management and PES schemes.

Government (and donors) have a vital role in promoting equitable governance, secure tenure, an enabling policy, legal and institutional framework, capacity building of national PES providers, collective institutions and transparent PES monitoring arrangements. Early PES experiences reveal some positive equity impacts like improved tenure security, community empowerment, organizational and social capital development. While PES do not essentially favor pro-poor outcomes, experience is showing that trade-offs between environmental and social objectives can be managed with appropriate external support. Thus PES could allow a redefinition of property rights and lead to more efficient environmental managemen. This has been noticed the case of the Costa Rica PSE programme.

3. The Coasian Approach towards PES

To date, the mainstream conceptual basis for PES in the watershed has been Coasian approach of externality, which favors policy options based on market or quasi-market bargaining, underpinned by the allocation of property rights, to achieve socially optimal levels of

environmental externalities. In the context of PES watershed design, the Coasian approach puts great emphasis on reducing transaction costs, allocating property rights and establishing bargaining processes between those who own or manage the natural assets and/or their associated services (i.e., providers of ES) and those who are willing to maintain or enhance the provision of such services through a payment (buyers of ES). However, the property rights in this context have to do not only with land ownership but also with land use rights and the right to commercialize services generated from natural assets (Muradian et al., 2010). In this light, payment reflect de facto re-definition of property rights insofar as service providers acquire contract obligations to maintain or undertake specific land use activities and in some cases buyers also gain right to trade the service units for their own commercial purposes (carbon sequestration purposes). Furthermore, Vatn (2010) points out that a wide variety of PES cases depend strongly on State and community engagement, and therefore cannot be considered as voluntary market transactions, at least from the buyer's point of view. Even if private transactions occur, sometimes the voluntary condition in Wunder's definition is not met. Kosoy et al. (2007) highlighted that upstream land manager are rewarded for improving their land use practices, but generally water users are not even aware of paying higher water fees for PES. Moreover, ES are often not fully defined, and in particular PES tend to be implemented without previously established clear-cut causal relationship between land use practices and the expected enhancement of the targeted ES. As a result, in many cases, the efficiency of PES can hardly be demonstrated. In addition, many PES cases in developing countries fail to meet the conditionality criteria in Wunder's definition. Usually, monitoring tends to be restricted to checking compliance with the promoted land use changes, instead of verifying changes in the actual provision of the targeted ES.

Another feature of the mainstream PES conceptualization is its distinctive separation between efficiency and equity considerations, which suggests that PES must be considered primarily as instruments for improving the efficiency of natural resource management and not necessarily for alleviating poverty (Pagiola et al., 2005). This vision according to Muradian et al. (2010), renders effects on poverty reduction as "welcome" positive "side effects", and the poor should be target as long as their inclusion does not imply efficiency loses. Pagiola et al. (2008) note that poorer landholders have been able to participate as providers of ES. Examples also include the community PES with CED and EU-WWF in Cameroon, where population hold use rights on the resource. Hence, PES in the policy arena may be explained in part by the expectation that they may become win-win mechanism for both environmental protection and

poverty alleviation. However, the available evidence to date on participation of the poor in PES programmes is mixed (Kareiva et al., 2006). Therefore, practitioners will increasingly face the challenge to link PES schemes with rural development, though the approach primarily concerned with pure efficiency goals.

4. Incomplete Information in PES: The role of Social Norms, Perceptions and Power Relations

In some circumstances as underlined Muradian et el. (2010), economic incentives many "crowd-out" local rules and social norms, affecting 'intrinsic motivations' for environmental protection. Moreover, social capital is a critical factor conditioning PES success, since stakeholders mistrust may prevent attaining environmental goals, and that economic incentives are insufficient on their own to engender full participation. Vatn (2010) elaborates further on these ideas and argues that PES schemes constitute a mechanism for reconnecting decisions about land use management across different actors through cooperation, and that such a process is mediated by existing institutions which include property rights, legal framework, social perceptions and values. For example, social perceptions about the relationship between land use and the provision of ES may be significant factors in determining the feasibility of PES, particularly in conditions of incomplete information. Many PES at the watershed level are based on the conventional wisdom that there is a positive relationship between forest cover and water quantity and quality, a shared belief that sometimes is not supported by hydrological evidence (Kosoy et al., 2007). Very often, practitioners base their decisions on assumptions about the relationship between the promoted land-use, the impact on the provision of ES and finally the induced changed in welfare. However, this is not necessarily seen as a design drawback, but as a "precautionary" strategy to deal with uncertainty and incomplete information.

The role of the intermediary is also key in understanding the performance of PES. Both Vatn (2010), and Kosoy and Corbera (2010) suggest that intermediaries often become the "dominant agent", who define the services to be traded, set the conditions among buyers and sellers, and largely influence the price of the exchange. However, although these author have tried to analyze the power of intermediary agents to pilot the transfer of resources between buyers and providers, this important subject has not yet been sufficiently addressed in the literature (see also Muradian et al., 2010).

2.3.1.3 Effectiveness and Efficiency of PES

According to Arriagada and Perrings (2009), the effectiveness of PES in meeting conservation goals is, still nonetheless not well understood. Indeed, an important feature of these incentive systems generally is that since they are voluntary, their outcomes are products of the private decisions of landholders, as the agency designs the scheme and offers to the landholder, which decide whether to participate or not. As in any economic problem, the agency influences but does not completely control program outcomes (Siikamaki and Layton, 2006). An important issue in PES concern the extent to which PES programs are able to meet their objectives, i.e., the extent to which the programme makes sure that ES "bought" constitute an improvement over the "business as usual" scenario (additionality), ensures that any mechanism exists which aimed at ensuring benefits beyond the duration of the programmes, and at ensuring that environmental damages are not transferred to other areas or locations (leakage).

Various types of inefficiency that a PES programme might experience have be identified by Engel et al. (2008). The first two are related to social inefficiency and concern with either the failure to adopt practices whose social benefits exceed their costs, or in the adoption of practices whose benefits are smaller than their costs. In both cases, social welfare is reduced over what it might have been. However, to these authors, judging in practice whether these problems are experienced is frequently not possible, as valuing ES in monetary terms is often very difficult or costly. Thus, the type and size of payments provided by a PES programme affect the likelihood of these social inefficiency arising. Costa Rica's PSA programme, for example, offers a relatively low, undifferentiated, and mostly un-targeted payment (Pagiola, 2008). Thus it will only tend to attract participants whose opportunity cost is low, or negative. Therefore, in such case, the socially-desirable land-use practices are not adopted because the payment offered is insufficient. The relatively low payments mean, however, the adoption of socially inefficient land uses is unlikely to occur on a significant scale. The third inefficiency concerns with paying for adoption of practices that would have been adopted anyway, known as "lack of additionality" or "money for nothing" (Ferraro and Pattanayak, 2006).

1. **Additionality Criterion**

Additionality is the measure of outcomes in relation to what would have occurred in the absence of intervention (Engel and Palmer, 2008). Lack of additionality concerns with paying for adopting practices that would have been adopted in the absence of payment. Therefore, it

is not problem of social inefficiency since the practices adopted are in fact socially efficient[19]. Rather, it is a problem of financial efficiency, which is generating less ES per dollar spent for example than if the problem was avoided. The key characteristic of PES deals is that the focus is on maintaining a flow of a specified ES such as clean water, biodiversity habitat, or carbon sequestration capabilities, in exchange for something of economic value. The critical, defining factor of what constitutes a PES transaction, however, is not just that money changes hands and an ES is either delivered or maintained. Rather, the key is that the payment causes the benefit to occur where it would not have otherwise. That is, the service is "additional" to "business as usual," or at the very least, the service can be quantified and tied to the payment. Figure 2.6 below shown an additionality for a carbon project[20].

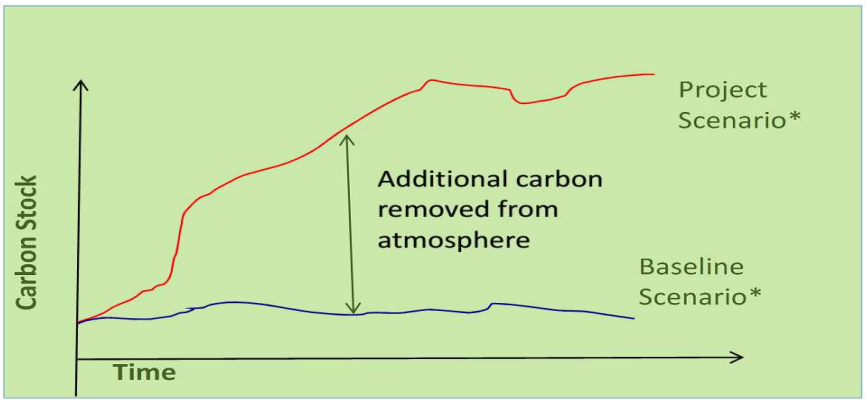


Figure 2. 6: Additionality in carbon stock enhancement project

In order to ensure that the ES is indeed maintained -as buyers expect for their money- the transactions require regular and independent verification of sellers' actions and their impact on the resources. Therefore, sellers must: maintain or enhance specific ecological structures and functions beyond what would have happened in the absence of payment, and remain accountable to independent verifiers (if a buyer requires) to ensure that the "service" being paid for is indeed being delivered (Forest Trends, The Katoomba and UNEP, 2008).. Furthermore, PES deals should ensure that environmental damages are not transferred to other areas or locations (leakage).

[19] It can result in social inefficiency, however, in cases where funds for PES are limited: payments to land uses that would have been adopted anyway reduce funds available to induce socially-efficient land-use change elsewhere. It is also inefficient in that the transaction costs involved are 'wasted'. PES programs that offer low, undifferentiated, and un-targeted payments are particularly likely to experience this problem.

[20] Net carbon stock changes from project activity = Baseline minus project emissions
Net change in non-CO2 GHG emissions with the project = Emissions without the project minus emissions with the project

2. Leakage or moral hazard problem in PES

Leakage or spillage refers to the intentional or unintentional displacement of activities damaging ES provision to areas outside the geographical zone of PES intervention once the contract is concluded (Robertson and Wunder, 2005; Engel et al., 2008). This issue of leakage, known as moral hazard in information Economics have been analyzed in market of Lemons, labor Market and insurance (Akerlof, 1970; Spence, 1974; Shapiro and Stiglitz, 1984). If leakage occurs, the environmental benefits obtained from PES may be overestimated. Leakage may occur directly, for example, if landholders protecting forest under PES shift destructive activities to other forest areas. It may also occur more indirectly through market mechanisms. For example, land enrollment in PES for forest conservation may lead to increased prices of forest products or agricultural crops, thus encouraging extractive activities or agricultural conversion in other forest areas. Furthermore, PES deals should ensure that any mechanism exists which aim at ensuring benefits beyond the duration of the programmes (Permanence).

3. Permanence Criterion

Permanence refers to the ability of PES to achieve long-term improvements in ES provision, including beyond the period of the payment proper when payment horizons are finite. Critics of PES have stressed that permanence may be hindered by changes in external conditions (e.g., increases in market prices of agricultural crop competing with forest conservation) or by lack of long-run funding for PES (e.g., due to limited project durations). Pagiola and Platais (2007) note, however, that one of the attractions of PES is precisely that it should be able to adapt to changing conditions. As long as participation is voluntary for both buyers and sellers, both have the option to walk away at any point if conditions change. What may seem as the essence of impermanence, however, is the means by which permanence is assured: by giving both parties the ability to require that contracts be re-negotiated to accommodate for the new conditions. However, if the conditions change so much that there is no longer room for a new deal between ES buyers and sellers, then it is actually desirable that the programme stops working, as continuing would be socially inefficient. More generally, the basic logic of PES of compensating ES providers for the externalities they generate means that it is not very useful to talk of permanence after payments end, there cannot be any expectation of permanence in the absence of payment. This makes the permanence of benefits of a PES programme dependent on the continued flow of financing. Lack of long-run funding may be a problem in government-financed PES programmes, where funding is subject to project

durations or policy cycles; it is less likely to be an issue in user-financed ones, as long as the programmes are delivering the ES that the users are paying for (Engel et al., 2008).

4. The role of targeting or Screening

The role of targeting concerns the selection of the number of participants or sites in a PES scheme. When the number of applications to participate in the PES programme exceeds available financing, service buyers can use targeting to select among applicant sites to maximize the programme's financial efficiency (Barton et al., 2003; Alix-Garcia et al., 2005; Engel et al., 2008). Targeting approached for conservation programmes may be based on benefit or cost considerations, or a combination of both (Babcok et al., 1997). *Benefit targeting* of PES would be based on actual ES (and possibly achievements of side objectives) delivered by a given site. Targeting could also be based on threats and hence the likelihood of additionality. By explicitly considering both ES levels and additionality in selecting among PES applicants, the real benefits of the programme can be enhanced (Engel et al., 2008). *Cost targeting* is related to making payments flexible. Fixed payments give high production rents to landowners with low costs of ES provision, while those with high costs of ES provision are likely to not participate in the programme[21]. Thus, flexible payments equal to (or just above) the individual costs of ES provision would allow larger areas to be included in a PES scheme for a given budget. However according to Engel et al. (2008), the challenge in cost targeting lies in estimating site-specific costs of ES provision, particularly opportunity costs in light of the information asymmetries. Moreover, there is need for targeting instrument that combines benefit, additionality, and cost considerations (Wünscher et al., 2008). In practice, the benefits from improved targeting are compared to the transaction costs associated with factors such as additional data needs and changes in administrative procedures (Engel et al., 2008).

5. Information Asymmetries Analysis in PES

PES generally have two common features. First they are voluntary. Second, participation involves a contract between the "conservation agent" and the "landowners*"[Here, "landowners" denotes any entity that is in the position (de jure or de facto) to supply ES through its influence on the ecosystem or watershed; while "conservation agent" denotes any entity that wishes to encourage landowners to supply* ES]. The landowner agrees to manage an ecosystem according to agreed-upon rules and receives a payment (in cash or in kind)

[21] However, when there are multiple potential producers of a benefit like carbon sequestration with different marginal costs which are not observable by the service buyer, price-based mechanisms on which PES is based are likely to be more efficient than quantities based mechanisms. Indeed, price based mechanisms screen out the high cost producers which encourage them to produce less and low cost units to produce more (Pagiola et al., 2005).

conditional on compliance with the contract. However, PES contractual relationship are subject to asymmetric information between landowners or ecosystem managers and conservation agent or agency. Indeed, asymmetric information refers to a situation in which different agents possess different information, which leads to inefficient outcomes arising from strategic opportunities (Jehle and Reny, 2011p.279). Information asymmetries can then limit the effectiveness of PES schemes and make them expensive to implement. There is a well- developed literature in "contracts theory" that provide abundant insights into the design of PES contracts (Hart and Holmström, 1987; Williansom, 1975; Laffont and Martimort, 2001; Bolton and Dewatripont, 2005). There are two important information asymmetries in the design of contracts: adverse selection or information hidden (pre-contractual private information) and moral hazard or hidden action (post-contractual information asymmetries) (Hart and Holmström, 1987).

Hidden action (moral hazard) arises after a contract has been negotiated. The conservation agent may find monitoring contract compliance costly and thus will be unwilling to verify compliance with certainty (Ferraro, 2008). Thus, the landowner has an incentive to avoid fulfilling his or her contract responsibilities, for example by displacing activities damaging ES provision to areas outside the geographical zone of PES intervention. Agri-environmental payment schemes have experienced the issue of hidden action (Fraser, 2002; Hart, 2005). Moreover, this concern have been underlined with respect to payment for carbon sequestration or REDD+, which is symptomatic of the general difficulty of establishing such international payment schemes (Barbier, 2011). As REDD+ primarily focused on one global ES which is the protection of forests for carbon sequestration, Karsenty (2008) and Kindermann et al. (2008) argued that monitoring and verifying changes in deforestation rates in developing countries and their impacts on carbon emissions could increase substantially the transaction costs of implementing a REDD+ scheme on a global scale. Thus, the high opportunity costs faced by many developing countries mostly in Africa from losses in foregone agricultural and timber benefits as noticed Angelsen (2010), uncertainty over future demand for carbon credits, the feasibility of long-term donor financial assistance and the possibility of a short-lived REDD+ mechanism (Phelps et al., 2011), could lead these countries to shift unsustainable practices into marginal lands, thereby, increasing the issue of leakage. However, in government-financed PES implemented by NGO, a leakage mitigation strategy based around participatory consultation is usually developed.

- **Hidden Information or Adverse Selection**

In contrast to hidden action, hidden information (adverse selection) arises when negotiating the contract. Landowners have better information than the conservation agent about the opportunity costs of supplying ES. Thus, landowners can secure higher payments by claiming their costs are higher than they are. More precisely, landowners use their private information as a source of market power to extract *informational rents* from conservation agents. These rents are payments above the minimum payment necessary to induce landowner participation in the PES programme (Ferraro, 2008). When conservation agents pay informational rents, they obtain fewer ES per dollar spent for instance than they could obtain in a world in which opportunity costs of supplying ES are observable. Thus, according to Ferraro (2008) society benefits more if the payments just compensate the landowners' opportunity costs of contract compliance.

An example of situation of hidden information in PES is illustrated by Ferraro (2008) with a conservation agent interested in contracting with landowners for habitat quality, h, which can be represented by numbers ranging from 0 (completely converted) to 100 (pristine). The participation is voluntary and thus contract payments must at least cover the landowner's opportunity costs (in the theoretical jargon, the "participation constraints" are satisfied). There are two types of landowners: those with high-opportunity costs (H) and those with low opportunity costs (L). A type H landowner has the cost function $2h^2$ and a type L landowner has the cost function 2h. The conservation agent would like to contract with type L landowners first, and only contract with type H landowners if the agent's demand for habitat quality was not satisfied by type L landowners. All landowners, however, would like to be paid as if they were type H landowners. But, if a specific parcel of land is considered and it is assumed that the conservation agent wishes to contract with a landowner to keep the landowner's habitat pristine for example at h=100, in a perfect information world, the agent would offer $200 if the landowner were type L and $20,000 if the landowner were type H. However, if the conservation agent could not determine if a landowner is H or L, all landowners would claim they were type H in order to receive the larger payment of $20,000. Thus, from foregoing example, as long as there is substantial heterogeneity in opportunity costs of supplying ES, hidden information will be a problem. Reducing informational rents to landowners may have implications for other goals associated with PES. Policy mechanisms that reduce these informational rents have been classified into three categories (Ferraro, 2008).

1) **Gathering more information on landowners in the form of "costly-to-fake" signals.**

Collecting information on "*costly to fake"* signals refers to gather information on observable landowner attributes that are correlated with opportunity cost and use these attributes to establish contract prices. With this information, one can create eligibility requirements for receiving a given contract type and price. This approach seems to be the simplest one and is common is U.S. agri-environmental schemes where posted contract prices differ geographically to reflect regional differences in opportunity costs (Ferraro, 2008). Soil type, distance to roads and markets, forest type and assessed value are other examples of attributes that are often correlated with opportunity costs and, importantly, are impossible or costly for landowners to fake or falsify. Economic models of agricultural returns based on observable characteristics help categorizing cost types (Naidoo and Adamowicz, 2006 cited in Ferraro, 2008). Regional and local intermediaries with better information about field conditions can facilitate the designation and collection of information on these attributes.

2) **Relying on Screening Contracts (self-selection mechanism)**

An alternative approach to gather on landowner characteristics is to induce landowners to reveal their "type" by offering a contract for each of the different types of landowners believed to exist. Contracts are designed so that a landowner could never be better off choosing the contract intended for another type. Considering the numerical example from the box above with type H and type L landowners, the essential insight is that two types of contracts should be offered: a high output contract for type L and low output contract for type H landowners. In addition to the requirement of choosing payments to at least cover all landowners costs, the contract design puts restrictions on the payments so that landowners pick the contract intended for their type, this to satisfy the "*incentive compatibility constraint"* as argued Ferraro (2008). This is underlined by Pagiola et al.(2005), where beginning with the work of Weitzman (1974), found that one of the cases Weitzman examined is particularly relevant to PES, notably when there are multiple potential producers of a benefit (e.g., carbon sequestration) with different marginal costs which are not observable by the service buyer. Pagiola et al. conclude of the efficiency of price-based mechanisms over quantity-based mechanisms, as they screen out the high cost producers, encouraging them to produce less and low cost units to produce more.

However, to encourage type L landowners to reveal their type, the conservation agent must compensate them at a level above their opportunity costs, resulting in "overcompensation". This overcompensation is then a rent from the private information held by the low cost landowners. Thus, through the use of screening contracts, the conservation agent has reduced the informational rents paid to the low cost landowners, but has not eliminated them. This results in a "second-best" rather than a "first-best" outcome. Moreover, despite the appeal of screening contracts, their design in the field is not straightforward. Designing a menu of contracts that satisfy the participation and incentive compatibility constraints and maximize the conservation agent's objective function requires knowledge about the distribution of landowner types and sophisticated calculations by conservation practitioners. In addition, Bolton and Dewatripont (2005) state "more often than not, research articles in contract theory are hard to penetrate even for a well-trained reader".

3) Harnessing competitive forces through procurement auctions.

Procurement of goods and services for which there are no well-established markets is commonly performed using auctions (Ferraro, 2008). This has been analyzed in microeconomics theory where the sellers does not have perfect knowledge of market demand, but only statistical information. Only the buyers themselves know precisely how much of the good they are willing to pay at a particular price. To overcome this issue, researchers have used tools from the theory of *mechanism design* (Jehle and Reny, 2011 p.427-484). Certain types of auctions have this property, in which the best bidding strategy is to bid one's true value for an object as given the definition of the like the *Incentive-Compatible direct selling mechanisms* (Vickrey, 1961). With PES contracts, an auction to allocate contracts creates a temporary market where one otherwise does not exist. A PES contract procurement auction is a process through which a buyer of ES invites bids (tenders) from supplies of ES for a specified contract and then buys the contracts with the lowest bids. The competition created gives participants an incentive to reveal their private information about the lowest payment that would make them willing to accept an ES contract (Ferraro, 2008), and reduces incentive for sellers to inflate their contract prices. In this type of "reverse auction" or procurement auction, only the lowest bidders receive contracts (Ajayi et al., 2012). In some auctions, bidders can only bid once (*simultaneous*), whereas in others they can bid more than one time (*sequential*). Moreover, in some auctions, bidders can see others' bids when making their own bids (*open bid*), or the bidders each make their bids without knowing what other bidders are choosing (*sealed bid*). Payments for winning bidders can be based on their own bids

(*discriminative-price auction*) or on a rejected bid (*uniform-price auction, which often used the lowest rejected bid to set the price*) (see Ferraro, 2008). The buyer may wish to buy a given number of contracts or service quantity, may have a maximum reservation price per contract, or may have a fixed budget. These buyer attributes may be common knowledge or only known by the buyer. Each combination of auction attributes can give rise to different bidding behavior (Ferraro, 2008).

Unlike screening contracts, auctions do not require the conservation agent to specify the distribution of landowner types. Landowners reveal their distribution through their bids. Auctions theoretically reduce informational rents with fewer distortions to the supply of ES and use competitive bidding to reduce the attractiveness of low-cost landowners claiming to be high-cost. Auctions also have the advantage of revealing to the conservation agent any changes in the cost distribution over time, which is useful when contracts are periodically purchased or renewed. As a matter of fact, with more commonly used *take-it or leave-it* prices in conservation initiatives, such changes can only be inferred indirectly by excess supply, implying that the price is too low, or excess demand for contracts, implying the price is too high. Auction mechanism is also used as research tools to make ex ante estimates or to reveal costly-to-fake associated with cost types (Ferraro, 2008). However, auctions require a large pool of bidders to induce competitive pressures and to reduce incentives to collude or otherwise behave strategically. Thus, how many participants constitute a "large" pool will depend on local conditions and the auction environment. Though an auction offers an approach to efficiently allocating contracts among least-costs landholders, which can improve the overall cost-effectiveness, experiences with auctions in developing country settings are limited (Ajayi et al., 2012; Ferraro, 2008), and the two dominant forms of price setting for PES contracts are bilateral bargaining and posted prices (fixed take-it or leave-it prices).

2.3.1.4 Voluntary PES: Current Markets and Transactions Types

What emerges is a picture of a market that support hundreds of projects globally, from capturing methane from landfill, replanting forests to distributing cleaner-burning cook stoves. Many of these projects provide additional benefits, including job creation, biodiversity conservation, watershed protection, and climate change adaptation; and target benefits to vulnerable groups including indigenous people. However, the focus here is on voluntary carbon market state and state of watershed payments.

1. Voluntary market state for climate regulation and carbon sequestration

Voluntary markets for carbon offsetting enable companies gaining an advantage by piloting new ways to reduce and price carbon. Under the Clean Development Mechanism (CDM) of the Kyoto Protocol of the UNFCCC, credits from activities that avoid carbon emissions such as avoided deforestation in the tropics are not considered. All forestry deal entering the regulated carbon market relate to reforestation and afforestation as defined by CDM, which traded around 1,266million tonnes of carbon dioxide equivalent (MtCO2e) and US$20 billion worth of carbon credits in 2009. The largest formal trading platform for the voluntary market is the United States-based Chicago Climate Exchange (CCX), where was transacted in 2009, 41.4 MtCO2e representing almost half the voluntary market in the form of Carbon Financial Instruments (CFIs). The other half was traded on the over-the-counter (OTC) market, between individual buyers and sellers (either directly or through brokers and retailers) (Herbert et al. 2010).

The voluntary carbon market allows not only investments in "green" renewable energy, but also in a range of land-use options that sequester carbon, including sustainable forest management (SFM) and agroforestry. In 2014, voluntary demand for carbon offsets grew 14% to 87MtCO2e transacted, at an average price of $3.8/tonne, but this volume represents only a fraction of 1% of total global emissions in 2014. In 2015, the volume transacted increased over 2014 by 10% to 84.1MtCO2e. However, total market value fell 7% to $278M due to the average price dropping of 14% to $3.3/tonne compared to 2014 (table 2.5). This demand for real, verifiable results is increasingly reflected in bilateral government to government climate finance (as public agencies seek ways to demonstrate tangible climate contributions ahead of the UN climate negotiations in Paris).

Table 2. 5: Voluntary carbon market average prices and values

Year[1]	**Pre 2005**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Average Price($/tonne CO2e)	4.1	4.1	4.1	6.1	7.3	6.5	6.0	6.2	5.9	4.9	3.8	3.3
Value[2]	$301 M	$48 M	$111 M	$359 M	$790 M	$485 M	$444 M	$602 M	$530 M	$339 M	$298 M	$278 M

Source, author from Ecosytem Marketplace's reports for 2014 and 2015

[1]The first Ecosystem Marketplace report was published in 2007, but the data collection encompasses years prior to that date;

[2] the value (volume weighted average price) excludes the REDD Early Movers (REM) agreement which used a $5/tonne proxy and that the average price is $4.0/tonne CO2e

A few countries have received the most voluntary carbon finance over the years[22], and the cumulative volume of offsets issued across the four major voluntary standards in 2014 [*the Verified Carbon Standard (VCS), the Gold Standard (GS), American Carbon registry (ACR), and the Climate Action Reserve (CAR)*] has reached 301MtCO2e over the last decade, with 119MtCO2e retired.

- **Voluntary carbon market state in Africa**

Historically, fewer than 3% of offsets developed under the CDM were sourced from Africa, and voluntary project development, too, has lagged behind that of other regions. According to Ecosystem Marketplace report of 2014, voluntary buyers have spent a cumulative US$253million on African-based offsets over the past decade, corresponding to about half of the cumulative value attributed to Latin American and Asia respectively. However, total offsets transacted have steadily risen over the years.

Demand for forest carbon in Africa: Voluntary buyers have shown steady interest in supporting avoided deforestation, cook-stoves, and other pro-poor project types in Africa. Project developers committed to the region are experimenting with new methodologies with large potential on the continent, such as avoided conversion of grasslands and blue carbon methodologies for mangroves. Buyers have contracted a total of 45.1MtCO2e from the continent, of which 54% was transacted in the last three years alone. Demand for African-based offsets reached 6.7 MtCO2e in 2014 with average prices of $5.7 per tonne, tracking above the global average. In 2015, African offset sales remained stable at 6.7MtCO2e, just slightly less than 2014's volume. The majority of volume originated from forestry or cookstoves projects as buyers sought to support emissions reductions that contributed to low deforestation and sustainable development of the continent. Though average prices decreased 9% to $5.2/tonne, buyers paid more for African offsets than from any other region except Oceania, for a total of $34.7M. Buyers (end-users or retailers) often contracted directly with project developers and 54% of Africa's 2015 offset transactions represented primary market demand while the remaining 46% of tones were resold by secondary market actors.

[22] The United States which never ratified the Kyoto Protocol, cumulatively transacted the largest volume 136 MtCO2e worth $656M, of any at the highest price of single country. Other countries home to the most voluntary offset supply locations are Brazil (39.5MtCO2e worth $233M); Turkey (31.7 MtCO2e worth $207M); India with $205M; Kenya with $154M; China with $153M; Cambodia (4.3MtCO2e worth $40M); the Democratic Republic of Congo (4.6MtCO2e worth $20.8M); Uganda (2.5MtCO2e worth $17M); Ghana ($11M); Mozambique ($7.2M) and Indonesia (4.6MtCO2e). None of these countries have implemented national carbon pricing regimes, and while US buyers transact international offsets to a limited extend, European buyers have traditionally transacted the majority of these assets.

Supply of Forest Carbon in Africa: Suppliers reported transactions from 21 different African countries in 2014. Kenya-based projects led the way, transacting 3.1 MtCO2e in 2014 and accounting for nearly half of the continent's volume over time (18.7MtCO2e). Historical projects development has also been strong in the Democratic Republic of Congo (DRC) (4.6MtCO2e), Uganda (2.5MtCO2e), Ghana (1.6MtCO2e), and Mozambique (1.0MtCO2e). In 2015, Kenya remained the primary source of offsets, supplying 3.1MtCO2e from cookstoves and forestry projects. Neighboring Uganda followed at 1.5MtCO2e, with Zambia, Madagascar, and Malawi also recording at least three transactions from separate organizations. South Africa plans to enact a carbon tax in 2017 that would allow compliance entities to offset up to 10% of their regulated emissions. Table 2.6 below shows the overall volume, value and the average price supplied until 2015, along with project categories and standards. The main African carbon offset suppliers that respond to Ecosystem Marketplace are reported in appendix.

Table 2. 6: African voluntary carbon market until 2015

Year	**Volume**	**Value**	**Average Price**
All time until 2014	38MtCO2e	$253M	$6.6
2014	7MtCO2e	$93M	$5.8
2015	6.7MtCO2e	$34.7M	$5.2
Top Transacted Project Categories			
Forestry and Land Use	***Household Device or Service***	***Efficient and Fuel Switching***	
46%	44%	4%	
Top Transacted Project Standards			
Gold Standard	***VCS***	***VCS+CCB***	
39%	30%	22%	

Source, Author from Ecosystem Marketplace's reports for 2014 and 2015.

Although some African countries have made efforts to integrate the Ecosystem Marketplace and are performing, Cameroon is still not "visible" despite the rich potential of natural forest ecosystems of the country, and some pilot projects that have been implemented. However, the Paris Agreement during the COP21 of the UNFCCC set the tone for ambition, cooperation and action at all scales for forest carbon in Africa, and in Cameroon in particular. The COP21 reaffirms the goal of limiting global temperature increase below 2 degrees Celsius, establishes binding commitments by all parties to make "nationally determined contributions", and to pursue domestic measures aimed at achieving them. The conclusions also reaffirm the binding obligations of developed countries under the UNFCCC to support the efforts of developing

countries, while for the first time encouraging voluntary contributions by developing countries too. The Paris agreement set the decision of mobilizing US$100 billion a year in support by 2020 through 2025, with a new, higher goal to be set for the period after 2025. Thus, unlike the CDM, a market-based mechanism under the Paris Agreement could potentially include any country and transfers could flow in any direction. This is very relevant for the country, which are seen REDD+ as a tool for sustainable development (R-PP, 2012), and has ratified the Paris Agreement with the commitment to reduce its emissions at 30% by 2025. Moreover, in its fifth report to the convention on biodiversity, the country committed to implement a national PES programme for biodiversity conservation by 2020, and to impute them into the national budget.

2. State of Watershed Payments

Ecosystem Marketplace through the Investments in Watershed Services (IWS) generally focuses on two leading instrument for watershed protection: Payment for Watershed Services (PWS) and Water Quality Trading (WQT). However, WQT are developed to meet traditional CAC water quality standards, where water quality goals are met by trading pollutant reduction credits between states, regional and local actors. PWS include both bilateral and collective action fund mechanisms (such as water trust fund) linking buyers and sellers of watershed services at the local, regional and national scale. These agreement are then usually voluntary although in some cases a regulatory driver is present, and they constitute the largest group of watershed investment projects tracked on the market, and also the most diverse: significant variation is size, transaction activity, and project sophistication (Ecosystem Market and Finance, 2015). Most PWS schemes rely on nature water infrastructure or “green infrastructures” to keep water sources clean and safe, including forest as green infiltration galleries (Germany), to mussel (mollusk) beds to filter nitrate pollution instead of treatment plant (Sweden), to wetland restoration at waterfront to deal with storm events (New York City). Other practices on the marketplace include agricultural best management practices, afforestation/reforestation or improved forest management (Ecosystem Marketplace “State of watershed payment”, 2012).

In terms of environmental outcomes, these payments have translated into efforts to rehabilitate and protect nearly 117 million hectares globally in 2011. However, not all these programmes measure success in terms of land, some also returned 130,000 megaliters of

water to rivers and aquifers and more than 4.6 million megaliters in 2012[23]. Thanks to watershed investment programs, 3.4 million pounds of nitrogen and 97,000 pounds of phosphorus were kept out of the global waterways in 2011, where they would have led to algal blooms and oxygen-starved "dead zones" (Bennett et al., 2013). All the PWS do not take the form of cash payments, watershed services provided are being compensated "in-kind" in the form of technical training, agricultural inputs, community economic development, or even tenure security. But according to Bennett et al. (2013), survey respondents where possible estimate the value of in-kind payments to be included in aggregate transaction figures. Transactions totaled US$8.17 billion in 2011, and globally IWS have steadily increased since monitoring began in 2008. Market saw a bounce in 2012, where China represents the lion's share of reported payments as the country has increased funding for "eco-compensation" mechanisms, i.e., the compensation for ecological restoration and protection[24]. The Chinese economic muscle has offset falling investments in ecological infrastructure in North and Latin America, traditionally global leaders in funding watershed protection (Bennett et al., 2013). In addition, the market has tracked growing interest in "stacking" and "bundling" payments for multiple ES, not just in the United States, but also in Indonesia, Vietnam, Tanzania, Kenya, and Colombia. "Bundling" refers to a payment that recognizes multiple ES delivered by an intervention, including habitat for imperiled species, carbon sequestration, or landscape beauty, while "stacked" payments not only recognize multiple services, but offer distinct revenue streams for each.

Globally, watershed services payments in 2013 have been estimated at US$690million, with most programmes on the smaller side (median land area protected is 2,000ha) and active at the sub-state/provincial scale (involving two or more municipalities). The network of water trust funds connected through the Latin American Water Funds Partnership is an exception that share financing models and project design elements, and is not seen to reinvent the wheel in project development as others. Moreover, these water funds, which draw on a mix of funding streams to capitalize a fund, generally managed in trust, to invest in conservation and restoration projects, are the fastest growing model in Latin American today. Eight funds existed in 2008 and at least seven were launch from 2012. US$ 27 million partnership between The Nature Conservancy, the FEMSA Foundation, the Inter-American Development

[23] The equivalent of enough water to nearly fill Lake Michigan.
[24] Water insecurity poses probably the single biggest risk to the country's continued economic growth today, and the government has clearly decided that its ecological investments will pay off

Bank, and the GEF aimed to have 32 funds capitalized across Latin America in 2015. These funds offer sustainable financing, long-term stakeholder engagement, and flexibility to select projects at a landscape scale (Ecosystem Market and Finance, 2015; Bennett et al., 2013).

Considering the payer type (beneficiary, polluter, or public good payer), payments are overwhelmingly initiated by public good payers like governments and NGOs (Figure 2.6a). The trend is dominated by Chinese' massive spending for eco-compensation *(public good payer share with China is 97% in 2011 followed by beneficiary pays with 3%, while without China, beneficiary pays gets the great share of 66% followed by public good payer with 31%).* Private buyer are typically companies with clear operational and reputational risks related to water: the Coca-Cola Company, Nestlé and SABMiller to date have been the "largest buyers". Though this segment remains tiny, with only US$0.3 million transacted in 2013, buyers considered current projects as an initial "proof of concept". Yet, the Coca-Cola Company and its partner bottling companies stood out in 2012-2013, and are involved in at least 20 watershed service programmes around the world). The payment by household water users are mostly experienced in the Southeast Asia. For instance, in the Branta watershed a quasi-compensation mechanism works, where household demand through the community water buyers association (HIPPAM) represents 25% of the total payment (Bennett et al., 2013). In Africa, projects have emerged in some countries like Ghana (Pra and Kakum River Basins), Kenya (Lake Naivasha), Gabon (Mbé watershed), Zambia (Water Futures Partnership), Malawi (Shire River Basin), Guinea and South Africa. Table 2.7 gives a summary details of IWS in Africa until 2012.

Table 2. 7: Summary details of Investments in Watershed Services (IWS) in Africa

Active programmes	6 in total
Programmes in development	10 in total
Value of transactions in 2011	US$109.3million
Value of transactions 1995-2011	US$864.7million
Hectares managed for watershed services in 2011	162,115hectares
Hectares managed for watershed services 1995-2011	2.3 million hectares

Source: Ecosystem Marketplace 2012

Looking at the supply side, a range of "sellers" exist, while private landholders (often agricultural producers and forestland holders) continue to be the most prominent "sellers" (figure 2.7b). On both the payer and provider side, participation is still largely voluntary. However, according to Bennett et al. (2013) the share of participants driven by policy

frameworks is growing, suggesting that compensation for watershed services is gaining popularity as a carrot to accompany regulatory batons.

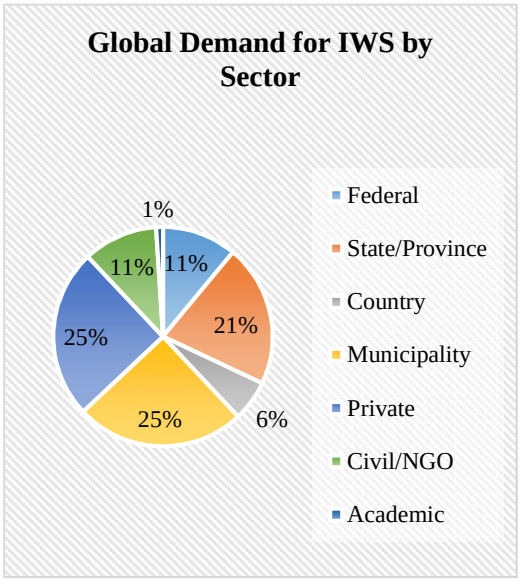


Figure 2.7a

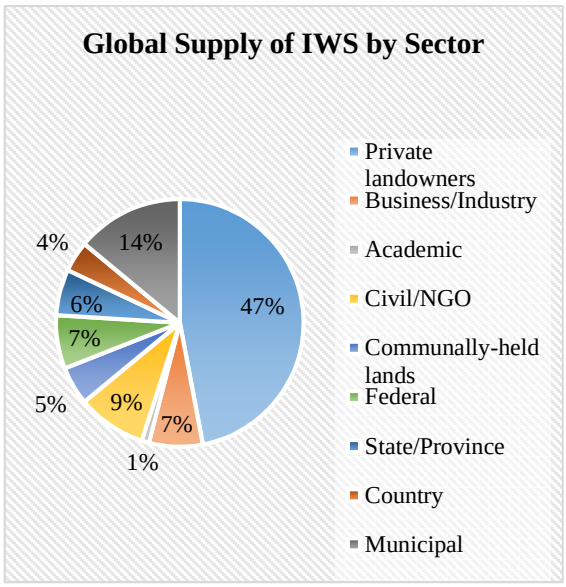


Figure 2.7b

Figure 2.7: Global demand and supply of Investment in Watershed Services, from Ecosystem Marketplace 2012

Today, PWS is a widely used policy tool for conservation, an instrument for facilitating transition to a green economy through a blue economy, and from this perspective, PES is seen as win-win solution to environmental degradation and poverty (Rodríguez de Francisco and Boelens, 2014). At the national level in Cameroon, there is no clear policy framework for PWS initiatives. Currently no legal framework directly supports the establishment of payment schemes and the engagement of stakeholders in the PES scheme is of fundamental importance. However, the land tenure laws, forestry laws and other environmental laws contain provisions that relate to PES and which influence the need to carry out PES schemes mostly dealing with the conservation, preservation and sustainable use of natural resources, including watersheds.

2.4 Watershed Management and PES Framework in Cameroon

The subsection presents first the management of the watershed in the country. This will be follow by the framework (Laws, institutions among others) of the payments for environmental services mechanisms

2.4.1 Watershed Management in Cameroon

Watershed or water resources management represents a major challenge for the socio-economic and sustainable development in Cameroon. It concerns the vital human needs, economic activities, protection of the ecosystems and the environment as well as land use and public health. Since water resources are complex; and that water is a dynamic natural resource whose supply is heterogeneous with different chemicals, biological and ecological attributes, steps have been taken in managing water resources in the country. This accounts for the different sources of contaminations which may be classified either as point sources or non-point sources. An important step has been taken with the adoption of Law No. 98/005 of 14 April 1998 on the Water Regime in Cameroon, which introduces a new regulatory environment.

2.4.1.1 Legal and Institutional Framework Governing Watersheds Management in Cameroon

The legal framework for water in Cameroon seems to be characterized by a very protective normative framework and a rigorously supervised operating system. Law No. 98/005 of 14 April 1998 on the water regime fixes on the framework of the respect of environmental management principles and protection of public health, the general legal framework of the water regime. This law makes water a good of national heritage of which the State ensures the protection and management, and facilitates access to all. Yet, the State may transfer all or part of its powers to regional and local authorities. Thus, although water appears to be a common resource, its management is under the state ownership. The merit of this framework is also to establish a typology of water in terms of surface water, groundwater, spring water and mineral water.This merit is explained that although surface water and groundwater are, in practical sense, distinct water supplies, potential threats to one, can have implications for the other because of the hydrological cycle that connects them. Moreover, this classification has an effect on the regime of exploitation which may be accompanied as appropriate with payment or fee when water is extracted for industrial or commercial purposes. Three taxes and royalty fees are in connection with water resources sector. These are, sanitation tax, extraction charge, and value added tax (VAT).

A sanitation tax is collected by the state on people/owners of facilities connected to public sewer systems, or private collection and treatment of waste water. The rates and methods to collect the tax are set by the Finance Act. This tax is intended to supply a Special Allocation

Account established for this purpose by a Presidential Decree. Under Article 11 of Decree No. 2005/3089 -/-PM of 29 August 2005 specifying the rules governing the assessment, collection and control of the sanitation tax and water extraction charge, the price of the sanitation tax per unit pollution load, referred to as *unitary tax of industrial waste water discharged*, is set at FCFA200. Moreover, according to Article 17 of the above Decree, the price units of water extraction charge are set according to the amount of cubic meter extracted as follow: FCFA 100 per cubic meter between 0 to 1 000 cubic meters of water abstracted; FCFA 50 per cubic meter over 1000 cubic meters of water collected. However, the unit price of water extraction charge for agriculture, livestock, or fish purposes, whose daily quantities are more than 500cubic meters of water per day is FCFA 25 per cubic meter. Whereas, the sanitation tax would affirm the "***Polluter-Pays-Principle***", the royalty fees in the water sector would affirm the principle of the "*Sampler-Pays*" (**Préleveur-Payeur**) and is according to GWP (2010), an incentive for the realization of water facilities by private actors who are large users.

The law also emphasizes the protection of water from various pollutants, the preservation of water resources, the quality of water intended for consumption, and the penalties due to non-compliance with the law. Thus, it poses at the same time, strict rules which are intended to protect water against all kinds of contamination and established a parallel system of liability and fairly dissuasive criminal penalties ranging from jail or prison sentence of 5 to 15 years and the payment of fines of an amount FCFA10 to 20 million francs, with the possibility of doubling the penalties and fines for repeat offenses. Other legislative and regulatory texts complement this device, including Law No. 96/12 of 5 August 1996 relative to the management of the environment (framework law), and Law No. 2000/2 of 17 April 2000 on maritime waters of the Republic of Cameroon. The current regulatory framework for water management is very broad, and includes essentially the first decrees of implementation of the Water Act system of the country.

For the purposes of law 98/005 of 14 April 1998, a number of decrees were issued including Decree No. 2001/162-/-PM of 8 May 2001 which fixes the procedure of appointing the agents in charge of the monitoring and control of water quality; Decree No. 2001/163-/-PM of 8 May 2001 regulating the perimeters of protection around catchments, treatment and storage of drinking waters, and formalizes the monitoring and control of these areas. Decree No. 2001/164 / PM of 8 May 2001 and its appendix details the extraction methods of both surface and groundwater for industrial or commercial purposes. It specifies amongst others

the classification of waters and the process of controling water extraction facilities. Decree No. 2001/165-/-PM of 8 May 2001 and its two appendixes specify the terms of protection of both surface and groundwater against pollution and some spills, and the general measures of protection. Decree No. 2001/216-/-PM of 2 August 2001 establishes a special account to finance sustainable development projects related to water and sanitation. However, the absence of a reference document in lieu of national water policy on which regulations should be underpined amplifies the normative and structural weakness of the water sector in the country.

The institutional framework[25] of the water sector is characterized by the central role of the Ministry of Energy and Water (MINEE). However, given the transversal nature of water resources, several other government departments are involved. While MINEE is the main actor responsible for the development, implementation and evaluation of the government's policy on production, transportation and distribution of water, the Ministry of the Environment, Nature Protection and Sustainable Development (MINEPDED) is responsible for the development of environmental policies and those relating to the conservation and protection of natural resources in general and of water resources in particular. The Ministry of Urban Development and Housing received the missions similar to those entrusted to MINEE in the mobilization of water resources for domestic purposes in urban areas. The Ministry of Livestock, Fisheries and Animal Industries is more focused on the protection of marine and river resources, studies and researches for the recovery of fisheries and fishery resources. The department is also involved in water resources management through the development of pastoral water. The Ministry of Agriculture and Rural Development focuses on the conservation, soil restructuring and the development of irrigation schemes, and also the development of rural water supply. Other administrations including the National Committee of Water and the National Committee for the Environment, both inoperative, should provide technical support, coordination and consultation. This sector is then composed of a plethora of stakeholders, which could result in a lack of coordination between them and the main actor MINEE. Moreover, this may result in incompleteness of information regarding water resources management and sanitation, and inadequate monitoring and evaluation of water resources, data collection, processing and management. Moreover, the decisions in terms of

[25] The configuration of the institutional landscape of the water sector falls into three major colleges of actors that are: i °) the state and its main divisions especially the Ministry of Energy and Water (MINEE) but also other ministries, agencies under guardianship, and regional and local authorities; ° ii) other users of the private sector and civil society; iii °) and the partners of cooperation.

"watershed management" are taken here in a comprehensive way from a top-down approach, rather than from an integrated management approach.

Due to the reforms implemented in the urban water sub-sector, public services for drinking water have been delegated to two companies. The first is the Cameroon Water Utilities Corporation (CAMWATER), a public company responsible for the management of assets and rights assigned to drinking water service in urban and sub-urban areas. It is also responsible for the construction, maintenance and management of infrastructure of collection, transport and storage of water. The second, the Camerounaise des Eaux (CDE), which operates within the framework of a public-private partnership, is responsible for the production and distribution of drinking water in urban and sub-urban areas, the maintenance of water treatment facilities and related activities linked to sales functions, including statement, billing and collection of revenue (MINEE/GWP, 2009d). Since both companies are responsible for the maintenance of water treatment facilities, this in some cases leads to a free rider problem, and therefore in a management conflict, when there is need to act. No responsibility is emphasized regarding the proper management of watersheds on which their activities and profits depend.

In terms of water and sanitation, the country cooperates with the international community. It ratified thirty multilateral environmental conventions including a number related to the problems of water and sanitation. Through the financing and facilitation organizations, this cooperation ensures the majority of funding to the water sector. Thus, the government represented by MINEE received in July 2006 the financial support of the Global Water Partnership in the framework of the programme "Partnership for African' Water Development (PAWD)". This support was directed to the implementation of PAWD II (the integrated water resources management (IWRM)), and to develop the integrated management action plan of water resources (PANGIRE), which the first step was reached in 2010 with the development of "*the state of the water sector in Cameroon*".

2.4.1.2 Externalities and the management of watersheds in Cameroon

I. Contribution of Water Sector to the Socio-economic development of the country.

Cameroon has enormous water resources, grouped into eight macro-watersheds and five river basins: the Lake Chad Basin, the Niger basin, the Sanaga basin, the Congo basin and the coastal rivers basin (MINEE/GWP, 2009a). Three of the five basins are shared with other

countries: Lake Chad, Niger and Congo basins (see Figure Annex). The river system is made up of waterways and natural or artificial lakes. The resources available are categorized into surface and groundwater representing respectively 55.98 km^3 and 267.88 km3, with groundwater representing 21% of surface water resources.

The country with its 475 442 km^2 area, accounts approximately 8.3% of inland waterways consisting of rivers (0.02%), flood plains and marshes (7.2%), natural lakes (0.4%) and artificial water reservoirs (0.6%). By its physical diversity, climate and geographical position, the country has several fragile ecosystems or wetlands, areas subject to desertification and floods. The main wetlands of countries are distributed into wetlands of running water, stagnant flood waters and of coastal areas (MINEE/GWP, 2009a). Moreover, water resources, especially cross-border, are subject of regional and sub-regional cooperation bodies of which Cameroon is a member such as the Niger Basin Authority (NBA), the Lake Chad Basin Commission (LCBC).

In terms of water resources exploitation, the greater part of water consumption needs goes to hydropower (88.74%), followed by irrigation (7.25%) and household consumption (2.96%). Farming, industry and mining are the last with 0.88%, 0.138% and 0.026% respectively as illustrated in Table 2.8. However, it should be noted that hydropower is within the non-consumptive demand and thus, is not competitive to other uses. Considering the competitive demand, irrigation is the largest consumer of resources of the country with 64.36% of needs, followed by home consumption (26.32%), farming (7, 85%), industry (1.22%) and mining (0.23%) (GWP, 2010). In the context of fulfilling the economic function of water, a major investment is made to generate a value added of FCFA 13.8 billion and FCFA 81.046 billion respectively in urban water and hydroelectricity. An offer in terms of achieving 17,745 equivalent waterhole (EPE), that ensures the provision of 116,935 m3 /day of water in rural areas (GWP, 2010). However, with the access to drinking water for 75.1%, 27.7% and 43.9% household respectively in urban and rural areas and the whole country, the country remains below the Millennium Development goals (MDGs).

Table 2. 8: Water needs per basin and types of end use

	Bassins						
Needs	Lake Chad	Niger	Sanaga	Congo	Costal Rivers	**Total for Cameroon (10^{-3} km^3)**	**% of the needs per usage, ratio to total**
Domestic /Households	55.07	65.9	101.6	14.9	88.8	**326.27**	**2.96**
Livestock	84.01	13.4	--	--	--	**97.41**	**0.88**
Irrigation	328.95	377.08	--	--	91.79	**797.82**	**7.25**
Hydroelectricity	--	7600	2169	--	--	**9769**	**88.74**
Industries	--	0.33	8.16	0.06	6.62	**15.17**	**0.138**
Mines	--	--	--	2.9	--	**2.9**	**0.026**
Needs(10^{-3} km$^{3)}$	**468.03**	**8056.71**	**2278.76**	**17.86**	**187.21**	**11,008.57**	**100**

Source: MINEE/GWP, 2009; GWP, 2010

Regarding the water resources management financing, the national budget has supported investments in the water sector by an average of CFA15 billion per year, or 0.73% of its total value and 0.2% of GDP between 2004 and 2008. These financial resources represent only about 7.5% of which should be allocated to that sector in respect to the commitments and statements of the government. Between 1997 and 2003, public resources for rural water amounted FCFA37.9 billion, covered at least in three-fifth by international aid. Comparing the budget of the water sector to those in social sectors, it occupies the last position with that of Social Affairs, both being preceded by the education sector and the health sector with an average annual budget of FCFA 310 and 87.6 billion respectively over the period 2004-2008. To improve access to safe water and sanitation, the investment effort to support should be in line with the MDGs. This effort is evaluated at FCFA277.985 billion between 2007 and 2016, and 270.2 billion between 2007 and 2015, respectively, for urban and rural water, and rural sanitation. To meet these needs, development partners have availed FCFA 400 billion, of which CFA200 billion francs for drinking water and CFA 200 billion francs for sanitation (MINEE/GWP, 2009c; GWP, 2010).

II. The issue of protecting water resources from various degradations

If the unavailability (quantitative and qualitative) of resources is detrimental to certain development activities, their relative abundance/scarcity involve risks, and are a source of nuisances. In Cameroon, as in many developing countries, water is one of the most threatened environments. Indeed, in urban and rural areas, 80 to 90% of wastewater discharged into rivers or coasts are raw sewage, that is to say, discharges that have not been treated. The

causes of the degradation of water resources are multiple and can be classified into two categories, namely those of climatic origin and anthropogenic origin (MINEPAT, 2007; Chifamba, 2011; Ajonina, 2011; Kometa and Ebot, 2012; GWP, 2010; R-PP, 2012). Regarding climate causes, the northern part of the country is characterized, for over thirty years by a decrease and irregular rainfall. This has resulted to a persistent drought that weakened the ecosystems and reduced the potential of natural resources such as land, flora, fauna, surface water and groundwater resources (MINEPAT, 2007; MINEE/GWP, 2009b; GWP, 2010).

Anthropogenic causes are related firstly to population growth which led to the overexploitation of natural resources to meet the needs of fuelwood energy increasingly important, secondly to poor farming practices such slash and burn agriculture that has contributed to further deteriorate the soil and destroy vegetation cover, and finally bush fires which destroyed vegetation and natural pastures (MINEPAT, 2007; Chifamba, 2011; Kometa and Ebot, 2012). According to Demenou (1997), commercial fuelwood collection significantly degrades forest in a few peri-urban areas specialized in this activity and in most other areas, families collect most of their fuelwood from forest they clear for crop production. Moreover, although fuelwood is considered as a by-product of clearing for agriculture, fuelwood and charcoal market is the largest market for forest products in terms of physical volume of timber felled. An annual per capita consumption estimate for the country in 1994 was approximately $1m^3$, with total national consumption estimated at 13 million m^3. According to MINEE (2010), fuelwood consumption increased from 1981/1982 to 2001/2002 at an annual rate of 2.67%. A recent study by the National Institute of Statistics (2008) shown that 83% of Cameroon's populations depend on biomass as a source of energy, and in rural areas it is the only available source of energy. MINEE's estimate consumption from biomass is 91.18% for firewood, charcoal (0.9%), bagasse and palm kernel shell (5.39%) and other waste (2.45%). Over-collection of firewood then destroys/degrades forest and riparian buffer along rivers or lakes. The bare soils due to these activities are exposed directly to the weather (wind, rain, sun) resulting in important water erosion which causes sedimentation of rivers, ponds or lakes.

The silting and siltation are observed on all rivers in Cameroon (MINEPAT, 2007; GWP, 2010). The inland shipping sector is most affected by this phenomenon because the safe waterway period is reduced year by year. Moreover, floating plants introduced as ornamentals

are now a serious threat to the existence of rivers and socio-economic development activities such as fishing, transport, distribution of water, hydro-electric power (GWP, 2010). Water resources are also subject to an increased risk of pollution from household activities with waste solid, waste waters and sewage systems leading directly into watercourses; industrial activities with the effluents from most industries which are dumped untreated into waterways, and poor fishing practices by pesticide use (GWP, 2010; République du Cameroun, 2012, 2014; Tchouto et al, 2015.). This pollution resulting from the rapid population growth, sanitation infrastructure and inadequate treatment of waste constitutes a threat to the public health, wildlife and also to the revenue sources, including fishing and tourism (GWP, 2010).

From waterborne diseases statistics, intestinal helminths have affected more than 10 million of Cameroonian between 2003 and 2006. On an average health expenditure per household health and per month of FCFA7, 854 (representing 29% of the average income estimated at FCFA 26 800), the share of poor water and non-sanitation diseases is 70%. The annual amount of expenses related to waterborne diseases per household is estimated at FCFA65, 975. From a value of imports-based medicines and medical equipments of FCFA 213.675billion between 2001 and 2005, poor water and non-sanitation diseases have caused an outflow of currencies of about FCFA149.572 billion, with FCFA29.914 billion a year (GWP, 2010).

Water sector financing in the country suffers among others of the non-consideration of water as a strategic sector from a socioeconomic development perspective, the low rate of implementation of the investment budget, the non-compliance with engagements particularly in urban water, the absence of a mechanism for coordination interventions of development partners in the water sector, and non-accounting for the payments for watershed protection. Furthermore, from the strategy paper for growth and employment (DSCE) of the country (which defines its vision by 2035 as an emerging country), activities related to water and sanitation although well mentioned, are reduced just to improving access to water quality and sanitation facilities, ignoring the other sub-sectors of water that include water for agriculture, livestock, fisheries, transport, and environment among others. (DSCE, 2009, p62-63). Therefore, water sector of the country is still far from being at the heart of the process of economic and social development, which should account for food security, livestock, and fishing activities.

Food security and navigation: The control of water through the watershed management will not only ensure food security through increased agricultural productivity due to the constant availability of water for several annual crop cycles (this in response to repeated and timely climate related drought), but also will ensure the safe transport of agricultural products in rural areas inland waterway. Moreover, from a hydro-agricultural potential estimated at 290,000 hectare, about 14%, that is, 40,000 hectare are under irrigation scheme. The country is the biggest and the leading center of agricultural production in Central Africa, and has a regional opportunity to increase its potential for vegetable crops and export (cocoa, coffee, etc.), especially in a context where the third sector (services) contribution to real GDP is increasingly important over the last decade and led growth between 2011-2013 (INS, 2013).

Livestock: There is a frequent dichotomy observed between water points and pastures in the country, that is, where there are pastures, there is little or no water and where there is plenty of water, that is, permanent water, there is no pasture. An integrated watershed management approach could allow a harmonious development of livestock, which by the nature is essentially of wanderer (nomad).

Fishing: The fishing sector plays a nutritional role of great importance. The fishery products constitute nearly a third of animal protein consumed in the country and occupy 5% of the active production. Its contribution to the GDP of primary sector is about 5%. In recent years, annual production has stagnated around a bit more 125,000 tonnes of fish including 9,700tonnes from industrial fisheries, 63,000tonnes of maritime fisheries, and 50,000tonnes of continental fishing. While fishing however, has great potential for development (the country has a coastline of 360 km with an exclusive economic zone (EEZ) of 40km, and varous species of fish), the main constraints to the development of craft, maritime and continental fishing have been identified. These include the remoteness of production areas and the lack of a structured network of fresh fish distribution within the country (resulting in huge loses of catch), the use of poor technique and production equipment (canoes in majority) and rudimentary conservation means, the difficulty in access to credit, the irrational exploitation of fisheries resources and the lack of control mechanisms, monitoring and surveillance of fishing activities. Most fishermen are foreigners and almost half of the fishing products are exported “illegally” to the neighbouring countries. Another constrainst is the lack of the organization of fishermen and other stakeholders (including community management of fisheries resources). Aquaculture or fish breading, despite its advantages (potential production

estimated at 20,000 tonnes), remains almost a confined family business (50tonnes in 1997/98) due to most of the constraints highlighted including high cost of ponds and training (GWP, 2010).

***Environment**:* The country is home to several wetlands and watersheds of great interest for ecosystem conservation. A number of them such as that of Barombi Mbo are threatened by both physical degradation due to human activities, but also by a reduction in vital water resources for their preservation (Ajonina, 2011; Tchouto et al., 2015). Since a wetland is an area where the main element influencing the biotic and the abiotic factors is water, improved watersheds management will ensure ecological sustainability in these fragile areas.

The strong correlation between water and economic and social development has led governments, private organizations, and donors etc, to develop watershed management projects in some regions of the country. Helvetas (1994) developed a watershed protection project in Tubah upland watershed and Bambui watershed which focused on rehabilitating the watersheds, preserving their rare biodiversity and conserving the water resources through vegetative cover establishment (see Kwenty, 2011). In addition, from the incentive mechanisms developed at the international level for climate change and the preservation of biodiversity including the international PES or REDD + (Barbier, 2011), positive effects could arise at the watershed level as local or regional ecosystem.

2.4.2 PES Framework in Cameroon

Cameroon is a signatory of the UNFCCC and in 2012, the country submitted its Readiness Preparation Proposal (RPP) to the United Nations REDD+ programme (UNREDD+), under the Forest Carbon Partnership Facility (FCPF) of the World Bank (CFA 100 billion). In the RPP, the country manifested its willingness to implement REDD+ at the national level as a tool to achieve sustainable development. More mobilization are being made in the country for the development of a REDD+ national strategy, which mechanism is viewed by the government as "*a participatory and inclusive mechanism that integrate loudly the concerns of the different stakeholders and indigenous people, and respond to the socio-economic development problems of the country by taking into account the set of solutions required to mitigate climate problem*" (R-PP, 2012). However, there is need to find a way to finance such mechanism through innovation financing means. Moreover, PES schemes have not yet been established by legislation in place, but there are a set of provisions that relate to them.

2.4.2.1 Legal and Institutional Framework for PES schemes in Cameroon

In Cameroon, the concept of environmental services lacks recognition in society as well as their formal establishment in the constitution or legislation. However, the concept of ES and PES could be easily taken up by the Cameroonian legislation.

The Constitution and laws governing natural resources or ecosystems management in the country does not explicitly mention PES. However, the country's constitution authorizes protection of the environment and recognizes the role of environmental resources in the development process. It grants citizens a 'right to a healthy environment' where it is mentioned in its preamble: *"…every person shall have a right to a healthy environment. The protection of the environment shall be the duty of every citizen. The State shall ensure the protection and improvement of the environment".* Nonetheless, the preservation and environmental protection have always been viewed as a duty, but not as a service that could be provided, through incentive mechanisms deriving from market failures behind ecosystems management.

Forestry law: Besides the Law No. 98/005 of 14 April 1998 on Water Regime and its implementation Decrees, the Forestry Law N° 94/01 of 20 January 1994 contains an explicit reference to forest ecosystem services and provides for their sustainable management, thereby linking environmental, economic and social concerns. Indeed, the forestry law is crucial for the governance of PES in the country. The country foresees management plans under its forestry law aimed at the sustainable use of forest goods and services in protected areas (national park, reserves, zoo, etc). The law also foresees community and commercial hunting zones (ZIC, ZICGC), and community forestry, where the communities around these areas have the duty to sustainably manage forests and wildlife resources (Section 24, 37). Section 14 (1) forbids any one to light a fire that may cause damage to the vegetation of the national forest estate without prior authorization from the local authority in accordance with the order of the Senior Divisional Officer. Furthermore, sections 15 and 16 of *the intervention norms in forestry zone* protect ecologically fragile areas of watersheds (wetlands) from mechanical activities such as agriculture and timber exploitation that degrade soil. *"Such activities in this area can cause the destruction of soil that would be subject to intense erosion. This area is entirely dedicated to protection". The exploitation of NTFPs is at all times, but the collection of wood and fuel wood is not done during dry season. Timber exploitation is forbidden in swampy areas and in a radius of 30 m around water sources and along streams. Moreover, in*

areas of steep slope, trees must not be cut down. This maintains around rivers, a gallery forest to protect their regime (MINEF, 1998).

Environmental law: the Law No. 96/12 of 5th August 1996 relating to Environmental Management is the national framework law that propagates a holistic view of the environment. It mandates the government to develop and implement environmental policies and instruments, establish environmental standards and research, and gather information on environmental issues. It establishes an environmental planning process and provides for public participation. Furthermore, it creates coordinating institutions, oversees a financial mechanism, and provides the basis economic instruments. This law just like the forestry law do not provide any particular specific provision for PES. However the law provides that "*the environment constitutes a national common heritage …its protection and rational management of resources it provides to human life are of general interest* (Section 2 (1), (2)). It mandates the President of the Republic to draw up the national environmental policy which shall define the national strategies, plan or programmes for the conservation and sustainable use of environmental resources, which shall be implemented by the government, decentralized authorities, grassroots communities and environmental protection associations.

The framework also provides that the laws and regulations should guarantee the right of everyone to a sound environment and ensure a harmonious balance within ecosystems and between the urban and rural zones (Section 5). Most of all Section 62 provides that: **'***The protection of nature, the preservation of animal and plant species and their habitat, the maintenance of biological balance and ecosystems and the conservation of biodiversity and genetic diversity against all causes of degradation and threats of extinction are of national interest'*. It then places a duty on the state and citizens to safeguard this natural heritage. The law also punishes any person who pollutes or degrades the soil and subsoil thereby altering the quality of water. Moreover, with respect to ***taxes and charges***, the law provides for tax exemptions as incentives for conservation measures. However, these provisions are not always implemented by the state financial authorities.

Land tenure Law: Land tenure rights are a very important aspect of PES and greatly affects the implementation of PES schemes and they determine the level to which PES schemes can be effectively carried out especially when it comes to PES schemes in watershed areas. Law No. 74-1 of 6th July 1974 establish rules governing land tenure in Cameroon. This law provides that the State is the guardian of all lands in the country (Article 1 (2)). However it

also provides that custodian communities who are occupying and using lands, which are occupied by houses, farms and plantations and grazing lands manifesting human presences and development[26] may apply for land certificates in accordance with the law governing the application of Land Certificates.[27] The law therefore makes it mandatory for communities to obtain land certificates on land that they have been occupying. The importance of property rights in watershed PES schemes cannot be overstated. Properly delimited boundaries promote effective PES schemes in watershed areas.

MINEPDED is the leading and coordinating government institution for REDD+ in Cameroon. Then, a national PES scheme would be under the trustship of MINEPDEP. Moreover, the National Programme for Participatory Development (PNDP) of MINEPAT is the structure undertaking the ongoing implementation of REDD+ projects for councils under the coordination of MINEPDED. This is expected to lead to the national REDD+ strategy. At the stage of the Project Idea Note (PIN), ten (10) projects were selected from 365 councils within the five agro-ecological zones of the country, and the next step will to develop the project description document (PDD) for the six (6) retained projects out of ten. MINFOF/CIFOR (2013) evaluated the contribution of PES to the national economy and concluded that once implemented, the mechanism could generate average annual net revenues from FCFA11.66 to 25.05 billion that would benefit to the government, councils, management structures and local communities. While the evaluation study also provides the key of sharing PES benefits among stakeholders based on that of annual forest fees, it further hightlights that this amount could increase with the valuation of watersheds protection.

2.4.2.2 Typology of Payments for Ecosystems Management in Cameroon

Figure 2.8 gives a conceptual analysis for the voluntary financing mechanisms for ecosystems services management in the country. These can be divided broadly into carbon based schemes (CDM, REDD+) and PES schemes including Trust funds and others compensatory schemes which can be held either by the government, communities, private sector or NGOs**.** Compensatory schemes held by government, private sector or communities may not necessary be monetary in nature but may be physical or capacity building activities. Despite some

[26] This land is called National Land. Section 14 of the Land Tenure Law does not give a definition of national land. It only lists the types of land that are considered national land. One of them is land that is occupied by the community and have been used by them for a long time.

[27]The Law on the application of Land Certificates is Law No. 76-165 of 27 April 1976 to Establish the Conditions for Obtaining Land Certificate as amended by Decree No. 2005-481 of 16 December 2005 to Amend and Supplement some Provisions of Decree No. 76-165 of 27 April 1976 to Establish the Conditions for Obtaining land Certificates.

promising local initiatives of PES pilot projects that have been implemented in the country little attention is given to these innovative financial mechanisms for ecosystem services that are PES for their own. The state of PES schemes or PES development is presented in Table 2.9.

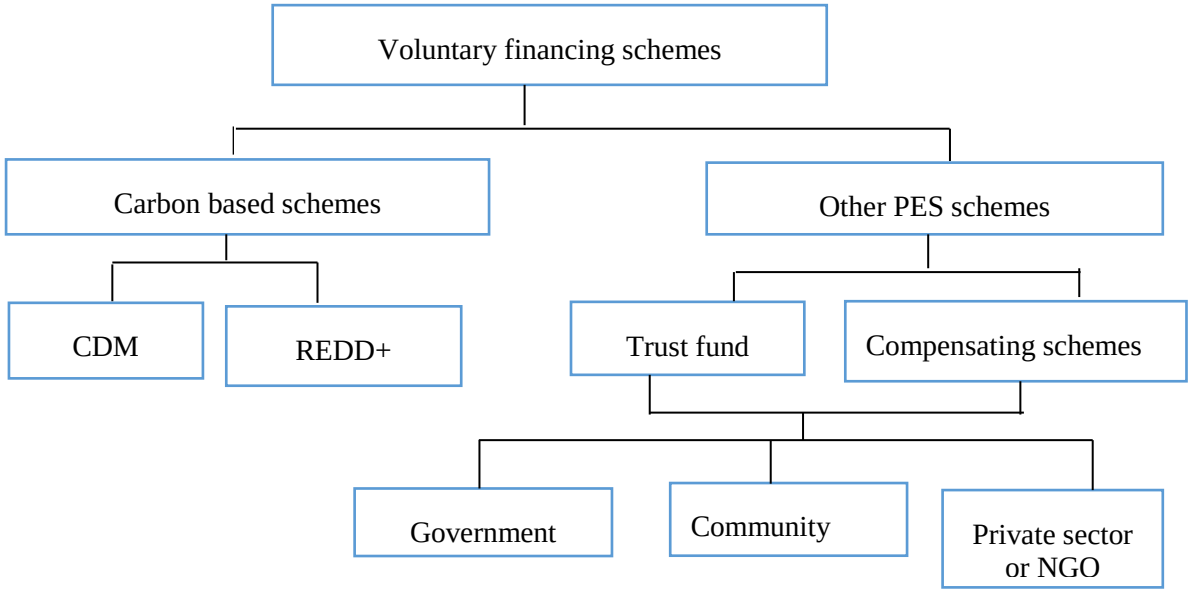


Figure 2.8: Conceptual analysis of voluntary payment for ecosystems management in Cameroon. Source: Author construction

Table 2. 9: State of 'potential' PES schemes in Cameroon

	Schemes	
Trust	**Government**	***Annual Forest Fee (AFF):*** The AFF is a fee transfert from forest concessions (forest management units) and production forests to riparian populations (Articles 26, 67 and 68 of the 1994 forestry Law). The AFF gives councils and local communities' access to funds that were previously completely controlled by the State. According to Order N°0076/MINATD/MINFI/MINFOF of 26 June 2012, the government share is 50%, while 50% goes to the community accounts (20% to all councils managed by FEICOM – Council Fund, 20 % to the catchment councils and 10% to concerned village communities).
		Hunting taxes revenue: In addition to the rental fees from hunting zone (ZIC) and the community hunting zones (ZICGC), the local committees that manage the ZICGC (COVAREF) and rent the areas to professional hunting guides, receive 10% of the leasing and hunting taxes from ZICGC operators (Article 8 of Order N°0076).
	Private or NGO	***The Sangha Tri-National trust fund (FTNS) activities:*** FTNS as trust fund for environment in Central African established in 2007, contributes to the long-term financing of conservation and eco-development activities, and to the cross-border cooperation in the forestry complex and protected areas of the Sangha Tri-National, which covers Cameroon, Central African Republic and Congo a surface area of 4.4 million hectares. FTNS pursuits activities of anti-poaching,

Fund		promotes ecotourism, supports institutions, and ensure the capacity building of local communities, their involvement in carbon emission reduction mechanism, and the improvement of their living conditions.
Compensating Schemes	**Biodiversity Conservation**	
	Marine turtle conservation in the Campo National Park: The initiative started in 1999 with the objective to protect the marine turtles with their habitats and improving wellbeing of local population, while creating a marine sanctuary for marine turtles. The project was funded by Tropenbos Foundation (1999-2002); EU (2003-2005); GEF/PNUD (2010-2011) and Tourists in Kribi. The sellers were fishermen who capture marine turtles accidentally in their fishing nets and other local communities who collect turtle eggs. This initiative for biodiversity conservation received the support of intermediaries such as WWF, local NGOs (KUD'A TUBE) and also from local government services of MINFOF, MINEP, MINEPIA, etc. The fisherman which accidentally captured an alive marine turtle receives FCFA 10,000 (US$20) based on the local cost of marine turtle and equivalent kg of meat, and CFA10 (US$0.02) per egg from a tourist through a system of sponsorship campaign for tourists who receive a sponsorship certificate. However, the main concern was that the payment depends on the tourist visit and the number of accidentally caught fish which cannot be known with certainty.	
	The Mount Cameroon National Park conservation incentives: The Programme for Sustainable Management of Natural Resources South-West Region (PSMNR-SWR) has signed a Conservation Development agreement with villages around the parks for enhancing management performance and communication. 91 villages are involved and the conservation incentives promote collaboration and create benefits at individual and community level. PSMNR-SWR develops income generating activities at the farm level with cocoa, cassava, plantain, agro-forestry development, and also improves socio-economic infrastructure including water, roads to main markets. Moreover, it encourages income from sustainable resource management and the use of Non-timber Forest Products (NTFPs) like bush mango and the prunus bark (*Prunus Africana*). As far as prunus bark is concerned, local communities revceive 60% of the benefits for road, and council infrastructures construction; 30% goes to the harvesters and 10% to the management structure. There is also a system of conservation bonus that is implemented for poaching and enroachment reporting. However, the scheme is not so far from the traditional ICDP although it introduced conservation bonus as incentive schemes and agro-forestry.	
	Carbon Sequestration	
	Community PES initiated by the CED, BioClimate Research & Development (BioClimate) and the Rainforest Foundation DFID,UK: This pilot initiative assists local community of Nkolenyeng (1043ha) and Nomejoh (1759 ha) in Cameroon, to protect their forest resources using PES. The initiative seeks to change forest management practices and enables local communities to adopt sustainable resource management and receive direct payment for their environmental performance. Beyond having local impact, the project aims to nourish debates that are influencing the development of national REDD+ policy, even though government support for the project has been lukewarm. Households in both villages expressed their willingness to base exploitation of their forest on principles of ecosystem conservation in the hope to receive in return compensation to reduce poverty. This project took up the challenge of reconciling local development and global challenges of greenhouse gases reduction. *However, CED states that its PES pilot cases was not implanted for carbon credits purpose, but only a way to reorganize community forest management as alternative to logging.* Mainly, monetary compensation were some FCFA 32million (US$64000) to be disbursed through the intermediantion of CED to bank accounts of community farming groups practicing improved sub-canopy agroforestry that conserves forest cover involving the cultivation of short rotation crops, beekeeping, livestock and NTFPs collection and commercialization. Payment	

	hinged on community defined simple forest monitoring parameters based on tree density and forest area changes. The scheme has been a much lauded initiatives but the major drawbacks was the sustainability of funding mechanism after the buyers (donor) (DFID) left, and the lack of legislation supporting PES to avoid conflicts with private logging operators that continue exploiting timber in those CF with the support of local elites.
	The PES initiative of Ngoyla Mintom developed by WWF and funded by the European Union: The Ngoyla Mintom PES scheme focuses on the socio-economic aspect of the Ngoyla- Mintom forest conservation and sustainable management. The implementation of PES in particular for carbon trade for which Wildlife Works Carbon (WWC), the Nedbank and mining companies (CamIron and Geovic) were interested, permit to raise resources durability and increase the welfare of the local populations in four communities forests, while ensuring the continuity of the project activities. The project accompanied by Plan Vivo standard for carbon credits certification on the voluntary market has been attrubuted the carbon certificate in early 2017. However, the major concerns is that the certification process took long (5years), leading WWF to develop other socioeconomic activitives to stop local population discouragement, while waiting for carbon revenues generated from the voluntary market.
	Watershed Protection
	An agreement of CFA400 Million (US$80,000) is still being negotiated with private sector that has elements both for biodiversity compensation and payment for watershed protection services, concerning the development of the hydroelectric power Lom Pangar along the National Park Deng-Deng and involve Electricity Development Coorporation (EDC), World Bank, French Development Agency (AFD) and World Conservation Society (WCS) . Yet, the project is based on a macro watershed where externalities are usually difficult to internalize because of the large number of stakeholders involved.

Source: Author construction, from existing secondary data on pilot initiatives in the country

A critical appraisal of the state of PES implementation of the country highlights:

i. A multiplicity of external donor driven short-lived projects with sustainability problems. The multiplicity of projects addressing various biodiversity and natural resources degradation problems mostly end after 5years with critical problems of financial and institutional sustainability for long-term impacts after project ends.

ii. Many projects are not initially conceived as PES. Only very few of these projects (Community PES within the South and East Cameroon, Turtle marine project) were initially conceived as PES schemes where payments have been made to communities in exchange of undertaking land management activities in order to perpetuate ecosystem services. Though the funding source was not sustainable.

iii. Active participation and facilitating role of NGOs. Most national and international NGOs have been playing facilitating or intermediary roles in meeting the objectives and outcomes of these projects. Most national NGOs being heavily donor dependent lack vision and continuity especially in the face of very competitive and scarce donor funds.

iv. Low private sector participation. There is little active participation of the private sector especially the non-forestry sector ones in these PES schemes, though they make more profits from ecosystem services that derive from their natural resources exploitation activities, and are considered as potential warranty for sustainable funding. They still fail to see the linkages between resources exploitation and need to support actions to sustain the flow of ecosystem services. No private scheme between water users (Hydropower, water utilities companies, etc) and local communities has been implemented up to date, although few researches have focused their attention (Ngondep, 2011; Green Synergy/WWF, 2009). Ngondjep (2011) identified the most likely internalization modality to encourage the preservation of the hydroelectric potential of the lake Lagdo through agricultural activities carried out in its watershed. It appears that the outcome of the preservation of the hydroelectric potential of lake Lagdo is equal to the value of power lost by the power company due to the silting-up of the lake. A compensation system for farmers in the watershed seems to be the most adequate modality to extend the life of the lake. However, no private initiative is undertaken until now.

v. Low incentives for community to maintain ecosystem services. In most of these projects there are little incentives for communities to be engaged in activities to perpetuate the resources since most of the funds are directed towards meeting transaction costs, with very little resources achieving the desired changes in attitude and customs for improved land-use practices. Moreover, these initiatives or projects though well-intentioned, rather generate conflicts within the communities that are the intended beneficiaries targeted for the agency (donors, NGOs, etc). This is especially the case wherever there is lack of collaboration between communities or often contradiction in messages received from donors if more than one. Consequently, most of these initiatives or projects hardly meet their objectives, leaving post-project communities even worse-off than the pre-project stage with an accelerated degradation of ecosystem services. Lack of a clear governance, benefit sharing mechanisms, and monitoring system from external resource exploitation for the catchment communities further discourages them to maintain these ecosystem services.

vi. Low incentives for downstream households to contribute to the sustainable financing of watershed protection. Watershed protection provides not only water quality for drinking purpose but also safe water for household activities. Moreover, protecting watershed helps not only to stabilize local climate through carbon sequestration, but also to conserve biodiversity

(fish, bushmeat), and increase access to fuelwood. All this have substantial positive effects on health and household well-being. The access to water quality involves costs to household including treatment costs, costs for searching of other water sources when tap water is no longer available, costs in terms of job loss and sickness. Downstream household could compare these costs to their willingness to pay for watershed protection by upstream users, and decide whether to contribute or not. Household may contribute if WTP is less than for example the treatment cost of obtaining drinking water.

2.5 Conclusion of the chapter

Watershed is an important component of rural development and natural resources management strategies in many countries. A watershed is a special kind of common pool resource due to the hydrological system that link its resources. Management is difficult because watershed systems have multiple conflicting uses, so, any given approach spread benefits and costs unequally among users. Theories from commons research predict great difficulty in managing complex watersheds and explain why success has been limited to isolated, actively facilitated micro-watershed projects with a focus on social organization. Encouraging collective action is easiest at the micro-watershed level, but often optimal hydrological management requires working at the macro-watershed level, and potential tradeoff are suggested between these two approaches. Moreover, while for Hardin, the solution to common pool resource management lies on the individual or the State, the work of Ostrom and colleagues emphasizes the potential of self-governance institutions (communal governance). Furthermore, policy makers and practitioners have long enjoyed a suite of tools for addressing environmental issues including prescriptive regulation, redefinition of property rights, market mechanisms, moral suasion, and other financial incentives. However, looking at the environmental and sustainability challenges through the framework of ecosystem services helped justifying the use of payments for environmental services (PES) in setting where the policy case have been or might be weak. More importantly, the framework helps inform better use of the tools by identifying those lands that would be most valuable to conserve and showing new ways to use them by creating new market for the ES (positive externalities) generated.

PES has appeared as particular valuable tool in meeting the increasing need for improved environmental conservation, and has been considered as an important supply side innovation of buying conservation. They have been widespread in developed countries and in general

successful in countries with well-defined properties rights on forest resources. In Africa, some initiatives have emerged, despite the weak and fragile institutional framework of the context, or the absence of clear defined property rights required for successful PES schemes. However, given the high potential of natural resources of the continent, PES have been shown to curb global and local environmental degradation and poverty reduction. In the watershed context, ES providers and buyers have been shown to be easily identified since it is viewed at local rather than global scale as it was the case with carbon sequestration, and the potential of the bundled of ES that can be provided. Although power asymmetries between buyers and sellers have been acknowledged, PES have usually presented buyers and providers as equal players. At a field level, marginalized peasant and indigenous communities have to bargain not only with large hydroelectric power and water companies, and agri-businesses, but also with representatives of national, regional and municipal governments. Hence, the value of ES should be set by services providers rather services users.

Furthermore, it was difficult to consider that there exist a real water polity in Cameroon, taken from the perspective of "public policy". Indeed, studying public policy is to treat the action of the government, to understand which aspects of collective management are support by what authorities, policies, through which concrete terms, and generating what consequences for who. From the literature, the treatment of watershed related problems remains marginal in the country, despite the importance of watershed services and the existence of a department that is dedicated to them. Indeed, there is relatively dense regulatory framework and institutional bodies that govern the management of water resources. But these are not structured around a real strategy that make watersheds or water as a resource that must be preserved and use in a sustainable and rational way, as an environmental resource that can cause social conflicts if it is not well managed, a public health and development issue above all. Watersheds or water management in the country still remain an affair of the State, public authority, and its implementing agencies CAMWATER and CDE. The involvement of private operators, local and traditional authorities and citizens remains weak. At this level, the responsibility of municipalities or councils at the field level is almost zero. Yet, they are positioning themselves as genuine actors of local development and should therefore be committed to the development work in this area. Furthermore, there is few national data on water, and the monitoring mechanisms of water quality available for public consumption by competent authorities were almost absent. The legal and institutional configuration does not yet integrate the principles of integrated water resources management. In addition, watershed services

valuation did not receive much attention in the country, which can lead to the payments for watershed services that could rise the scare financial resources required to fill the gap with investment needs.

The next chapter explores the conceptual framework and methodology of the valuation of ecosystem services in the watersheds, and presents the study zone. Although ecosystem services valuation has been shown to be certainly difficult and stressed with uncertainties, one considers the exercise of valuing the ecosystem services or services of natural capital 'at the marginal', which consisted of determining the differences that relatively small changes in these services in the watershed make to human welfare. Indeed, changes in quality or quantity of ecosystem services have value insofar as they either change the benefits associated with human activities or change the costs of those activities. These changes in benefits and costs either have an impact on human welfare trough established markets and non-markets activities or free markets such as PES. The study zone is presented, with consideration of the upstream and downstream parts of the lake watershed along with the different stakeholders that intervene.

CHAPTER THREE

Conceptual Framework and Methodology of Environmental Services Valuation in Watersheds

3.1 Introduction

Watershed jointly produces both commodities and non-marketable goods and services including carbon sequestration, flood control, biodiversity and cultural services that are not necessarily traded on markets but highly valued by society. Created by the interactions of living organisms with their environment, these ecosystem services provide both the conditions and processes that sustain human life. People are part of ecosystem and, like all other living organisms, they affect the processes taking place there, as well as deriving welfare gains from them. Compared to organisms, people have an enormous influence on ecosystems as a results of the population numbers and densities, patterns of consumption and use of technology. Therefore, the provision of these ecosystem services is of highest societal and policy relevance, and a better understanding of the role of ecosystem services is critical for well-being, and sustainable development. Nonetheless, despite their obvious importance to our well-being, the recognition of ecosystem services and the roles they play rarely enters policy debates or public discussion. One of the major methodological challenging in assessing the provision of ecosystem or environmental services (ES) is the integration of risks and uncertainties across different ES as well as of spatial and temporal scales to assess synergies, trade-offs and threshold effects.

In recent years, a substantial research effort and policy interest of ES emerged, and the ES concept is used for diverse purposes such as raising awareness, policy analyses, regional and national land use planning or payments for environmental services (PES). In this context, the valuation of ES is crucial because the values associated with the provision and management of ecosystems have to be considered in the decisions we make as a society. This chapter focusses on the valuation of ecosystem services. It first presents the general framework of ecosystem services valuation, then the conceptual framework of ES valuation along with an overview of the different methods, the Contingent Valuation method (CVM) and choice experiment (CE) methodology are presented and discussed in section three. Section four presents the study zone.

3.2 Ecosystem Services Valuation: A General Framework

The general ignorance of ecosystem services is partly the results of modern society's dissociation between goods (computers, cars and clothing) on the one hand and services (biodiversity, nutrient cycling, and pollination) on the other hand. For example, it is perhaps not surprising as argued by Salzman (1997) that many children, when asked where milk comes from will reply without hesitation, 'from the grocery store'. However, the primary reason that ecosystem services are taken for granted, is that they are free. We explicitly value and place monetary figures on ecosystem goods such as timber and fish. Yet, the services underpinning these goods generally have no market value, not because they are worthless, but rather because there is no market to capture and express their value directly.

Classical economists (Smith, 1776; Ricardo, 1817; Say, 1829) emphasized the relative importance of ecosystem services by recognizing them as "*nature's benefits"* or "*use values*" for which no price could be paid. Smith (1776) emphasizes that the wealth of a particular society is the result of the amount of labor it embodies, including timber, pasture from rangeland and the yield of soil as "natural production". He does not consider value to stem from nature itself, but from rent derived from its appropriation. Ricardo (1817) wrote: "*natural agents are serviceable to us […] by adding to value in use; but as they perform their work gratuitously, as nothing is paid for the use of the air, of heat, and of water, the assistance which they afford us, adds nothing to value in exchange"*((1817), 2001, p.287). In line with Ricardo, Say (1829, p.250) states*: " the wind which turns our mills, and even the heat of the sun, work for us; but happily no one has yet been able to say, the wind and the sun are mine, and the service which they render must be paid for"*. Thus, Say poses the idea of nature's services as costless, free gifts of nature. However, Marx[28] (1891, 1970 p7) considered value to emerge from the combination of labor and nature. He states: *"Labor is not the source of all wealth. Nature is just as much the source of use values (and it is surely of such that material wealth consist!) as labor, which itself is only the manifestation of a force of nature"* (Gómez-Baggethun, E., et al., 2009). Figure 2.3 shows an evolvement of natural capital consideration in Economics.

[28] See also Marx ((1867), 1887p13; (1859); 1989pp22-23; cited in Gómez-Baggethun, E., et al., The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes, Ecological Economics (2009), doi:10.1016/j.ecolecon.2009.11.007

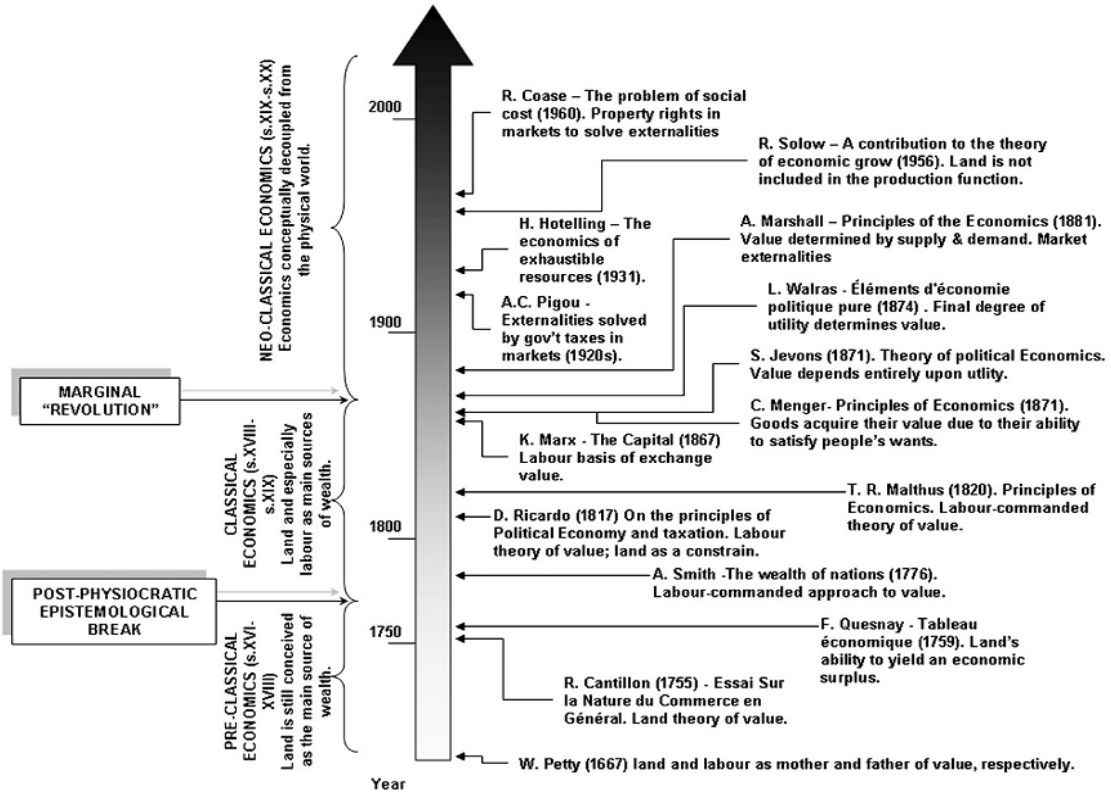


Figure 3. 1: Evolvement of the conception of nature in early Economics literature .Adapted from Gómez-Baggethun, E., et al., 2009.

Although awareness of ecosystem services in the watershed dates back to Plato, and to classical economists, efforts to identify and calculate these services' valuable contributions to social welfare by ecologists and economists are surprisingly recent (Costanza et al., 1997; Daily, 1997; Salzman, 1997; Toman, 1998; Loomis et al., 2000; Dasgupta, 2008; Barbier, 2011). Their research has demonstrated the extremely high costs of replacing many of these services if they were to fail (Dasgupta, 2008; Barbier, 2011). The book *Nature's Services: Societal Dependence on Natural Ecosystems* edited by Daily (1997) is an important synthesis. The book presents the first rigorous attempts to identify the range of ecosystem services and to objectively value the services in dollars; the book's findings also provide important insights for environmental law. The *New York Times* has welcomed the book as 'the pioneering efforts of some practical ecologists who are eager to make common cause with economists.

In line with Daily, Costanza and his colleagues in their paper "*The Value of the World's Ecosystem Services and Natural Capital"* of 1997, set out to capitalize all the existing data allowing to obtain an approximation of the total economic value of all the ecosystem services provided by the biosphere. They estimated the current economic value of 17 ecosystem

services (most of which is outside the market) for 16 biomes, based on about 100 published studies and a few original calculations. Each data is converted into US dollars (1994 base) per hectare per year. For the entire biosphere, the value is estimated to be in the range of US$16-54 trillion per year, while global national product is around US$18 trillion per year. But with the uncertainties surrounding ES, this value is considered a minimum estimate. However, the reactions aroused by this paper are going to be passionate and the positions taken, quite marked both positively and negatively. For example, Norgaard and Bote (1998), major actors of the strong sustainability view adopt a very critical attitude by titling their paper "*Next, the Value of God, and Other Reactions*" and justify it in this way: *"Will ecological economists bring us the value of God next? And will this be the end of history for economic valuation? Or, now that we know the exchange value of the earth, we wondered with whom we might exchange it and what we might be able to do with this money sans earth*[29]*…"*. Reaction unpleasant to Daily (1998, p.21) who reacts in turn specifying that *"The purpose of the authors of 'Pricing the Planet' is quite reasonable, and not, contrary to some wags, to sell, or rather rent, the earth to extraterrestrials. Nor do I consider their exercise in any way blasphemous, akin to putting a price on God (…)"*. Most negatively reactions arise due to the "large attempts" by authors to place a monetary value on the biosphere as an ecosystem, which one could either be sold or compared to another equivalent ecosystem that does not exist. But, the idea of Costanza et al. paper was to show that replacing the world's total natural capital is by definition impossible, for the simple reason that there would be nothing left to replace it with, because the value of the world's natural capital is "infinite". Hence, the issue of valuation is inseparable from the choices and decisions we have to make about ecological systems.

Furthermore, Water Act, the Endangered Species Act, and the National Forestry Act implicitly protect ecosystem services through their habitat protection and planning procedures. Hence, although some argue that ecosystem services cannot be evaluated, that we cannot place a value on such intangibles as human life, environmental aesthetics, or long term ecological benefits, in fact, we do so every day. We implicitly assess the value of these services every time we choose to protect or degrade the environment (Pearce, 1990). In this view Myers and Reichert (1997 cited in Meral 2012) underlined the leitmotiv: *"we don't protect what we don't value"*. Nonetheless, despite these statutes and initiatives, ecosystem

[29] http://www.sciencedirect.com/science/article/pii/S0921800998000123

protection remains inadequate (Salman, 1997). Perhaps, as underlined Salzman (1997), the most policy challenges facing protection of ecosystem is that of valuation, that is how to translate ecosystem's value into common units of assessment of development alternatives. In this sense, the hard decisions revolve not around whether ecosystem protection is a good thing, but rather how much we should protect and at what cost. For example, how would the flood control and water purification services of a particular forest be diminished by clear cutting or selective logging of 10%, 20%, 30% and 40% in a watershed? At what point does the ecosystem's net value to humans diminish, and by how much? Can the degradation of these ecosystem services (in addition to ecosystem goods) be accurately measured? And if so, how can partial loss of these services be balanced against benefits provided by development? Therefore, the fundamental issue is then whether our implicit valuation of ecosystem services is accurate, and if not, what should be done about it[30]. Moreover, while the estimated value of these services is impressive, it is important to recognize that these are estimates with significant challenges:

Landscape-specific nature of ecosystem services: A challenge in valuation is that an ecosystem service's value can be landscape-specific. The benefit to humans of an ecosystem is not a straightforward biophysical measure, it depends on its vegetation type, its goods, services or its amenities. Furthermore, identical ecosystems in different locations will have very different values. For instance, an ecosystem's carbon sequestration and biodiversity will be valuable even if distance from human population, but its role in pollination and flood control likely will not (Salzman, 1997).

***Absolute and marginal valuation of ecosystem services*:** Policy makers must concern themselves with two different types of valuation. The first is the absolute value of the ecosystem service. Methods to determine this have been identified. These values may prove important for political or advocacy purposes. Knowing that watersheds provide billions of dollars of services to local communities may make it easier to adopt regulations restricting development of watersheds or other protective measures. The second type of measure is marginal value. Land use decisions are made on the margins, such as whether to allow development of ten hectares in a seventy hectare wetland for instance. Absolute service values cannot inform this decision. Thus, the greatest need for ecosystem service valuation may be at the margins, determining how much is service provision worth in this particular location?

[30] This also refers to the size of ecosystem (national, local, particular) we should consider for valuation.

***Relative cost*:** Often, policy makers do not need to know the absolute value of a service at all, so long as it is obviously important. In deciding whether or not to invest in an ecosystem service or a technological service provider, the key question is relative cost, i.e. which approach provides the needed level of service at lowest cost? If it costs $10 million to build a treatment plant and $5 million to institute land use changes with the same resulting improvement in water quality, then investing in an ecosystem service makes financial sense irrespective of the absolute value of the water purification service. In this respect, valuing the costs of substitutes may be more important than valuing the absolute service. Moreover, other insight of an ecosystem services perspective is that investing in natural capital can prove more efficient than using built capital to deliver key services. For example, floodwaters can be addressed through built capital, such as engineered works (e.g., construction and maintenance of dikes and levees) or through natural capital, such as landscape management (e.g., restoration of wetlands in flood plains). In some instances, perhaps many, landscape management may prove a better public and private investment strategy for providing flood control once one accounts for the positive externalities of improved water quality, wildlife habitat, and recreational amenities.

Hence, ecosystem services make critically important contributions to human welfare and valuation can make this clear. Depending on the circumstances, policy makers may need to decide whether an absolute and marginal valuation is most useful. A broader and more complete understanding of ecosystem services can further help justify the use of positive incentives. In using scarce governmental funds to promote particular environmental behavior, policy-makers generally would like to show that the funds generate equal or greater public benefits.

3.2.1 The Concept of Total Economic Value

The concept of total economic value (TEV) provides a framework to value ES uses and to take these into account when making policies that affects ES of watershed; and there is an increasing consensus that it is the most appropriate one to use (Barbier et al., 1997). Before proceeding with the conceptual framework of environmental valuation and the analysis of the techniques available for expressing in money terms the value of ES, the nature of such value must be explored. Two broad categories of values are defined in the literature as components of the TEV of ES: *Use value and Non-uses values*. The TEV of ES as applied to watershed is illustrated in figure 3.2.

1- The concept of Use Values (UV)

Use values are defined as the benefits that derive from the actual use of ES. For example, people can derive a benefit from burning firewood, using herbs for medicinal purposes, walking in a forest, watching birds, or admiring the landscape (Markandya et al., 2002). UV are grouped according to whether they are direct or indirect (Pearce and Turner, 1990). The former refers to those uses which are most familiar to us: harvesting of fish, collection of fuelwood and use of the watershed for recreation. Direct uses of watershed ES could involve both commercial and noncommercial activities. Commercial uses may be important for both domestic and international markets. In general, the value of marketed products (and services) of watersheds is easier to measure than the value of non-commercial direct uses such as transport through a river or lake.

In contrast, an additional category of UV is suggested to include those values that are not readily perceived when individuals are asked to evaluate the value of ES. For example, an individual may not be aware of the value of trees on greenhouse effects and the importance of the latter. This is one reason why policy makers often fail to consider these non-marketed informal uses of watersheds in many development decisions. Therefore, various ecological functions of watersheds may have important indirect use values (IUV). Their values derive from supporting or protecting economic activities that have directly measurable values. The IUV of an environmental function is related to the change in the value of production or consumption of the activity or property that it is protecting or supporting (Barbier et al., 1997). However, as this contribution is un-marketed, goes financially unrewarded and is only indirectly connected to economic activities, these IUV are difficult to quantify and are generally ignored in watersheds management decisions. For example, natural floodplains may recharge groundwater used for dryland agriculture, grazing livestock and domestic or even industrial use, yet many of these floodplains are threatened by dams and other barrages diverting water for upstream and water supply (Barbier et al., 1997; Gopal, 2016).

2- The concept of Option Values (OV)

In addition to the above UV, the concept of *option value (OV)* has also been introduced, that is, the additional value placed on a watershed by those people who want to have the option of using its ES in the future. According to Markandya et al. (2002), this concept is based on two basic arguments: uncertainties and irreversibility related to environmental issues. It is assumed here that if an individual is uncertain whether the ES will be available in the future,

he/she will be willing to pay a sum in excess of his/her expected consumer surplus to ensure that the ES will be available in the future. The OV therefore, can influence decision making regarding the most efficient allocation of ES (that is, conservation versus development). According to Barbier et al. (1997), in most cases, the preferred approach for incorporating OV into the analysis is through determining the difference between ex ante and ex post valuation. Moreover, if an individual is uncertain about the future value of a watershed, but believes it may be high or that current exploitation and conversion may be irreversible, then there may be quasi-option value derived from delaying the development activities. Thus, quasi-option value is simply the expected value of the information derived from delaying exploitation and conversion of the watershed today. Therefore, quasi-option value consists not as a separate component of benefit but involves the analyst in properly accounting for the implications of gaining additional information (Barbier et al., 1997).

3- The concept of Non-use Values (NUV)

Non-use values (NUV) are described as "*existence values (EV)*" and "*bequest values (BV)*". The argument behind existence value is that people do care about ES, not only because they or their heirs, can get some sort of benefits or can avoid some sort of loss by using or preserving ES. People wish to maintain or improve ES out of sympathy for animals and nature or from moral conviction. There is therefore an intrinsic value, a value that resides 'in' something and that is unrelated to human beings altogether (Markandya et al., 2002). For example, there are individuals who do not currently make use of watersheds but nevertheless wish to see them preserved "in their own right". EV is a form of NUV that is extremely difficult to measure, as EV involve subjective valuations by individuals unrelated to either their own or others' use, whether current or future. Another important subset of NUV or preservation values is bequest values (BV), which results from the desire of people for preserving ES for the enjoyment of other people of both the present and future generations. BV involves altruism such as, for example, the desire of individuals placing a high value on the conservation of tropical watersheds for future generations to use. BV may be particularly high among the local populations currently using a watershed, in that they would like to see the watershed and their way of life has evolved in conjunction with it passed on to their inheritors and future generations in general. Figure 3.2 provides an example of taxonomy described above with references to the forest and water resources in the watersheds.

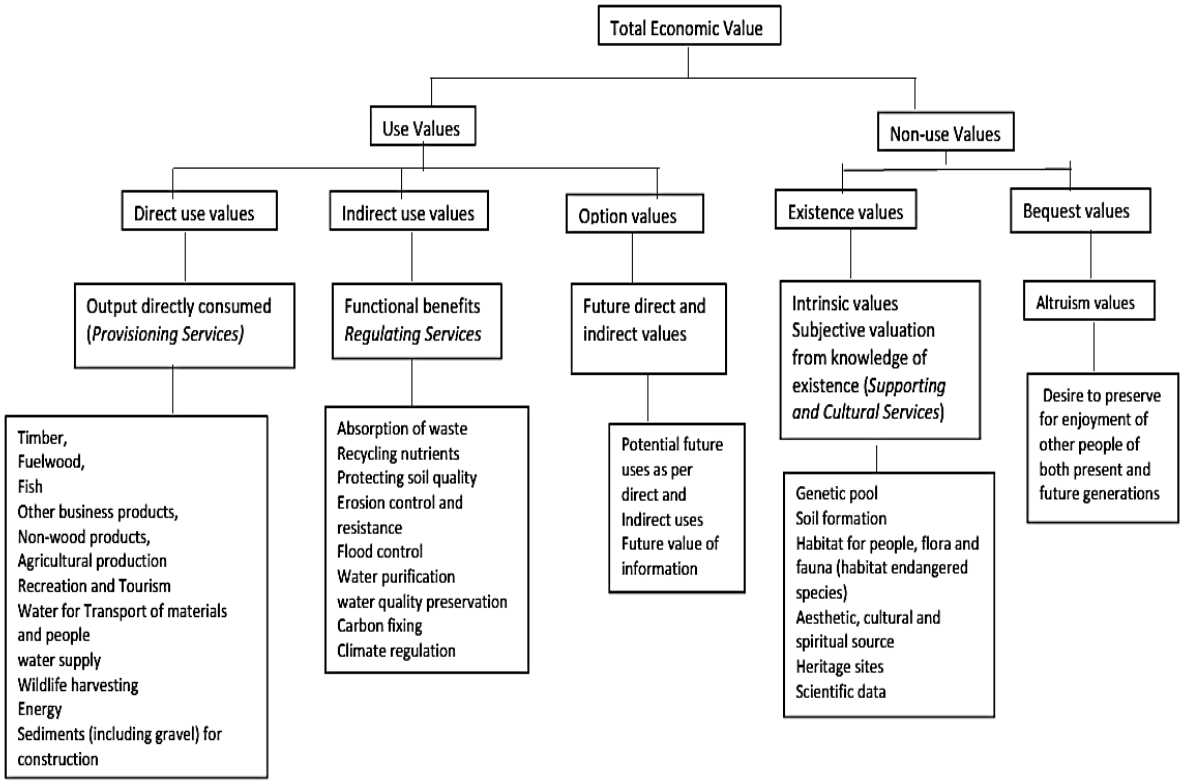


Figure 3. 2: Definition of the TEV of watershed ES. Adapted from Barbier et al., 1997; Pearce and Moran, 1994; Markandya et al., 2002, and Gopal, 2016

From figure 3.2, the total economic value of ES in the watershed is obtained as follows:

$$TEV = UV + NUV = (DUV + IUV + OV) + (BV + EV) \qquad (3.1)$$

However, even if, in practice, it is not easy to untangle these different components of TEV, the above concepts are usually bear in mind when estimating the value of environmental services. Moreover, in many circumstances, it is of crucial importance to assess the total value of ES, or that of some components of it, in monetary terms. Often, the benefits of a proposed development will be much greater than the primary use value of ES, but much less than the TEV of these ES. Furthermore, the measure of the value of ES is needed to comparing alternative projects, policies and programmes, to determine how far a policy should go. For example, how aggressive should greenhouse gas emissions be controlled (this, is a function of the magnitude of social losses and how these are to be measured). Moreover, the value of ES involves accounting for their depletion, often through green national accounting, or the promotion of landscape amenity. Measuring the ES value also could help in informing user pay policies, and to solve environmental litigation through compensation payment. All this however, usually depend on the monetary value individual place on the ES.

3.2.2 Welfare Foundation of ES Valuation: Basic Concepts of valuation methods

The monetary valuation of an ES is usually based on the monetary value that individual place on it. Thus, the maximum amount of money an individual is willing to pay for obtaining a benefit or avoiding a loss in most situations reflects the intensity of his/her preferences for such a benefit or loss. These preferences in turn are based on the value she or he attaches on the watershed (Markandya et al., 2002). Therefore, the maximum willingness to pay (WTP) can then be considered as an expression of individual's values, and the minimum willingness to accept (WTA) is an amount of money considered as compensation for producing the benefit or for incurring a cost and this reflect the value of such benefit or cost. For example, when an individual buys an ES paying market price, the price pay directly reveals a lower bound of his/her maximum WTP. Similarly, when an individual sells an ES receiving the market price, the amount of money received directly reveals upper bound for his/her minimum WTA for foregoing the use of such asset or to produce the asset. However, when there is no market for an ecosystem good or service, obviously there is no price that reveals the lower bound of individual's maximum WTP and the upper bound of the minimum WTA. In this case, to evaluate people WTP or WTA, that is, to obtain a monetary measure of the value individuals attach to a non-marketed ES, alternative means are used. But before discussing these means, some general concepts regarding WTP/WTA need to be presented.

According to Markandya et al. (2002), both maxWTP and minWTA of individuals for a change in the level of an ES can be measured looking at the variations of the individual's monetary expenditure required to keep him/her indifferent in terms of satisfaction (welfare), when change occurs. MaxWTP and minWTA can then be taken as the monetary indicators of the individual's welfare changes. Changes in the level of an ES in the watershed can then affect the welfare of individuals in different ways, according to basic economic features of the watershed. An ES may be priced, such that individuals have to pay some amount of money to secure its use (tap water supply). However, many ES are public or quasi-public goods, which while affecting the welfare of each individual, are not under control the control of each individual (for example air quality). According to these specific features, an individual therefore may be willing to pay or accept as compensation, to obtain, provide /avoid these changes that follow in the watershed ES: *price increase; price decrease; improvement in the quantity/quality available; and degradation of the quantity/quality available*. In these different contexts, the individual's maxWTP and minWTA are measured using the economic

concepts of *compensating variation (CV), equivalent variation (EV), compensating surplus (CSU) and equivalent surplus (ESU)* (Markandya et al., 2002). We will focus here on CSU and ESU of quantity/quality change of ES.

1- Measures of Welfare for free or uncontrolled ES

When considering ES outside the control of the consumer, it appears that any changes in their level affects the utility of the individual (figure 3.3b). Such effect will lead the self-interested consumer to make the following commitments/requests for payment as underlined by Markandya et al. (2002):

- In the case of an environmental improvement, to be willing to pay something to bring about the environmental improvement, or to require compensation to provide or supply the expected environmental improvement;
- In case of environmental degradation, to require compensation for the environmental damage or to be willing to pay something to prevent such damage.

In both cases there are measures of the WTP/WTA of the consumer for the environmental change (figure 3.3a). Figure 3.3 illustrates the welfare measure due to quantity/quality change in ES and the CSU and ESU for environmental improvement.

The *compensating surplus (CSU)* for an ES improvement is the amount of money that needs to be deducted from income of the consumer to keep him/her at the same level of utility as without environmental improvement (noted U_o) (figure 3.2b). While the *equivalent surplus (ESU)* for an environmental improvement is the additional income to be given to the consumer to bring him/her to the same level of utility U_1 that s/he would attain with the current income if environmental improvement from E_0 to E_1 occurred.

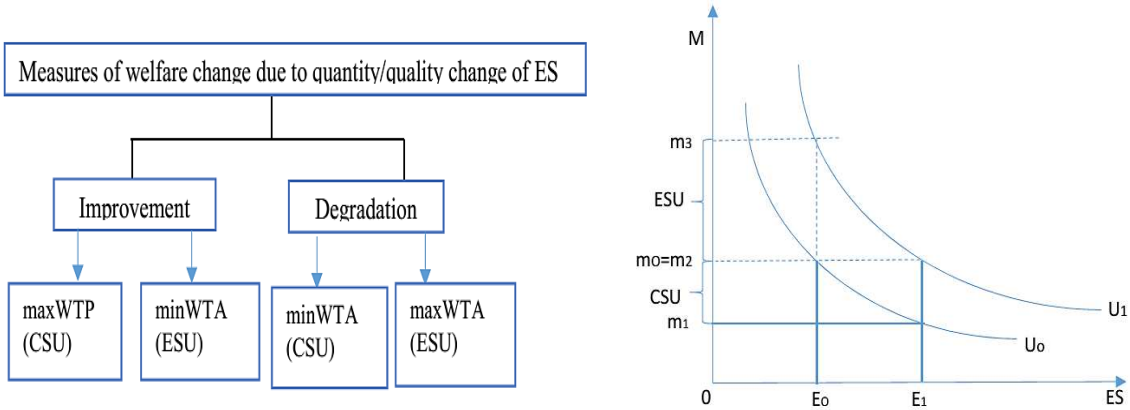


Figure 3.3a: Measure of minWTA & mawWTP for quantity/quality change; Figure 3.3b: ES improvement (CSU and ESU)

Figure 3. 3: Welfare measure due to quantity/quality change in ES and the CSU and ESU for environmental improvement

2- WTP/WTA for an environmental improvement

The maxWTP for an improvement is measured by CSU. Thus, if an environmental improvement from E_0 to E_1 occurs, other things equal, to keep the utility of the individual constant, this needs to be compensated by reductions of income available for consumption M. Hence, if the individual is asked how much s/he would be willing to pay at maximum to get environmental improvement, assuming that he behaves in a rational way, s/he would be willing to pay at maximum the difference $(m_o\text{-}m_1)$. That is, the savings in expenditure she would obtain to keep the utility level Uo if the environmental improvement does not occurs. The difference $(m_o\text{-}m_1)$, representing the WTP of a rational individual to get an environmental improvement, is then the CSU of the consumer's expenditure for the ES improvement.

The minimum required compensation to forgo the envisaged improvement or (to supply the improvement) is measured by ESU. An environmental improvement from E_0 to E_1, leads, *ceteris paribus*, to an increase of utility from U_0 to U_1. If the individual is now asked how much s/he would be willing to accept as a minimum, to forgo (or to supply) the environmental benefit, assuming he/she behaves in a rational way, s/he would be willing to accept at minimum the difference $(m_3\text{-}m_2)$, that is, the increase in expenditure s/he would incur to reach level U_1 if the improvement does not occur (or the expenditure s/he would incur to allow achieving the utility level U_1 if improvement of the environment occur). The difference $(m_3\text{-}m_2)$, representing the minimum compensation required (minWTA) of a rational individual to forgo (or supply) an environmental improvement, is then the ESU of the consumer's expenditure for the ES improvement. Different approaches have been use to assess the ES values and to compute the WTP and WTA for the watersheds environmental improvement.

3.3 Approaches of the Evaluation of watershed ES

Some popular and accepted evaluation approaches of watershed services have been proposed in the literature. These range from environmental costs-benefits analysis (ECBA) to the valuation methods. We first present the different approaches of watershed environmental evaluation and then the valuation methods.

3.3.1 Environmental Evaluation Approaches

This approaches include cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), multi-criteria analysis (MAC), cost-utility analysis (CUA) and impact analysis (IA) (i.e, environmental impact assessment (IEA), socioeconomic impact assessment).

1- Cost-Benefit Analysis (CBA) Approach to ES Evaluation

The CBA is used to compare costs of a policy (project) with the benefits to determine whether there is a net benefit to society. Given that resources are scarce, the selection of a given investment means that the resource will not be available for other alternative. Thus, there is an opportunity cost (OC) to carry out the investment. This OC is taken to be the cost of the project or the WTA for the project to be implemented. Similarly, the benefit is taken to be the WTP for the good or service. Hence, the net social benefit (NSB) is defined as: $= WTP - OC$. The rationale of CBA is that if NSB>0 then, in theory, the state can use the surplus to compensate the losers, i.e., potential Pareto improvement. Though this rule has generated controversy because it does not require actual compensation to take place, increasingly, we are seeing cases in which government is required, sometimes through the court system, to actually compensate losers in big development project. This is also the idea emphasizing the PES mechanism. The first formal application of CBA was in 1768 to evaluate the net benefits of Forth-Clyde canal in Scotland; and CBA first received official government recognition under the U.S Flood Control Act of 1936. Under this act, CBA was required to evaluate the benefits and costs of all water resource projects to whoever they accrue; and to show that flood control was in the interests of social welfare.

However, the first application of CBA that accounted for the value of amenity services, i.e, the application of the environmental CBA (ECBA) was done by Krutilla and Fisher (1975). In their model, the value stream of the commodity development alternative was larger in early years and diminishes steadily over future time, whereas the comparable amenity services stream increase over time.

- **Krutilla-Fisher (1975) Model**

Let $NSB_t = B_{d,t} - C_{d,t} - EC_t$ (1), where NSB = Net social benefit in time t for t = 1,2, ..,T, where T = project lifetime.

Let $EC_t = B(P)_t$ = environmental benefits of preservation in time t.

Similarly let $B_{d,t}$ and $C_{d,t}$ be written as $B(D)_t$ and $C(D)_t$, respectively for the benefits and cost streams associated with development without the environmental impacts. We can therefore write Equation 1 as:

- $NSB_t = B(D)_t - C(D)_t - B(P)_t$ (2)

Treating time as continuous, we can write (2) as

$$NPV(NSB) = \sum_{0}^{T} \frac{[B(D)_t - C(D)_t - B(P)_t]}{(1+r)^t}$$

Where NPV= Net Present Value. This can be written as

$$NPV(NSB) = \int_{0}^{T} [B(D)_t - C(D)_t]\, e^{-rt} dt - \int_{0}^{T} B(P)_t e^{-rt} dt \qquad (3)$$

According to Krutilla and Fisher (1975), the value of the wilderness amenity services will rise over time relative to the prices of the inputs and outputs from development. Most development options have close substitutes (e.g. fossil fuel vrs hydro power and nuclear). Rising demand for extractive outputs can be met at decreasing real costs over time. However, wilderness preservation benefits have effectively zero substitution possibilities, even with technological progress. Environmental amenity services have a high income elasticity of demand. But technological progress cannot augment the supply of these services. Therefore, with economic growth and technological change, we expect the relative value of natural environmental assets to increase.

We introduce this into the model as follows:

$$NPV(NSB) = \int_{0}^{T} [B - C]\, e^{-rt} dt - \int_{0}^{T} [Pe^{at}]\, e^{-rt} dt \qquad (4)$$

Where preservation benefits are assumed to grow at a constant rate a, giving a flow of benefits of Pe^{at}. While development benefits and costs are constant, we can rewrite Equation 4 as:

$$NPV(NSB) = NPV' - \int_{0}^{T} Pe^{-(r-a)t}]\, dt \qquad (5)$$

Thus, things to note given that "r" and "a" are corrective factors are:

1. If a > 0, NPV will be less than a=0 for a given NPV', i.e., if we take the Krutilla-Fisher argument on board, a development project is less likely to pass the inter-temporal allocative efficiency test for a given NPV'. Therefore, the demand for natural environment will be growing faster.

2. If a = r, then in effect preservation benefits are not discounted.

3. If a > r, then the benefits are discounted at a negative rate, and the discounted stream for P_t will be growing over time.

Assuming that $T \rightarrow \alpha$

We can rewrite (5) as NPV (NSB) = NPV' – P/(r-a) (6)

Therefore, for a ↑ => P/(r-a) ↑ => NPV↓ for a given NPV'

From the model presentation, Krutilla-Fisher stand in the intergenerational inefficiency this generates in allocations of natural environments as between development and amenities services. Furthermore, CBA applied to sewage treatment project in order to build a wastewater treatment facility and associated pumping stations and drainage pipework, reveals that the primary socio-economic benefits are a reduction in health costs and mortality rates due to reduced pollution to water resources and domestic drinking water, a reduction in the costs of treating increasingly polluted water supplies, and an increase in labor productivity as a result of a reduction in absence from work due to illness. Secondary economic benefits from projects include benefits to industry and agriculture from using recycled water, and additional revenues from re-afforestation (Asafu-Adjaye, 2014 notes).

2- Cost-Effectiveness Analysis (CEA)

The CEA technique is generally used for selecting among competing options to achieve a pre-established decision. The rationale is to compare the relative costs of the readily alternatives available and to choose the least cost option. In this approach, benefits are specific and common, but are not valued in monetary terms. CEA have been used by policy makers in finding out the least cost option to achieve a water pollution standard fixed at a certain level.

3- Environmental Impact Assessments (EIA)

An EIA imposes a participatory process through which the promoter of a project provides all information related to the proposed activity (e.g., location, nature, type of impact on the milieu and people, mitigation measures) in a public document. This information is placed at the disposal of the public and local communities at the project site. The resulting public consultations provide an opportunity for communities to draw attention to possible impacts on ecosystem services that have not been identified. In Cameroon, though foreseen in the 1996 Environmental Framework Law, EIAs were not implemented until 2005. The Ministry of the Environment and Protection of nature (MINEP) played a key role in preparing EIAs and the

current Ministry of the Environment, Protection of nature and Sustainable Development (MINEPDED) gives the green light for execution of the projects. These EIAs cover issues relating to ecosystems in urban and rural areas and established inconsistencies between proposed construction or project development and areas exposed to natural hazard such as floods, erosion, landslides and earthquakes.

4- Multi-Criteria Analysis for evaluating ES management

MCA provides a framework to explore and evaluate the effects of uncertainty and multiple objectives. It deal with qualitative or quantitative scores or measures, provides a flexible framework and has the ability to incorporate stakeholder preferences in considering people from different sciences. Thus, MCA is adopted when the problem is complex, and information discovery is important and could involve input from multiple disciples; when outcome are uncertain and difficult to value in monetary terms, and the stakeholders are in conflict about the importance of multiple outcome or criteria. In addition, MCA requires the final decision to represent a satisficing solution and not necessary an optimal solution. With the MCA, one can adjust the ranking of criteria, adjust scores shapes, and include additional criteria or options. However, under MCA, stakeholders are usually required to have a certain level of education, and information requirements can be excessive (money consuming) along with mathematical foundation which is weak. Furthermore, requirements to apply weights can be more problematic for policy-makers (time consuming). All these issues make MCA not easy to implement in developing countries. .

From the foregoing environmental evaluation approaches, CBA is the preferred approach in large and complex projects with significant social and environmental implications. Whereas, CEA is preferred where major economic benefits cannot be valued in monetary terms. However, the major limitations of these approaches, especially of CBA, when environmental issues are involved, include their inability to account for the uncertainty due to complexity of ecosystems, and the valuation, in money terms, of non-marketed ES such as fauna and flora.

3.3.2 Valuation Methods employed for watershed ES

Various methods have been used to estimate both the market and non-market components of the values of ecosystem services in the watershed. These methods are usually divided into two main classes: Revealed preference (RP) methods and stated preference (SP) methods. But sometimes, the Benefit transfer (BT) and a combined of revealed and stated preferences are considered (Figure 3.4).

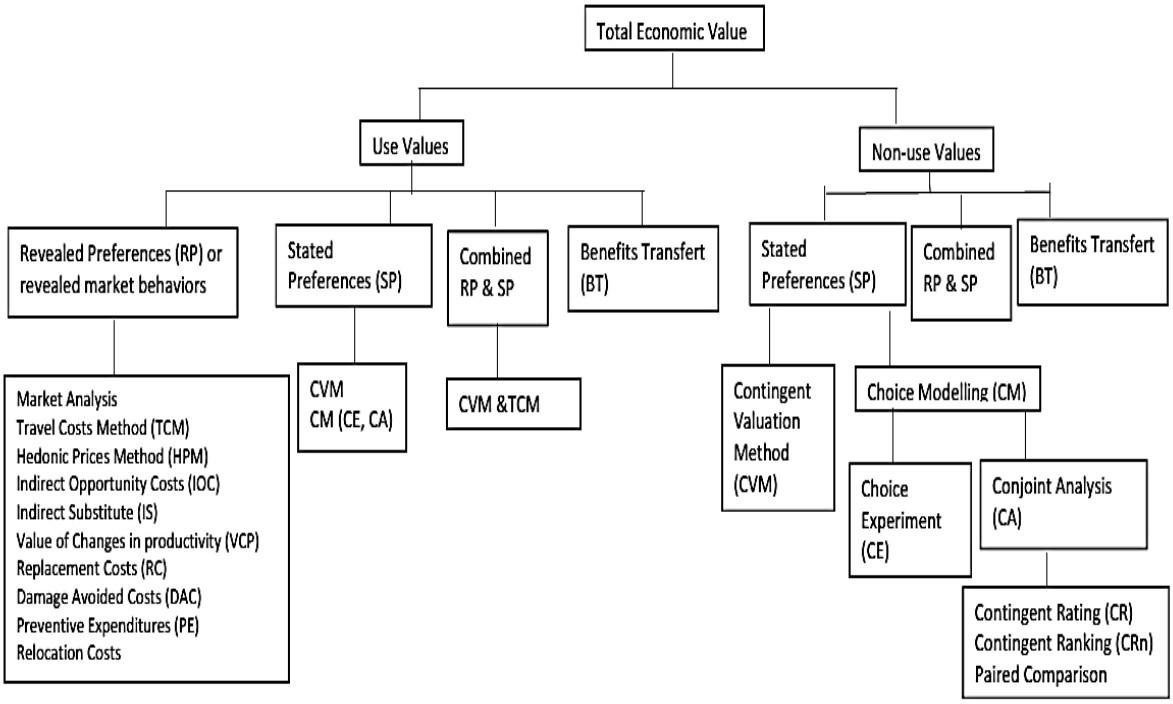


Figure 3. 4: Watershed ES valuation methods

As noticed early, many watershed values are not directly reflected in market prices at all. This is true for all the environmental functions, for resources harvested for own use by households, for most recreation and water transport services, and for all non-use values. Moreover, the application of valuation techniques requires an understanding of the economic concept of willingness to pay (WTP) and willingness to accept (WTA), which is the basis for economic valuation of any ES. Thus, techniques such as the *travel cost method (TCM), hedonic price method (HPM), contingent valuation method (CVM) and choice experiment method (CE)* have been employed to estimate directly WTP and sometimes WTA in the watershed. However, such valuation methods are not easily applicable in remote and rural settings of developing countries as quoted in this citation of Whittington Dale (1998, p.21, cited in Milanesi (2007)) for CVM: *"Ten years ago only a handful of very rudimentary contingent valuation (CV) studies had been conducted in developing countries; at the time conventional wisdom was that it simply could not be done. The problems associated with posing hypothetical questions to low-income, perhaps illiterate respondents were assumed to be so overwhelming that one should not even try. Today we have come full circle; it is now assumed*

by many environmental and resource economists and policy analysts working in developing countries that contingent valuation (CV) surveys are straightforward and easy to do"[31].

In certain circumstances, valuation techniques such as *indirect substitute (IS), indirect opportunity cost (IOC), relocation costs (RC) and replacement costs methods (RC),* which do not related uniquely to WTP have been applied (Barbier et al., 1997). For example, in the case of wetland, some non-market values have been approximated through the use of *surrogate market prices*, which is the use of an actual market price of a related good or service to value the wetland use that is non-marketed. In the case of harvested or directly used wetland resources that often have no market (e.g., fuelwood), the value of their use has been estimated by the market price of similar goods (e.g., fuelwood purchased from other areas) or the next best alternative or substitute good (e.g., charcoal).

In case apparently no marketed substitute or alternative exists, other methods of valuing a non-marketed watershed or wetland resource have be employed. These include the *indirect opportunity cost (IOC)* approach, where the time spent collecting or harvesting, or planting trees is valued in terms of foregone rural wages, the opportunity cost of labor based on other employment. These methods also include the *indirect substitute approach*, where the opportunity cost of using a substitute for watershed resource is employed as its value measure (Barbier et al., 1997). For example, the costs of obtaining water outside the watersheds could be costed as a substitute for using the watershed as a source. In addition, the OC of using manure (compost) that is normally applied as fertilizer as a substitute for fuelwood could be used to value fuelwood. The actual expenditures on direct use-values of watershed services such as recreation/tourism, water transport, may not reflect individuals' WTP for them since they may be non-marketed and therefore unpriced. In this case, alternative methods of valuation have been applied. For water transport, the value has been expressed in terms of the cost of alternative/substitute means of transport. For recreation/tourism, the *travel cost method (TCM)* has been applied, where the value of visiting watershed areas is derived from the cost of travel, including recognition of the opportunity costs of travel time. However, more often, CVM and CE has been used to value recreation in watersheds (Adamowicz et al., 1998; Loomis et al., 2000, Carlsson et al., 2003).

Furthermore, the values of watershed environmental functions arise indirectly through their support or protection of economic activity and property. Hence, where economic production

[31] The developing countries concerned with CV applications up to 2005 are listed in Milanesi (2007, p96-97).

is being supported, the value of these functions has been measured in terms of the *value changes in productivity (VCP)* attributed to these functions operating normally (Barbier et al., 1997). Moreover, where economic activity or property is being protected, the values have been expressed in terms of *preventive expenditures (PE)* that would be required if the functions were degraded or irrevocably disrupted; the *damage avoided costs (DAC)* where these functions were to continue normally; and the *costs of alternatives/substitutes* to replace these functions, or the *relocation costs* required if these functions were lost. For example, hurricane damages were avoided by maintaining coastal wetland strips to reduce storm intensity inland (Barbier et al., 1997).

Benefits transfer (BT) refers to the practice of using values estimated for an alternative policy context or site as a basis for estimating a value for the policy context or site in question. BT studies are often the only recourse where data is poor or funds are not sufficient for a full-scale valuation study. This method has been employed by Costanza et al. (1997) in estimating the value of the world's ecosystem services and natural capital. However, BT application depends on a number of factors, including similarity of the sites, i.e., the ES in both sites should have roughly similar characteristics and the population in both areas should be similar; the values in the first study should not have been estimated a long time ago because preferences change over time.

Contingent valuation method (CVM) and *choice experiment (CE)* attempt to assess non-use value and option values associated with watershed ES. As underlined by Barbier et al. (1997), estimating non-use values is extremely difficult and any option associated with preservation will also be difficult to assess and quantity. Indeed, the general presumption is that the option values (including quasi-option values) attached to the majority of tropical watershed may be very high, as they represent unique and irreplaceable assets that generate significant environmental benefits. The full value of these benefits may not always be realized currently, but may only become apparent as these watersheds are preserved over time. Thus, because option values arise out of the uncertainty over future unknown watershed benefits, the value may be extremely difficult to estimate. A further consideration is about the sustainability of the current uses of a watershed. Indeed, direct uses of watershed area such as harvesting for fish and timber, may significantly affect ecological relationships in the long term. Thus, some attention must be paid to determining the "sustainable yield" of watershed ES with regards to

current direct uses. Therefore, unless use is made of such techniques such as CVM and CE, estimating non-use values and option values will be extremely difficult or impossible.

Contingent valuation and CE are survey techniques using direct questioning of individuals while they are on-site or by mail to generate estimates of individuals' WTP for ES they value, or of how much compensation (WTA) they would require if they no longer had access to the ES as before. In the watersheds, the general approach involves ascertaining from the individual either how much s/he is willing to pay to ensure that the watershed attributes are preserved, or alternatively, how much s/he is willing to accept in compensation for the loss of some or all of these watersheds attributes, or to accept to allow the increase of some watershed attributes (Hanley et al., 2001; Bateman et al., 1996; Carlsson et al., 2003).

3.4 Contingent Valuation (CVM) and Choice Experiment (CE) Methodologies

To obtain and estimate the WTP/WTA for ES, there are in the literature, two valuation methods based on stated preferences of individuals as indicated early in figure 3.4: Contingent valuation method (CVM) and Choice Modeling (CM) (which include *Choice Experiment (CE)* and Conjoint Analysis (CA)). Indeed, economists routinely use non-market valuation techniques to estimate the WTP for public goods (Mitchell and Carson 1989). In particular, CVM has been extensively used to directly estimate the public WTP for ES. The application of CVM and other stated preference methods in estimating non-market value of ES are widely reported in economics literature (Adamowicz et al. 1998; Bateman and Willis 1999, Loomis et al., 2000). Under the CVM, the choice of elicitation formats for WTP questions has passed through a number of distinct stages. In the early years, open-ended elicitation formats were predominant amongst practitioners. Nonetheless, dissatisfaction with the approach gradually grew because of the incidence of protest bids resulting from the associated cognitive burden, and of the potential for strategic bidding (Hanley et al., 2001). Moreover, during the 1980s, there has been a shift towards the use of dichotomous choice elicitation, which not only provided incentives for the truthful revelation of preferences but also simplified the cognitive task faced by respondents (Bishop and Heberlein, 1979). However, an increasing number of empirical studies revealed that dichotomous choice results seemed to be significantly larger than open-ended valued, possibly due to yeah saying (Hanley et al., 2001). But, neither approach is ideally suited to deal with cases where changes are multidimensional. Hence,

partly as a response to these problems, valuation practitioners increasingly developed an interest in alternative stated preference formats such as Choice Modelling (CM).

Choice Modelling (CM) is a family of survey-based methodologies for modelling preferences for goods and services, where goods and services are described in terms of their attributes and of the levels that these can take (Hanley et al., 2001). Respondents are presented with various alternative descriptions of a good or service, differentiated by their attributes and levels, and are asked to rank the various alternatives, to rate them or to choose their most preferred. By including price/cost as one of the attributes of the service or good, WTP can be indirectly recovered from people's ranking, ratings or choices. As with CVM, CM can also measure all forms of value including non-use values. The conceptual microeconomic framework for CM lies in Lancaster's (1966) characteristics theory of values which assumes that consumers' utilities for goods can be decomposed into utilities for composing characteristics. Empirically, CM has been widely used in transport literatures and in marketing or market research (Henscher, 1994), but has only relatively recently been applied to other areas such as the environment (Hanley et al., 2001). Since individual preferences or WTP can be uncovered in CM surveys by asking respondents to rank the options presented to them, to score them or to choose their most preferred, these different ways of measuring preferences therefore correspond to different variants of the CM approach namely contingent ranking, contingent rating, paired comparisons and choice experiments. However, Choice experiments (CE) is shown to be a welfare consistent estimate whereas contingent ranking depends on the context and contingent rating and paired comparisons are doubtful (Hanley et al., 2001). Moreover, contingent rating and contingent ranking do not provide respondent with an opportunity to reject the good. The only way they allow opposition is by registering a low rating or ranking. In that sense they are considered to be unconditional or relative measures of WTP and could be understated.

In choice experiment (CE), respondents are presented with a series of alternatives, differing in terms of attributes and levels, and are asked to choose their most preferred one. A baseline alternative, corresponding to the status quo or 'do nothing' situation or "opt-out", is usually included in each choice set. This is because one of the options must always be in the respondent's currently feasible choice set in order to be able to interpret the results in standard welfare economic terms. CE approach was initially developed by Louviere and Henscher (1982) and Louviere and Woodworth (1983) to valued environmental attributes of public

goods. However, the public goods supplied through environmental management of watershed services are rarely valued using CE (Shrestha and Alavalapati, 2003; Scarpa et al., 2007; Rai et al., 2014).

3.4.1 Theoretical Framework of CVM and CE: The Random Utility Model.

CE shares a common theoretical framework with dichotomous-choice CV in the Random Utility Model (McFadden, 1974), as well as a common basis of empirical analysis in limited dependent variable econometrics (Hanley et al, 2001). However, the attributes of the alternative being valued are not identified in the CVM because either you want the entire panel or not. Under CE you have many options that are proposed and defined by many attributes, and attributes are defined in different levels. That is, attributes vary across alternatives and respondents are then required to choose their most preferred options or alternatives. Therefore, the CE will allow to value the attributes of each environmental function in the watershed.

1- Random Utility Model Framework

Random utility Model (RUM) provides the basis for CE valuation method. Under this model, each of the environmental attributes of the improved services in the watershed forms an alternative, *i*, in a choice set, *Ø*. Alternative *i* would be one specific type of consumption bundle representing an improvement in the environmental quality of the watershed with its conditional indirect utility function U_{ni} for an individual household or land manager *n* expressed as:

$$U_{ni} = V_{ni} + \varepsilon_{ni} = bX_{ni} + \varepsilon_{ni} \qquad (3.2)$$

Where U_{ni} is an individual n's utility from choosing alternative i ; V_{ni} is the deterministic component of utility and is specified as a linear index of the attributes X_{ni} of the *i* different alternative in the choice set; and ε_{ni} is the stochastic element that represents unobservable influences on individual choice.

We assume *i* = improved state, and *j* = status-quo.

In addition the probability of a land manager or individual choosing alternative *i* over *j* is given by:

$$P_n(i) = \Pr\,(U_{ni} > U_{nj};\ \forall j \in \emptyset, \quad i \neq j) \qquad (3.3)$$

$$= \Pr(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj};\ \forall j \in \emptyset,\ i \neq j)$$

$$= \Pr(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj};\ \forall j \in \emptyset,\ i \neq j)$$

Indeed, V_{ni} include the attributes of the alternatives being valued such price (direct payment) or tax. $\emptyset$ is the set of alternatives being valued. However, individual *n* will answer "yes" to a proposed bit if the policy change (i = 1) causes his utility net of the required payment, to exceed utility of the status quo (i = 0). Furthermore, by assuming:

(i) An individual additively separable utility in stochastic and deterministic preferences and that it is a function of Y (Discretionary income or profit) and W_n (socio-economic characteristics) affecting his/ her preferences. And

(ii) $\varepsilon_{n0}\ and\ \varepsilon_{n1}$ are identically, independently distributed (i.i.d) random variables with zero means, we can then write the Radom utility as:

$$U_{ni}(Y_n; W_n;\ \varepsilon_{ni}) = V_{ni}(Y_n; W_n) + \varepsilon_{ni} \qquad (3.4)$$

Individual will accept the bid or payment mechanism if:

$$V_{n1}(Y_n - B_n; W_n) + \varepsilon_{n1} > V_{n0}(Y_n - B_n; W_n) + \varepsilon_{n0}$$

Will reject if:

$$V_{n1}(Y_n - B_n; W_n) + \varepsilon_{n1} \leq V_{n0}(Y_n - B_n; W_n) + \varepsilon_{n0}$$

The utility difference ($\Delta\gamma_n$) between the acceptance and rejection of the bid is thus given by:

$$\Delta\gamma_n = V_{n1}(Y_n - B_n; W_n) - V_{n0}(Y_n - B_n; W_n) + \varepsilon_{n1} - \varepsilon_{n0} \qquad (3.5)$$

W_n, B_n and Y_n are elements of X_n and *b* is the vector of parameters β and α

2- Estimating model or model specification for WTP

In order to identify the most preferred alternative, equation (3.5) can be econometrically estimated based on responses to a household or individual survey. Assuming that the error term is identically and independently distributed (iid) and follow a type I extreme-value or Weibull distribution and that indirect utility (U) is linear in attributes (W), equation (3.5) can be estimated with a conditional logit (CL) model (McFadden, 1974). In fact, some conditional multinomial studies used datasets that include alternative-specific variables, such as prices and quality measures for all alternatives, not just the chosen alternative as under the multinomial logit model (MNL). The MNL model structure represents the probability of choosing an alternative *i* such that the utility of the alternative is greater than the utility of all other alternatives (Shrestha and Alavalapati, 2003). However, in analyzing the relationship to

multinomial model, Cameroon and Trivedi (2009) showed that MNL and CL models are essentially equivalent as the parameters of the MNL can be estimated by using asclogit command as the special case with no alternative-specific regressors. Therefore, yields the same estimates as the mlogit command. Moreover, going the other way, they showed the possibility to estimate the parameters of a CL model using mlogit. But this is more difficult because it requires transforming alternative-specific regressors to deviations from the base category and then imposing parameter-equality constraints.

Furthermore, the MNL and CL models impose the restriction that the choice between any two pairs of alternatives is simply a binary logit model. Indeed, the selection from the choice set must obey the Independence from Irrelevant Alternatives (IIA) property which states that the relative probabilities of the two options being selected are unaffected by the introduction or removal of other alternatives. This property follows from the independence of the Weibull error terms across the different options contained in the choice set (Hanley et al., 2001). Moreover, socioeconomic variables (s) are sometimes introduced in this model (CL) to detect sources of heterogeneity amongst land managers and households. But since they are constant across choice options for any given individual, they usually entered as interaction terms, i.e. interacted with choice specific attributes. This usually leads to the estimation of a random parameter logit (RPL). The CL model is expressed as:

$$\Pr\left(U_{ni} > U_{nj};\ \forall\, j \in \emptyset, \qquad i \neq j\right) = \frac{\exp(Vni)}{\sum_i \exp(Vni)} \qquad (3.6)$$

Where V_{ni}, include the socioeconomic characteristics and environmental attributes or variables. Therefore; W_n, B_n and Y_n are elements of V_n and b is the vector of parameters β and α associated to X_n since V_{ni} is linear in attributes ($V_{ni} = bX_{ni}$). These variables or attributes are usually derived from focus groups discussion, empirical literature review and secondary data while designing the research instrument (questionnaire) and considerably depend on the local context.

The respondent's WTP representing the compensating CSU is estimated using CL model (Louviere et al. 2000; Adamowicz et al. 1998). A simplified method of estimating WTP for a level of change in environmental attributes is to take the ratio of the estimated coefficient of the attribute (β) and the coefficient of the cost attribute (α). This ratio is commonly known as part-worth or utility representing the marginal value of a change in the attribute, i.e., the

marginal rate of substitution between income change and the change in the attribute under consideration. Therefore, β and α estimates will then be used to compute the aggregate WTP and then the demand for Watershed ES by substituting them in the following equation.

$$WTP = -\frac{\beta_{attribute}}{\alpha_{price}} \qquad (3.7)$$

As far as WTA is concerned in the CVM, the WTA has been usually estimated using the Tobit model developed by Tobin (1958) for analysis of consumption spending in durable goods and which focused on a regression taking account specifically the fact that the spending cannot be negative, or Heckman model (two stages). Tobit models are qualified of censored or truncated regression models. In a censored regression model, one disposes of observations of the explanatory variables at least over the overall sample, whereas, in a truncated regression model, all the observations of explanatory and dependent variables out of a certain range are totally lost. These models are those for which the dependent variable is continuous but it is observed only in a certain interval. In the studies of WTA estimate, one model the probability for the variable WTA to belong to the interval $[0 \quad +\infty[$ in which it is observed as no compensation is negative (Dupraz et al., 2003; Buckley et al., 2009; 2012).

3.4.2 CVM in practice: Steps, Issues and limitations

It has been highlighted that a good CVM study in watershed should consider the following steps in its application. Steps that some are also used for CE.

- Before designing the survey, the applicant should learn as much as possible about how people think about the watershed goods or services in question. S/he should consider people's familiarity with the goods or services, as well as the importance factors such as quality, quantity, accessibility, the availability of substitutes, and the reversibility of the change. As a matter of fact, CVM studies assumes that people understand the ES in question and will reveal their preferences in the contingent market just as they would in a real market. However, most people are unfamiliar with placing monetary values on ES. Therefore, they may not have an adequate basis for stating their true value. Hence, people should be familiar with the goods or services in question, and the applicant should determine the extent of the affected populations or markets for the ES in question, and chooses the survey sample based on the appropriate population. This is in order to avoid the *non-response bias* that arise from the CVM application.

- The hypothetical scenario should provide an accurate and clear description of the change in environmental services associated with the programme, investment, or policy choice under consideration. It could conveys if possible this information using photographs, videos or other multi-media techniques, as well as written and verbal descriptions. This is in order to avoid the *information bias* that arise whenever respondents are forced to value attributes with which they have little or no experience, and in which cases, the amount and type of information presented may affect their answers;
- Unlike ordinary survey questions, which often ask respondents whether they are willing to pay X monetary unit to improve 'air quality, the nature of the watershed uses and the changes to be valued should be specified in detail. Thus, respondents would assume that one or more related improvements are included. For example, people have tendency to think of environmental improvements in general in the watershed, even when asked about water quality alone, and as result, the WTP response in these two cases may be similar. Therefore, to avoid the *Part-whole bias*, which leads to the same WTP response when people are asked to value one part of the good and then subsequently asked to value the whole[32], it would not be necessary in the CVM methodology to point out specifically only water quality, since biodiversity or fish would not remain the same. However, in a CE study, it would be necessary to point out specifically only water quality, since biodiversity or fish would also be considered as another attribute of the watershed, to which a monetary unit will be affected. Some researchers have argued that part-whole bias could be avoided by reminding respondents to consider their budget constraints;
- Questions can be asked in a variety of ways, using either *bidding games, payment card*, or *open-ended and close-ended* formats. In the bidding games, respondents are offered progressively higher bid (lower amount) until they reach their maximum WTP (minimum WTA). With payment card, a range of values is provided on a card and the respondents is requested to choose one. In the open-ended format, respondents are asked to state their maximum WTP or minimum WTA. With close-ended format, also referred as discrete choice, two variants are usually considered: *Dichotomous choice (referendum),* where a single amount is offered and respondents are asked whether or

[32] An example is that if people are first asked for their willingness to pay for one part of an environmental asset (e.g. one lake in an entire system of lakes) and then asked to value the whole asset (e.g. the whole lake system), the amounts stated may be similar

not they would be willing to pay /accept this particular amount for ES improvement, or whether they would vote yes or no for a specific policy at a given cost. This also refers to as the "take it or leave it" approach; and *Double-bounded referendum,* where respondents who answer 'no' to the first amount are offered a lower amount, and those who answer 'yes' are offered a high amount;

- In addition to the hypothetical question that asks for WTP/WTA, the survey specifies the mechanism by which the payment will be made (*Bid vehicle*), for example, through increased taxes or water bill fees. However, in order for the question to be effective, the respondent must believe that if the money was paid, whoever was collecting it could affect the specified environmental change. Thus, a useful vehicle is usually the donations to a trust fund to be administered by an independent NGO, or the collection of fees by a municipality or council, which is usually closed to the population.
- Applicant should specify whether comparable services are available from other sources, when the ES is going to be provided, and whether the losses or gains are temporary. Indeed, people will reduce their WTP or increase their WTA if they are aware of the substitutes. Thus, the specification of comparable services available from others sources has as result to avoid the *embedding effect (a bias)* which is attributed to the existence of substitutes, or which occurs because people are seeking a 'feel good' or "warm glow" associated with contributing to a good cause[33];
- Respondents should understand the frequency of payment required, for example monthly or annually, and whether or not the payments will be required over a long period of time in order to maintain the quantity or quality change. Moreover, they should understand who would have access to the ES and who else will pay for it, if it is provided;
- Respondents should understand that they are currently paying for a given level of supply. Therefore, the scenario should clearly indicate whether the levels being valued are improvements over the status quo, or potential declines in the absence of sufficient payments. Furthermore, when the household is the unit of analysis, the reference

[33] The expressed answers to a WTP question in a CVM may be biased because the respondent is actually answering a different question than the surveyor had intended. Rather than expressing value for the good, the respondent might actually be expressing their feelings about the scenario or the valuation exercise itself. For example, respondents may express a positive WTP because they 'feel good' about the act of giving for a social good (referred to as the "warm glow" effect), although they believe that the good itself is unimportant. Respondents may state a positive WTP in order to signal that they place importance on improved environmental quality in general.

income is the household's income rather than respondent's income. However, a *strategic bias* may arise when the respondent may provide a biased answer in order to influence a particular outcome. For example, if the decision to preserve a stretch of river depends on whether or not the survey produces a sufficiently large value for fishing, the respondents who enjoy fishing may be tempted to provide an answer that ensures a high value, rather than a lower value that reflects their true valuation. Thus, responses may be unrealistically high/low if respondents believe they will not have to pay for the good or services and that their answer may influence the resulting supply of the good. This bias is well overcome in choice modelling technique;

- The questionnaires should be pre-test for potential biases such as starting point bias, which occurs in the prompt respondents by suggesting a starting bid and then increasing or decreasing this bid based upon whether the respondent agreed or refused to pay such amount. It has been shown that the choice of starting bid affects respondents' final WTP/WTA response. Pre-testing includes testing different ways of asking the same question, testing whether the question is sensitive to changes in the description of the ES or resource being valued, and sometimes conducting post-survey interviews to determine whether respondents are stating their values as expected. In relation with this latter point, some researchers argue that there is a fundamental difference in the way that people make hypothetical decisions relative to the way they make actual decisions. Therefore, this leads to the *hypothetical bias*, which occurs when respondents may fail to take questions seriously due the hypothetical nature of the exercise, and because they will not actually be required to pay the stated amount.
- Validation questions are included in the survey, to verify the comprehension and acceptance of the scenario, and to elicit socioeconomic and attitudinal characteristics of respondents, in order to better interpret variation in responses across respondents;
- CVM and CE are conducted as in-person interviews, telephone interviews or mail survey. However, though the in-person interview is the most expensive survey administration format, it is generally considered to be the best approach, especially if visual materials are presented;
- A large, clearly defined, and representative sample of the affected population should be interview; and a high response rate should be achieved. This is then in order to improve the statistical efficiency of the analysis and results obtained.

- Once the results of CVM studies are obtained, they are not difficult to interpret, since monetary values (WTP/WTA) can be presented in terms of mean, median per capita or per household, or as an aggregate value for the affected population.
- In theory, the results of the WTP question and WTA question should be very close. However, when the two formats have been compared, WTA significantly exceeds WTP. Critics have claimed that this results invalidates the CVM approach, showing responses to be expressions of what individuals would like to have happen rather than true valuations. But, this divergence usually depends on the income elasticity and the substitution effects (Hanemann, 1991; Shrogen et al., 1994), or loss aversion for public goods that may have serious implications for welfare (Coursey et al., 1987). Hanemann (1991) demonstrated that the divergence can range from zero to infinity, depending on the degree of substitution between goods or ES and given a positive income elasticity. Hanemann showed that one should only expect convergence of WTP and WTA value measures when the ecosystem good or service has a very close substitute; and that when the good has an imperfect substitute, a value divergence will exist and will expand as the degree of substitution decreases. Furthermore, in the context of PES mechanism, this divergence is required to ensure the participation constraint identified by Wunder (2008).

Although CVM is the most widely accepted method for estimating TEV including all types of non-use values, some issues and limitations have been underlined, and a great deal of research has been conducted to improve the methodology (Milanesi, 2007). Choice experiment (CE) have been shown to overcome the strategic bias by not requiring respondents to state their bids. Non-response bias is overcome by the easier to the respondent to tick its best alternative or option on a choice card illustrated by photograph.

3.4.3 CE in practice: Steps, Experimental Design Efficiency, and Heterogeneity

In the last decade, the use of discrete choice experiments (CEs) for the purpose of nonmarket valuation of environmental goods and services has gained favor with many applied environmental economists. The first study in applying CE to non-markets environmental valuation was that of Adamowicz et al. (1994). CEs are used when policy outcomes may be usefully described in terms of attributes and the objective is to infer the value attached to the respective attribute levels. Attributes could be relevant policy traits (behaviors) and typically include the policy cost to the respondent (see Eq 3.7).

❖ Steps in conducting Experimental Choice Analysis

Some steps have been underlined in conducting an experimental choice study. An overview of the effort necessary is provided under the characterization of the decision problem below.

1-Characterization of the decision problem: This is a most important stage of the study. Through focus groups, literature review, interviews with experts, etc., the applicants seeks to characterize the decision problem in terms that the decision maker understands. Specifically, the applicant needs to understand *how individuals become aware of the need to make the decision in question*, need to *define the dimensions of evaluation of the ecosystem goods or services*, to search for *information on attributes and alternatives*, to construct *choice sets*, and to *make decisions*. These items are crucial in formulating a decision problem that is most similar to the decisions that individuals make in real life, when the selection problem of interest is on relatively familiar to decision makers. Indeed, when the choice being studied is less familiar to the respondent, this stage maximizes the chances of communicating the desired information to him or her. The applicant also seeks to identify *sources of individual heterogeneity* (e.g education, income, attitudes towards environmental issues) that could lead to important behavioral differences. Therefore, the outputs of this stage are usually: relevant attributes and attributes levels selection, choice set size and composition, relevant sampling frame for the study and individuals differences.

2-**Attributes and attributes levels selection**: Based on study objectives and step1 information, the attributes, the number and value of the levels for each attribute must be defined. Often, this stage is conducted in parallel with step1. For example, when defining the dimensions of evaluation of the ecosystem goods or services. Commonly, attributes are identified from prior experience, secondary research and/or primary, exploratory research (Louviere, 1988). After identifying the attributes for a particular experiment, the analyst must assign values or levels to each attributes. *These levels should be chosen to represent the relevant range of variation in the present or future market of interest*. Though commonly presented in words and in numbers, attributes levels have been also communicated via pictures (static or dynamic), computer graphics, and charts etc. To the extent that visual (rather than text) representations of attribute levels are utilized, it likely that respondents will perceive levels more homogeneously, likely leading to more precise parameter estimate in the modeling stage (Adamowicz et al., 1998a). However, the tradeoff is that non-textual presentation of information is costly and often time-consuming to produce.

3-**Experimental Design Development**: Once attributes and associated levels have been determined, analysts typically use some form of design (full factorial or orthogonal) to generate different combinations of attribute levels called "profiles" (Louviere, 1988). A "profile" is *a single attribute level combination in a complete factorial combination of attribute levels*[34]. While a *"design" is a sample of profiles which have a particular set of statistical properties that determines the utility specification (s) that can be estimated (i.e identified)* (Adamowicz et al., 1998).

A number of methods have been suggested for building choice designs related (Bunch et al., 1993 and, Kuhfeld 2000 cited in Zwerina et al., 1996, Louviere and Woodworth 1983). Most of the methods use extensions of standard or traditional linear experimental designs (Green, 1974; Hanley et al., 2001; Martinsson et al., 2001). However, the use of linear designs in CEs may be non-optimal due to two well-known differences between linear and choice models. First, probabilistic choice models are nonlinear in the parameters, implying that the statistical efficiency of a choice design depends on an (unknown) parameter vector. This property implies the need to bring anticipated parameter values in choice designs. Second, choice design efficiency depends both on the creation of appropriate profiles and properly placing them into several choice sets. *For example, it has been shown that in a linear design, the order of the 16 profiles in a conjoint exercise does not affect its formal efficiency, whereas the efficiency of the same 16 profiles broken into four choice sets depends critically on the "grouping"*. Despite its limitations, linear design theory has been used to produce satisfactory choice designs for many years, but has generally been not optimal in a statistical sense (Ferrini and Scarpa, 2007).

Experimental design (ED) is concerned with how to create the choice sets in an efficient way, i.e., how to combine attribute levels into profiles of alternatives and profiles into choice sets. The standard approach in marketing, transport and health economics has been to use so-called orthogonal designs, where the variations of the attributes of the alternatives are uncorrelated in all choice sets. In addition, recently, there has been a development of optimal EDs for CEs based on multinomial logit (MNL) models. These optimal design techniques are important tools in the development of CE, but there are other more practical aspects that should be considered.

[34] *In the statistical design literature, the profile is "treatment combination".*

- **Optimal Design Techniques**

A design is developed in two steps: (i) *obtaining "profiles", i.e., the optimal combinations of attributes and attributes levels to be included in the experiment*, and (ii) *combining those profiles in choice sets*. A starting point is a *full factorial design*, which is a design that contains all possible combinations of the attribute levels that characterize the different alternatives. A full factorial design is, in general, very large and not tractable in a CE. For example, in an experiment with 5 attributes, each with 4 levels, the full factorial design will give $4^5 = 1024$ profiles, which are too much to be considered for reasonable choice sets. Therefore, there is usually need to choose a subset of all possible combinations, while following some criteria for optimality and then construct the choice sets. Hence, the following 'sentence' is often stated in CE studies: *"The total number of combinations implied by the full factorial could not be employed, so a main effects orthogonal fraction of such factorial was employed. Choice sets were then formed by blocking the resulting set of profiles into n blocks"*. Moreover and ccording to Adamovicz et al. (1998a), *a "Main effects plan" is an orthogonal subset of the complete factorial which allows an analyst to estimate a strictly additive, "main effects only" (no interaction terms) utility specification. The means of blocking or dividing a design into manageable subsets of profiles can be accomplished, by randomizing the profiles, then subdivide the reordered design to obtain subsets of desired size, or alternatively, generate a design that contains the blocking factor as an attribute with as many levels as there are blocks. If the blocking factor is orthogonal to all other design columns, the resulting blocks will have the desirable property that all levels of all attributes will be present in every block*[35].

In CEs, while, orthogonality in particular has been used as the principal part of an efficient design, more recently researches in marketing have developed design techniques based on the D-optimal criteria for non-linear models in a CE context. Several strategies explore some or all of the requirements for an efficient design of CE. Kuhfeld et al. (1994) use a computerized search algorithm to minimize the D-error (see appendix) in order to construct an efficient design (linear), but not necessarily orthogonal. But, these designs do not rely on any prior information about the utility parameters and hence do not satisfy utility balance. Zwerina et al. (1996) adapt the search algorithm of Kuhfeld et al. (1994) to their four principles for efficient choice designs. In order to illustrate their design approach, Zwerina et al. return to

[35] But Adamovicz et al. (1998a) underlined that this property may come at the price of a larger design than permitted by other considerations, in which case a tradeoff must be made.

the MNL model, and McFadden (1974) analysis that showed that the maximum likelihood estimator for the conditional logit model is consistent and asymptotically normally distributed with the mean equal to β and a covariance matrix given by:

$$\Omega = (Z'PZ)^{-1} = [\sum_{n=1}^{N}\sum_{j=1}^{Jm} Z'_{J_n} P_{J_n} Z_{J_n}]^{-1} \qquad (3.8)$$

Where $Z_{J_n} = X_{J_n} - \sum_{i=1}^{J_n} X_{in} P_{in}$

This covariance is the main component in the D-optimal criteria, and depends on the true parameters in the utility function, since the choice probabilities, P_{in} depend on these parameters (Alpizar et al., 2001). D-optimality is related to the covariance matrix of the K-parameters, defined as:

$$D - efficiency = \left[|\Omega|^{\frac{1}{K}}\right]^{-1} \qquad (3.9)$$

Zwerina et al. (1996) identify four principles for an efficient design of CE based on a nonlinear model: these are *(i) orthogonality, (ii) level balance, (iii) minimal overlap and (iv) utility balance*. *Orthogonality* requires that the levels of each attribute vary independently of one another. Level balance requires the levels of each attribute to occur with equal frequency in the design. A design has *minimal overlap* when an attribute level does not repeat itself in a choice set. Finally, *utility balance* requires that the utility of each alternative within a choice set is equal. This last property has been shown to be important since the large difference in utility between alternatives the less information is extracted from that specific choice set (Alpizar et al., 2001). However, at the same, this principle is shown to be difficult to satisfy since it requires prior knowledge about the true distribution of the parameters, though some researchers provided strategies for obtaining this information, which includes results from other studies, expert judgements, pilot studies and sequential designs strategies. Zwerina et al approach holds several important advantages over previous choice design strategies in that: it optimizes the correct criterion of minimizing estimation error rather than following linear design principles, it can generate choice designs that accommodate any anticipated parameter

vector, it can accommodate virtually any level of model complexity, and finally it can be build using widely available software[36] (Alpizar et al., 2001).

However, according to Martinsson et al. (2001), there are several other problems with these more advanced design strategies due to their complexity and it is not clear whether the advantages of being more statistically outweigh the problems. Although some information about the coefficients is required for other design strategies as well, more elaborate design based on utility balance are more sensitive to the quality of information used, and incorrect information on the parameters may bias the final estimates. Empirically, utility balance makes the choice harder for the respondents, since they have to choose from alternatives that are very close in terms of utility; and which might results in a random choice. Moreover, these designs are based on a conditional logit model where, for example, homogeneous preferences are assumed. Violation of this assumption may bias the estimates. There are other simpler design strategies which do not directly require information about the parameters. Ferrini and Scarpa (2007) after reviewing recent advances in ED for logit models, contribute to the existing literature by exploring empirical performance of a number of recently proposed approaches to construct designs for discrete CEs. The investigation is conducted by means of Monte Carlo experiments designed to focus on the finite sample size properties of frequently employed logit estimators for value derivation in environmental valuation. However, in all cases, some information about the shape of the utility function is needed in order to make sure that the individuals will make trade-offs between attributes. In environmental valuation, the only CE study that has adopted a D-optimal strategy is Carlsson and Martinsson (2001).

- **CE vs CVM Design Development**

The theory of optimal design for CE is related to optimal design of the bid vector in a CVM survey. Indeed, it is showed that the optimal design in a CVM survey depends on the assumption regarding the distribution of WTP (Kanninen, 1993 cited in Alpizar et al., 2001); and as in the case of the optimal design of bid values in a CVM, an optimal design of a CE depends on the value of the true parameters of the utility function. Generally, attributes and levels are selected on the basis of both the objective of the study and information gathered from focus groups, prior research or secondary/primary research, exploratory research

[36] They used a SAS program that generates relatively simple choice designs and can be generalized to handle more complex problems (Scarpa et al, 2007).

(Adamowicz et al., 1998a). However, differently from CVM-type tasks, CEs require that the analyst defines how many choice sets or scenarios (i.e. replications) each respondent will be asked to do. While there are no hard and fast rules, the analyst generally must balance respondent learning and fatigue against efficient use of the respondent (Adamowicz et al., 1998a). It has been shown that including more than 4 to 5 attributes in a choice set may lead to a severe detriment to the quality of the data collected due to the task complexity (Alpizar et al., 2001). The number of choice sets each respondent is asked to evaluate ranged from 4 to 16 (or very occasionally even 32) and the number of alternatives in each choice set from 2 to about 8 (Carson et al., 1994). The most frequent choice set composition is that of two alternatives and the status quo, where the status quo is added to ED alternatives, rather than being built into the overall design efficiency. The allocation of alternatives in the single choice set is either randomized or with different combinatorial devices.

4-**Questionnaire Development, Sampling and Data Collection**: The questionnaire is either self-administered or presented through an interviewer. While its main content is one or more choice sets through which the respondent will be guide, it may also include sections requesting sociodemographic, psychographic, attitudinal and past behavior data. It has be argued that this last item (past behavior data) may be of particular interest if the analyst intends to combine RP data with SP results. Analyst does not only have to collect information on what the individual actually did (e.g. where he/she fished or obtained drinking water), but also what other alternatives were considered, and if necessary, the characteristics of both chosen and non-chosen alternatives. As in the CVM survey or in any survey based research, pretesting of the questionnaire is a necessary component in CE study. Furthermore, there is little analysis that underlined non-response bias in CEs, either item-non response or survey non-response. However, more complex, demanding survey designs will results in increased item non-response. Furthermore, the usual considerations of desired accuracy levels versus data collection costs must guide definition of sample sizes. In CEs total sample size is further affected by the total number of choice sets and the number of choice alternatives in a given choice set. *For example, in our CE study with a sample size equal to 383 households, where each household responds to 4 choice sets, each formed by 3 alternatives or options, the final sample size (number of observations) for data analysis will be 4x3x383=4,596 observations*. In addition, if analyst is estimating models that account for individual differences, s/he has to impose in the case of blocking design, minimum sample size requirements within segment to enable accurate predictions within segment.

5-Model estimation: Statistical models used with CEs differ according to: (1) the specific functional form for the probability that a particular alternative is chosen, (2) the specific functional form that links the predictor variables to (1), and (3) the nature of the random component assumed for the difference of the utilities of the two choices (Scarpa et al, 2007; Alpizar et al, 2001; Carson et al, 1994), (see also theoretical framework developed early). The most common model estimated has been the Multinomial Logit (MNL) or Conditional Logit (CL), and the most common estimation criterion is maximum likelihood. However, other choice model specifications such as Multinomial Probit, Nested MNL or Mixed Logit as well as other criteria such as parametric and non-parametric have been applied to CE data (Scarpa et al., 2007). Moreover, combination of multiple data sources, involving both RP and SP data (CVM and CE data) has been performed (Adamowics et al., 1998b). The resulting estimated coefficients are used to compute the marginal WTP (as given in equation 3.7 above). CE methods have been only applied in computing WTP, although Legesse (2015) used the method to analyze WTA. But neither the mean nor the marginal WTA was computed, and there was no outcome arising from his analysis.

- **Treating Heterogeneity in CEs**

Treatment of taste heterogeneity in CEs have been made either in defining *a priori* segments (e.g. income, location, experience, frequency of use) and interact them with design attributes to capture differential attribute sensitivities (Louviere, 1988); in estimating a latent class model, which is a special case of a random parameters specification in which a discrete number of support points are hypothesized (Scarpa et al., 2007), or in estimating a random parameters model, which postulates continuous distributions for parameters (Birol et al., 2006; Carlsson et al., 2003).

o Study Brief Experimental Design Presentation[37]

Our CE consists of selected subsets of all possible "profiles" obtainable by combining and varying attribute levels. For the watershed management valuation, attributes are *water quality*, *fish*, *air quality* and *fuelwood (forest)*, and the *watershed management fee (price)*. Four attributes have two levels and one with four levels. Their levels are either continue (quantitative) or discrete (qualitative). Experimentally varying the levels of an attribute allows us to estimate how the frequency that a particular alternative is chosen varies with the changes in the level of that attribute. The lack of sufficient variation in the levels that an attribute takes

[37] More developed in Chapter five

in actual market data was one of the principal reasons for using CEs, since that variation is now under our control through a hypothetical market. The effect of changing the level of a single attribute represents the "main effect" that has be estimated for each attribute.

However, the five attributes and the respective levels would provide a total of $2^4x4^1=64$ profiles or combinations, which would be difficult and expensive to implement in a survey. As we are in a multi-attribute multilevel context of choice, the identification and efficiency of the estimates depends crucially on the choice of *experimental design (ED),* that is, *how we combine our attributes and attributes levels to create alternatives in the choice sets to be presented to the respondents*. Moreover, since researchers have shown that the ED should be statistically efficient, providing the maximum accuracy of the estimates for the unknown population parameters given the available sample size, and that at the same time the resultant choice tasks should require a relatively low cognitive effort from respondents, so as not to impair respondents' efficiency, an orthogonal design (in SPSS Software) was used to generate the optimal profiles to be assigned to choice sets or cards. Eight (08) profiles were generated, and were then used as alternatives of the choice sets. Alternatives, described in terms of attributes and their levels were policy situations. Given the number of profiles obtained, there was not need to block the design. By using a randomized method, four (04) choice sets were then created and was assigned to each household. For example, profile 1 and profile 8 were put together plus status quo to form choice set number or card 1. Table 3.1 illustrates an example of profile and choice set in our CE study.

Typically, respondents were asked to select the best from a set of alternatives in the choice set, and to repeat this choice task four times over the course of the interviews, each time choosing from a choice set with different alternatives. This results from the fact that, CEs are repeated referendum contingent valuation responses where the choice situation requires the respondent to select from possibly two or more policy situations (alternatives), each succinctly described in terms of attributes and their levels. Using the set of these observed discrete choices, we have estimated separate marginal values (or main effect) for each attribute used in describing the policy alternatives. Interactions of socioeconomic variables with attributes were also estimated in chapter five.

Table 3. 1: Profile, attributes and levels, and choice set in CE

Number of profile 4

ID of card	Water quality	Fuel wood	Air quality	Fish	Cost
4	100	3	Moderate	Species	400

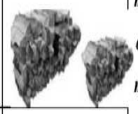
Profile generated using SPSS orthogonal design.

Attributes and their levels

Attributes	Description	Levels	Status quo
Water quality (Watqlty)	Amount of water availability per household per day for household activities	**1.** As much as now **(100 liters/day)** 2. Twice as much as now **(150 liters/day)**	No change
Fuel wood (WFW)	Amount of fuel wood available per household per day from the LBMFR watershed. This can result to a reduction of fuel wood to the household.	**1.** As much as now **(2 bundles/day)** 2. Twice as much as now **(3 bundles per day)**	No change
Air quality (CO2 absorption) (Airqlty)	Change in air quality in Kumba municipality due to reforestation in the watershed. This will contribute to the household well being	1- High change 2- Moderate change	No change
Fish (Fish)	Quantity and species of fish available to the household per month. This can result to a increasing of fish price to the household while conserving the critically endangered species.	1- Increasing in fish stock and diversity 2- Increasing in fish stock	No change
Watershed management fee (Cost)	An introduction of new monthly l fee for watershed management. This fee could be a fee additional to what households are paying now for water bill or could be a labor contribution for reforestation	1- 200 FCFA 2- 300 FCFA 3- 400 FCFA 4- 500 FCFA	0 CFAF

Example of Choice Set

Which of the following improved watershed management options do you prefer? Option 1 and Option 2 would entail payment to your household. No payment would be required for option 3 (Status quo) that is "No change", but the conditions at the watershed would still continue deteriorate with drastically loss of fish species and size, deforestation until at the vicinity of the Lake which affect water quality and quantity, also air quality and fuel wood availability.

Attributes	*Watershed management Option 1*	*Watershed management Option 2*	*Status quo option Option 3*
Water quality	150 liters/day for drinking purpose 	150 liters/day for drinking purpose 	*Neither management option 1 nor management option 2: I prefer NO improved watershed management*
Fuel wood			
Air quality (CO_2 absorption)	High change in air quality	Moderate Change in air Quality	
Fish	Increasing fish stock and diversity	Increasing fish stock and diversity	
WTP for Improved watershed management / month	500FCFA	300FCFA	0 FCFA
Your choice (Please tick one box)	☐	☐	☐

Source: Author construction

3.5 Study Zone

3.5.1 General description of the Lake Barombi Mbo Watershed

- **Geographical and Administrative Location**

The Lake Barombi Mbo Watershed (LBMW) is situated in the Meme Division of the South West region of Cameroon and comprises the Lake Barombi Mbo Forest Reserve (LBMFR) in its upstream part. The LBMFR was created in 1940 and covers about 920 ha. It is located between longitudes 04° 39' 10" South to 04° 40' 14" North and latitudes 09° 23' 53"West to

09° 25' 11" East. It hosts the largest Crater Lake in Cameroon which represents the main source of portable water for the Kumba town and the surrounding villages. The Lake measures about 2.5 km width and 110 m deep and was designated as a RAMSAR[38] site in 2006 (Eyenga et al. 2004; Schliewen and Tanjong 2006). The Reserve is bounded to the North by the Barombi Mbo village, to the South by the Kumba town and in the West by Kake 1 (see Figure 3.4). The following villages and settlements are found at the periphery of this Reserve: Barombi Mbo, Small Ekombe, Kake 1, Njurky, and New Barombi town.

These villages constitute the upstream part of the watershed (see Figure 3.5); while Kumba city constitutes the downstream part of the watershed. Kumba is located between latitudes 3° and 4° north and between longitude 9° and 10° east and is also known as K-Town or Green-Town. The city is a trade Centre for cocoa and palm oil, and has timber industries as well. The town is a local road junction, making it one of the main commercial towns in Anglophone Cameroon. Trading in Kumba attracts the interest of foreigners, mostly Nigerians (the Igbos tribe), who always control a greater percentage of Kumba main market. Because of its size, most of the major roads to the regional interior radiate Kumba, running to the Nigerian border at Mamfe, to the Korup National Park, and to the Mount Cameroon (Northeast) and Mount Koupe (East). The main geographical attraction is the Lake Barombi Mbo. As menthe water supply in Kumba is mainly from the Lake Barombi Mbo.

- **Biophysical Characteristics: Climate, Geology and Soil, Vegetation and Fauna.**

LBMW has a typical equatorial climate with two major seasons, which are made of a long rainy season (March-November) and a short dry season (December-February). The average annual temperature is approximately of 18°C or even less as the altitude increases and annual precipitations range from 1,825 to 3,000 mm (Nkafure 2002; RIS 2006-2008).

The area has been experiencing drastic climate changes as rains come sometimes earlier in March with unexpected rains during dry seasons. Rainfall was experienced right up to December in 2010 instead of October–November as was the case in the past, altering planting and production seasons of cash and food crops as well as other economic activities (Tchouto et al. 2015). Furthermore, the area is made up of steep slopes prone to erosion and has a mixture of limon, laterite, sandy, clay, and volcanic soils. These soils have a high content of

[38] The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

andosols and are composed of volcanic materials, usually dark. They are generally fertile and favor the growth of food and cash crops.

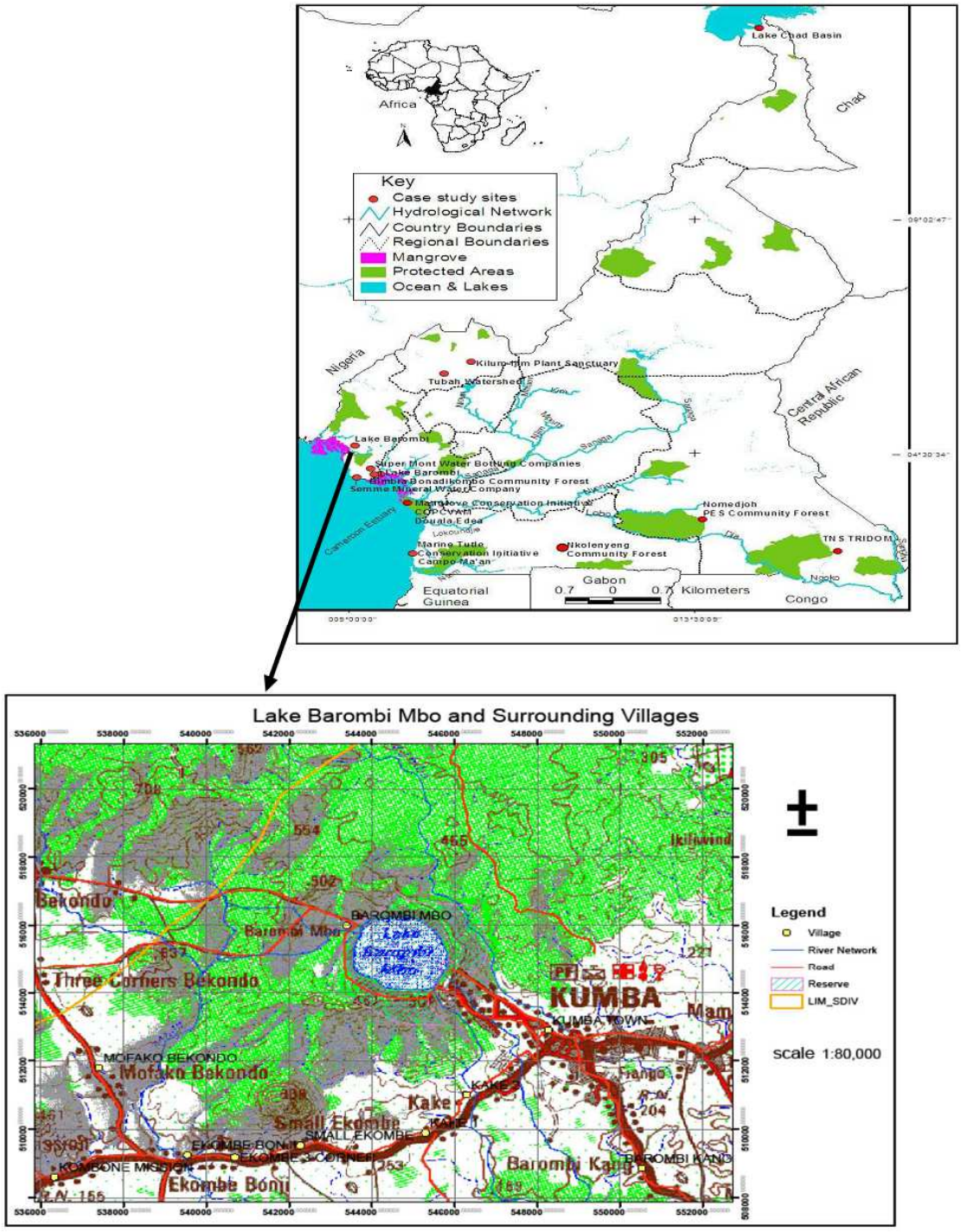


Figure 3. 5: Location of the Lake Barombi Mbo Watershed

However, in deforested and degraded areas, soils are gradually losing fertility due to increased slash and burn, soil exposure, pollution, over cropping, and leashing (Tchouto et al. 2015). Agriculture is gaining more and more importance in the area at the expense of forest, with as

a result the pollution of the lake by the accumulation of fertilizers used, if nothing is done to protect the area.

At the creation of the forest reserve, the Lake was surrounded by a lowland evergreen and semi deciduous forest that has suffered and continues to suffer from human activities such as farming, hunting, timber, the NTFPs exploitation, and uncontrolled fishing (Agbor 2008; Nkafure 2002; Schliewen and Tanjong 2006; Tchouto et al. 2015). Over the years pass, these resources attracted more people, and the major food crops cultivated are cassava (*esculentum*), plantain (*Musa paradisiacal*), maize, cocoyams, Egusi melon (*Cucumis sativus*), and taro (*Colocasia antiquorum*). The major cash crops in the zone are cocoa, palm oil, and rubber; characteristics of the humid forest agro ecological zone of the South-West.

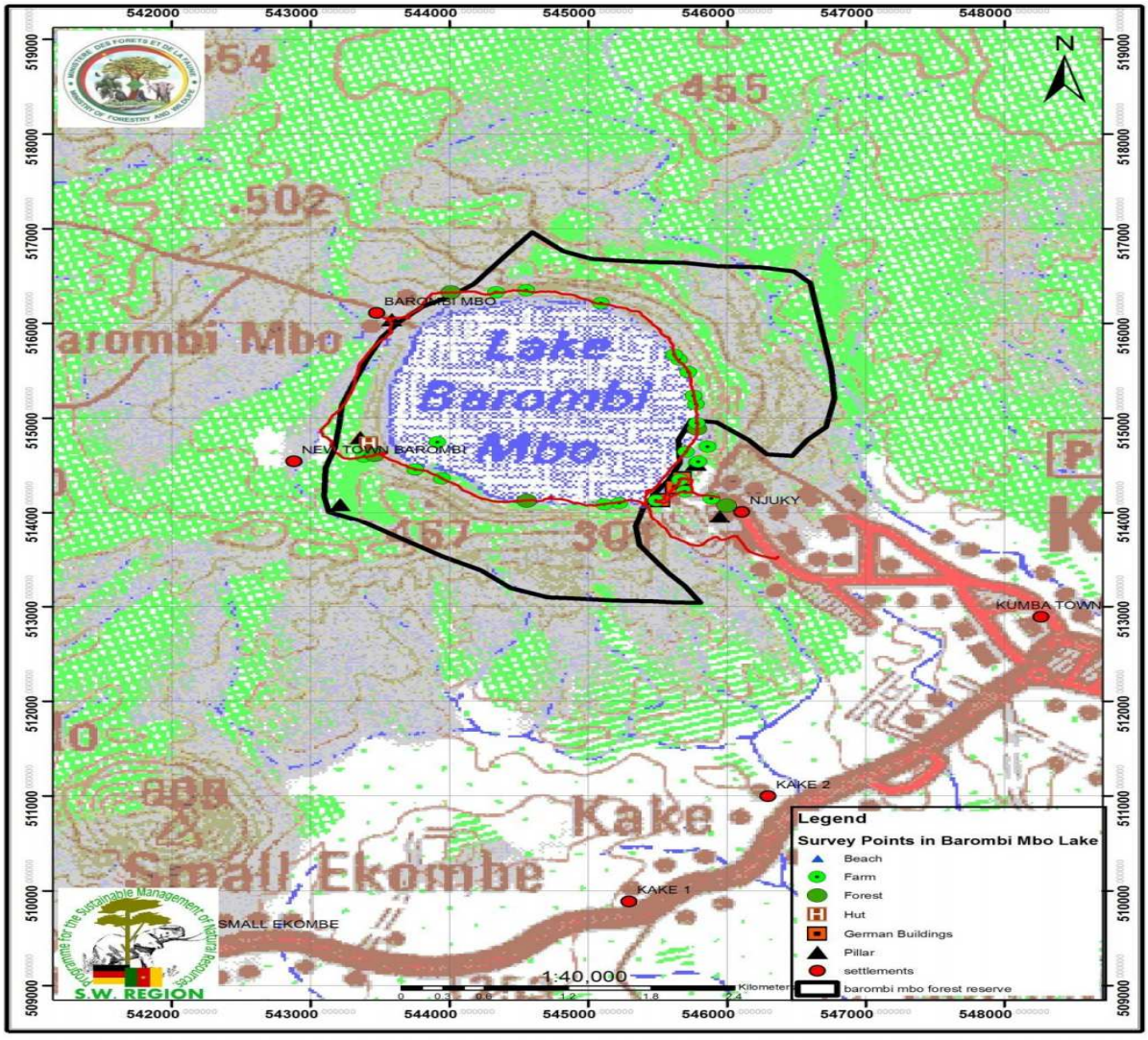


Figure 3. 6: Upstream part of the Lake Barombi Mbo Watershed. The map shows the Forest Reserve and surrounding targeted villages, and the farms (in green) located at the border of the lake (see Legend)

The fauna of the LBMW is very "poor" but "critical" and is composed of few mammals, reptiles, amphibians and birds. Several species of kingfishers, cormorants and birds of prey can be observed regurlay, especially in the dry season (Tchouto et al., 2015). Small monkeys are also observed around the lake. Chimpanzees were also reported to occur in the reserve area. Moreover, with the presence of freshwater sponges, the Lake is also an important biodiversity hotspot famous for the occurrence of 12 endemic fish-species, which renders Barombi Mbo, one of the areas with the highest densities of endemic species per area in the world (Schliewen and Tanjong, 2006; Eyenga et al, 2004). However, the population of these wildlife species is reducing significantly due to illegal hunting and poaching. Moreover, most of the endemic fish species are seriously threatened by pollution and sedimentation from human activities, including agriculture, forestry, water extraction and fishing. The endemic fish species of the Lake such as *Clarias maclareni* is being drastically reduced and the *Stomatepia monogo* has been classified as critically endangered in the UICN Red List. About 3.5 tons to 4.2tons of fish are caught per month in the lake and fish species are then expected to reduce as the declining quality of water and fishing practices will no longer be able to support the current biodiversity number.

- **Population and Socio-cultural Characteristics and Activities**

Lake Barombi Mbo Watershed has about 419,630 inhabitants, of which 400,000 inhabitant downstream and 19,630 inhabitant upstream (Tchouto et al., 2015). Moreover, the lake watershed is an attractive touristic (leisure, sightseeing), research and education site. The forests, hills, rock features, lake itself and fish species constitutes the main attractiveness. While constituting a conservation (Forest Reserve) and socio-cultural site, the watershed is also a source of livelihoods to the surrounding communities. The demand for agricultural products, fish, wood and fuelwood[39] in Kumba trigger intensive farming with multiple food and cash crops and heavy use of chemical in the watershed. These practices occurring until at the vicinity of the lake lead to erosion and contribute to water quality degradation (Agbor, 2008; Tchouto et al., 2015). This has already resulted in increasing water purification cost for the Cameroon Water Utilities Company (CAMWATER) and Camerounaise des eaux (CDE), as well as shortage of water to households. From field survey, the decreasing of water quality in 2012 has increased the costs of water filtration systems that were installed at FCFA 15

[39] Fuel wood is a major source of energy for rural and urban poor households in Cameroon as in the area and the demand has increased substantially following the currency devaluation of 1994 which led to major increases in prices of energy substitutes such as cooking gas and petroleum (Demenou, 1997; Ndoye, 1997; Adesina et al., 2000).

million to the CDE and CAMWATER, coupled with unpaid water bills by households during at least seven (07) months; this, because of poor or bad water quality from the tap. However, agreements with farmers to change land management practices would resolve water quality problems and enhance other ecosystem services.

3.5.2 History of Lake Barombi Mbo Watershed Management

Towards the end of 1937, the Senior Conservator of Forests for Cameroon noticed that most of the forests found between the cliffs and the North-eastern shores of the Barombi Mbo Lake was cleared and transformed into cocoa farms, and that especially only the forests found on steep slopes were not destroyed. He recommended therefore to the residents and the District Officer of Kumba that the lake and the portion of forest at the vicinity of the Crater Lake should be reserved. The residents and the District Officer agreed that reservation was desirable and the consent of the Bafaw (Kumba) and Barombi tribes was obtained in May 1938. In August 1939, the settlement was held and the terms of this settlement recognized only rights to fish and the authorization to harvest cocoa in existing farms. Although no timber exploitation was ongoing, felling was not authorized in the reserve. Lake Barombi Mbo Forest Reserve (LBMFR) of 920 hectares was then created by the colonial government following *Order No.17 of 1940* in accordance with *Forestry Ordinance 38 of 1938*, published in the *supplement to Gazette No.20 of 25 April 1940*[40]. This *Order* also establishes the rules for the management.

The creation of the reserve aimed at ensuring that farm encroachment and consequent erosion would cease, and therefore for the lake to be as amenities of an exceptional beauty, and the site as a potential sanctuary for the Chimpanzee population found in the Barombi forests. In 1947, the reserve boundaries were resurveyed by including the path South-wards to the Kake River and an amendment order was signed by the Native Authority and published in the Gazette of the 26th of August, 1948. From its creation until 1970, the reserve was managed on the basis of its working plan. Then, in accordance with the 1994 Forestry Law, LBMFR has become a permanent state forest for protection, where local communities living at the periphery were authorized to apply their user rights for consumption.

[40] *page B.42 of Laws of Nigeria (Ivo, 2008)*

The lake served as an important reservoir for drinking water, which is still exploited as the single major source of drinking water for the metropolis Kumba and its surroundings. The exploitation of the water started in 1978 with the former Cameroon National Society of Waters (SNEC). In 2005 and following the reform implemented in the urban water sub-sector, two companies have had the privilege of receive delegation of public services of drinking water. The first is the Cameroon Water Utilities Corporation (CAMWATER), a public capital company and responsible of the management of assets and rights assigned to drinking water service in urban and sub-urban areas; also responsible for construction, maintenance and management of infrastructures of collection, transport and storage of water. The second, la Camerounaise des Eaux (CDE), operates within the framework of a public-private partnership, and is responsible for the production and distribution of drinking water in urban and sub-urban, maintenance of water treatment facilities and activities related to the sales, including statement, billing and collection of revenue. Since 2005 then, the water of the lake is exploited by these two companies that supply water to Kumba town and surroundings.

Nevertheless, since 2006, it is noticed an expansion of upstream cultivated areas of the watershed reaching the vicinity of the Lake, mainly food crops, cocoa and rubber plantations, which increased pollution levels in the surface water due to pesticides and fertilizers use (Agbor, 2008; Tchouto et al., 2015), and erosion that has narrowed the depth of the lake of about 10m (CDE survey, 2015). Because of these threats facing the Lake biodiversity (endemic fish species) and the surrounding vegetation, the Lake BMFR was designated a RAMSAR site in 2006 by the Cameroonian Government (Schliewen and Tanjong, 2006). Before August 2012, the reserve management was under the control of the Ministry of Forestry and Wildlife (MINFOF) through the Control Post of Barombi Mbo, Divisional Delegation of MINFOF of the MEME Division. But the management of LBMFR was transferred by Ministerial Decision N°2002/D/MINFOF/SG/DF/CSRRVS of 21stAugust 2012 to the Kumba 1 council who signed a 3 year provisional convention with MINFOF. The transfer modalities require the Council to elaborate the management plan of the reserve, carry out proper demarcation of the reserve and an annual regeneration in the reserve with the technical support of MINFOF. As mentioned in section 2, (4) of the above convention, from the regeneration activities, the council could expect the benefits from the emission reduction financial mechanism REDD+ that will be implemented at the national level of the country.

As a lake watershed, the upstream part of LBMW is constituted by the above five villages (recalling here Barombi Mbo, Kake 1, Njurky, New Barombi Town, Small Ekombe) and the downstream part by an urban community of households, public and private administrations of Kumba town. Besides farmers of the five villages and the population of Kumba town, six (06) divisional delegations of government agencies; Kumba City Council and Kumba I Council are involved in the management of LBMFR (Figure 3.6). *These divisional delegations are those of the Ministry of Forestry and Wildlife (MINFOF), Water and Energy (MINEE); Fishing, Livestock and Animal Industries (MINEPIA), Environment, Nature Protection and Sustainable Development (MINEPDED), Agriculture and Rural Development (MINADER) and Economy and Planning (MINEPAT).* Their activities or contributions vary with respect to the attributes of the watershed. MINFOF, MINEE, MINEPIA, MINEPDED focus on forest cover, water quality and quantity, fisheries and environmental protection respectively, whereas MINEPAT and MINADER indirectly support communities around the watershed through public investment credit via MINEPAT/CAMCUL, agro-forestry practices (*farmer field school and farmer business school*) or some pesticides and fertilizers. Kumba City Council and Kumba I Council focus mainly on promoting ecotourism in the LBMFR and in ensuring its sustainable management (Author Survey with administered questionnaires, 2015).

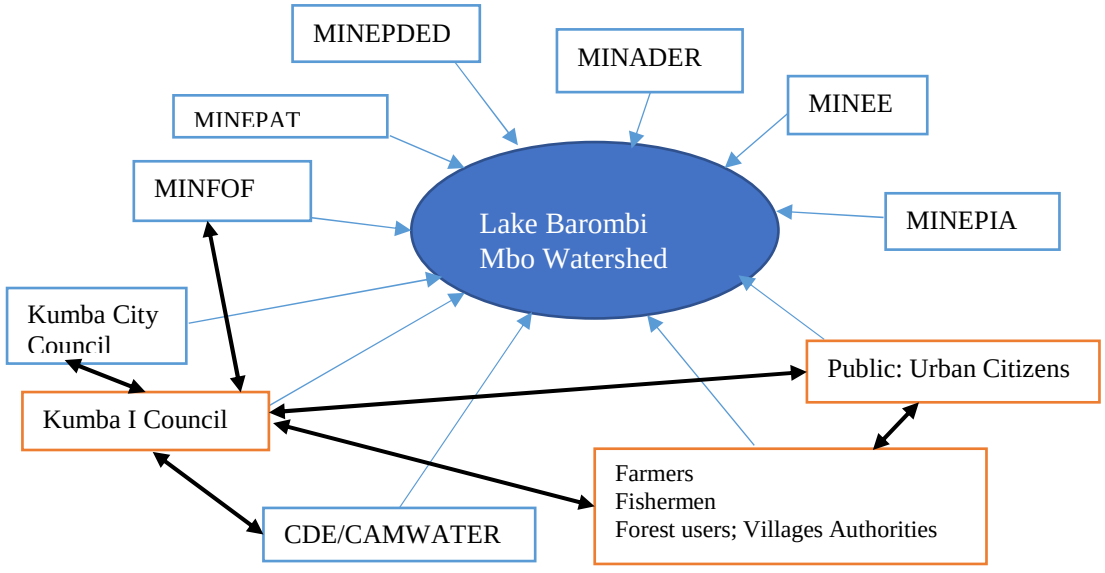


Figure 3. 7: Stakeholders intervening in Lake Barombi Mbo Watershed

- **State of Lake Barombi Mbo watershed management**

From field survey, all the stakeholders highlighted that the current management of LBMFR is not sustainable. According to some of them, enough attention was not paid. They reported that

50% and 75% of forest cover is destroyed, and the non-existence of management plan for the LBMFR. But, in collaboration with Kumba I council, the programme for the sustainable management of natural resources South-West Region (PSMNR-SWR) foresees to develop one under the management convention (Author Survey with administered questionnaires, 2015; Tchouto et al., 2015). In regards of the collaboration with the surrounding communities, MINFOF sensitizes communities on the negative impacts of farming, and has sometimes organized patrols and controls with Eco guards to fight against illegal logging, wood collection, etc. These activities of eco-guards created conflicts with the communities, as the land for cultivation is short in the area coupled with the increasing farmer population, since most of the Forest Reserves in the South West have been created during the colonial period (Tchouto et al., 2015). Kumba I council contributed to the livelihoods of the surrounding communities via school and road construction, ecotourism[41] promotion in the framework of local development. Moreover, MINFOF and Kumba I Council started to regenerate forest cover[42] in LBMFR. Nonetheless, the regeneration activities faced difficulties among which, conflicts with farmers. The trees planted were destroyed by farmers, who see these trees as intrusion to their own farms. Yet, no incentives were given to these farmers for the MINFOF and Council strategies to succeed. A list of farmers from Barombi Mbo village has been made available.

Water Utilities Company CDE and CAMWATER extracted about 4,500m^3 of water per day from the lake. Almost all community including households representatives and village authorities noticed a positive relationship between forest cover and water (quality and quantity), and the importance of forest in protection watershed, and to regulate local climate. But, village authorities highlighted the non-existence of financial compensation scheme with CAMWATER & CDE to the village as potential provider of watershed protection service. This is in part due to the free riding possibility between the two companies. As a matter of fact, because both companies are responsible for the maintenance of water treatment facilities, they tend to free ride in this case when there is need to act to preserve the water source.

[41] The statistics on the ecotourism activities vary between the City council and Kumba I council. About 700 to 800 people visit LBMFR each year, coming from Europe, USA and other part of the country. However, in addition to people from Kumba, the number of visitor increases to about 10,000 people per year (Kumba I Council). The visit fees paid to the council vary with respect to the status of the visitor. Visit fees for Cameroonian is between 100 to 500fcfa, while foreigners pay between 2,000fcfa to 2,500fcfa. No statistics are provided on the total amount per year.

[42] About 8,000 to 17,000 trees have been planted so far in the reserve by service providers and GREENFIELD NGO with the funding from MINFOF. The total cost of the regeneration programme started in 2013, was about FCFA 17 million, with a cost of CFA 1,000/tree. The corresponding hectare varied between 20ha to 345ha.

Indeed, no responsibility is explicitly emphasized regarding the proper management of watersheds in the country law to any of them (GWP, 2010); each of them tends to point out the responsibility of the other one at the field level, and then does not feel itself concerned with the sustainability of the watershed. In addition, the two Councils underlined the possibilities offered by the reserve and Lake for the environmental services payment; but stated of having signed no partnership for PES till now.

Furthermore, households underlined the substantial effects the erosion that narrowed the depth of the lake have had on their health and well-being. This has implied an increase of the costs of access to water quality including cost of water treatment, cost in terms of time for searching for other water sources when tap water was not available, and diseases. Therefore, a PES with farmers and households could have the potential to reduce these socioeconomic and environmental costs in the future. PES scheme should be included in the management plan of the reserve foreseen in order to cope with the financial resources scarcity and their unsustainability. This surely pass through the estimation of the value each of the major stakeholders, according to their activities and roles, attach to the ecosystem services of this watershed.

3.6 Conclusion of the Chapter

Although ecosystem services valuation is shown to be certainly difficult and stressed with uncertainties, one then could chose to make these valuation explicit or not; could do them with an explicit acknowledgement of the huge uncertainties involved or not (e.g. incorporating option values or not). The chapter went through the process of valuation. The exercise of valuing the ecosystem services or services of natural capital 'at the marginal' consisted of determining the differences that relatively small changes in these services make to human welfare. Changes in quality or quantity of ecosystem services have value insofar as they either change the benefits associated with human activities or change the costs of those activities. These changes in benefits and costs have impacts on human welfare trough established markets or through non-market activities.

Furthermore, although some valuation methods could be used to value watershed ES, CVM has been and is still a widely accepted method for estimating TEV including all types of non-use values. The methodology has been presented as well as some of the issues that arise. Due to some of its issues, researches have been conducted to improve the methodology. Hence, the

emergence and development of CE approach. CE has been presented and has its roots in Lancaster's characteristics theory of value, in random utilities model (RUM) and in experimental design. Successful implementation of CEs requires considerable up-front work dedicated to understanding the choice process and context(s) involved, identifying the attributes that influence choices, and selecting appropriate attributes levels. Careful consideration have also be paid to the differences among respondents and task complexities. Thus, once these elements have been understood, a design strategy for creating sets of choice alternatives is selected that is consistent with these elements and simulates actual market conditions of ES valuation as closely as possible.

Despite all the development and advancement of these two methodologies, their implementation in developing countries have been very few. This can be due to the costs involved or the validation issues that often arise as underlined by Whittington Dale (1998, p.21, cited in Milanesi (2007)). In the country, CVM has been mostly applied in internalizing pollution in urban area or in valuing urban park (Melachio et al., 2011). Few cases have been applied in rural area in valuing biodiversity (Nlom, 2008), in computing the TEV of tropical forest (Lescuyer, 2000), or the TEV of the watershed (Ruitenberk, 1990). No application of CE has been identified till now, whether in valuing forest ES or watersheds ES, though this is crucial in establishing PES scheme as stated early. Furthermore, the issue of the divergences between WTA and WTP in the literature has not been empirical examined in this context, whereas in the framework of PES mechanism, this divergence is used to ensure the participation constraint of the programme. Hence, there is need for an empirical valuation of watersheds ES and an examination of this participation constraint or condition in the country, particularly in the study zone.

Following this, the next chapter focuses on the provision of environmental services through sustainable agriculture and fishing activities in the watershed by estimating a willingness to accept of upstream farmers of Lake Barombi Mbo watershed. The chapter contributes to the internalization of negative externalities that affect the valuable services ecosystems provide to local, regional and international communities. Indeed, traditional markets have been underdeveloped or lacked for many environmental services including watershed protection. This generally resulted in the failure to take into account the costs of these services loss in the decisions to convert or alter natural habitat toward market-based agricultural or timber activities. However, where these services have been of direct, indirect, or nonuse value to

neighboring or distant communities, the internalization of these external values rose the scales in favor of environmental service provision, particularly in the case competing resources, such as agriculture or timber are only marginally profitable. Hence, the role of sustainable agriculture and fisheries in providing environmental services through internalization of the negative externalities of farm activities is identified in the next chapter. Agro-forestry and forest regeneration are considered as the main sustainable agriculture practices that could be promoted in the study zone, and the determinants of willingness to accept (WTA) along with the mean WTA will be determined.

CHAPTER FOUR

Sustainable Agriculture, Fishery and the Provision of Environmental Services in the Watershed: A Willingness To Accept Estimate of Upstream Users

4.1 Introduction

The rapid disappearance of the world's tropical forest cover, despite socially useful goods and services they provide, suggests that the society misallocates these natural resources (Amigues et al., 2002; FAO, 1997; MEA, 2005; Pagiola et al., 2002). Watersheds connect and encompass terrestrial, freshwater, and costal ecosystems, and perform a wide variety of valuable ecosystem services, including the supply and purification of fresh water, the provision of habitat that safeguards fisheries and biological diversity, the sequestration of carbon that helps to mitigate climate change, and the support of recreation and tourism (Postel and Thompson, 2005). In many tropical settings, these services primarily contribute as inputs to agricultural production and fishery. But, the economic worth of protected watersheds is rarely quantified (Dixon, 1997; Georgiou et al., 1997; Gregersen et al. 1987; Pattanayak, 2004).

The market values these services partially or not at all, and consequently, economic agents and policy makers receive distorted market signals and/or unreliable and incorrect information regarding the value of these services (Barbier, 1994; Panayotou, 1994). The failure to incorporate adequately these values into decisions about the use and management of watershed lands reduces net benefits that societies derive from watersheds. Land use changes from forests to farmlands, for example, diminish the ability of a watershed to perform its ecological work (FAO, 2007a; Postel and Thompson, 2005). Moreover, the conversion and modification of watersheds (streams, lakes, and rivers) have already progressed to a large extend. Revenga et al. (1998) in a global analysis of 106 primary watersheds found that in nearly one-third of them, more than half of the land area has been converted to agriculture or urban-industrial use. Such effects are negative externalities, as their costs are not reflected in market prices (Baumol and Oates, 1988; Coase, 1960; Dobbs and Pretty, 2004; Pigou, 1920).

Agriculture and fisheries are therefore global enterprises and the need for sustainable solutions to pressing environmental and production challenges is acute almost everywhere

(FAO, 2007a; Roberton and Swinton, 2005). Hence, current trends suggest that, during the twenty-first century, a continuing and growing demand for agricultural and wild products and ecosystem services will require farmers, agricultural planners, fishermen, and conservationists to reconsider the relationship between the agricultural production and the conservation of biodiversity (Asche, 2011; FAO, 2007b, 2010; Robertson and Swinton, 2005; Scherr and McNeely, 2008; Swinton et al., 2007; Zhang et al., 2007). Current priority research areas include soil carbon and plant nutrition, water quality and quantity from a watershed perspective, water as habitat for living aquatic resources, forests for both timber and non-timber forest products, and incentive systems for improving the provision of beneficial externalities, including payments by non-agriculturalists for environmental services provided by agriculture and forestry (FAO, 2007a; TAC-CGIAR, 2001).

While fishing activities are not practiced at a larger scale in the country and do not significantly contribute to its Gross Domestic Product (GDP), agriculture is the mainstay of the country's economy. About 75% of the active population is involved in agricultural production, which accounts for 50% of total exports and 19.7% of GDP (République du Cameroun, 2014). Peasant farmers have used traditional methods to grow crops for subsistence. A system of shifting agriculture was common and long fallow periods ensured ecological sustainability in the country. Export crops such as cocoa, coffee, banana, palm oil, and rubber were introduced far more earlier, by the German colonial ruler and became the focus of the national agricultural production and research (Grehrke, 1997). With the Cameroon Green Revolution launched in the South West region (Buea) in 1972, the Government encouraged mono-cropping and the use of chemical inputs, subsidizing up to 65% and 100% the cost of fertilizers and pesticides, respectively. With government subsidies and credits, many farmers shifted toward producing export crops and became heavily dependent on external inputs. However, excessive use of chemicals in agricultural production affects water quality and threatens the wetland or watershed's functional capacity to purify water; consequently affecting food production as noticed Banerjee et al. (2013). Furthermore, because of forests conversion to farmlands, the total forest area passed from 22.5 million ha in 1975 to 19.5 million in 2005 (République du Cameroun 2014). Thus, these threats from agriculture due to conservation have led conservationists to develop Protected Areas where agricultural activity is officially excluded or seriously circumscribed (Scherr and McNeely,

2008). Government has created a number of Protected Areas[43] (PAs) to conserve the country's biodiversity (République du Cameroun, 2012; 2014), and with the decreasing in land availability[44], in areas where traditional shifting agriculture is still applied, fallow periods have been reduced or are non-existent anymore. Hence, soil fertility in the cleared land cannot recover to optimal levels and thus slash-and-burn farming systems become unsustainable. In some areas of the country such as that of Lake Barombi Mbo, these threats are considerable.

Very extensive areas of the Reserve have been encroached and transformed into food crops farms and cocoa, palm oil and rubber plantations (Agbor, 2008). Unsustainable farming practices such as slash and burn have largely contributed to the high rate of deforestation and forest degradation recorded in the area (Tchouto et al., 2015). Some of the farms and cocoa plantations are located at the border of the lake (see Figure 3.6), and the use of chemical fertilizers and pesticides to spray cocoa harms water quality and the life cycle of the twelve endemic fish species of the lake. Moreover, fishing activities as implemented in the lake by inhabitants are neither selective nor sustainable, leading to the extinction of the endemic fish species (*Clarias maclareni)* and the pollution of the lake (Schliewen and Tanjong, 2006); the *Stomatepia mongo* species has currently been considered critically endangered (IUCN Red List) (Darwall et al., 2011). These illegal and unsustainable farming activities into the reserve coupled with unsustainable fishing activities contribute to the destruction of wildlife habitat and the depletion and loss of biodiversity as well as the environmental quality.

Given these unsustainable farming practices that affect both biodiversity and ecological sustainability in the zone coupled with the growing population due to soil fertility and reserve's resources, there is need to promote the adoption of production models favorable to biodiversity conservation such as agro-ecology. Preserving agricultural biodiversity depends on a fuller recognition of the importance and the economic value of natural resources, including soils, forests, and the ecosystem services they provide. Hence, attempts to place a monetary value on environmental services provided by agriculture underline its rising importance in ecological and economic terms (Stevens, 2011). Valuable approaches for promoting agricultural practices, which promote biodiversity conservation are Payments for

[43] Ten Protected Areas (National Parks, Reserves, etc) were created within the country between 2006 and 2011 and about 174 protected areas have been created within the country from 1880 to 2015.

[44] As a matter of facts and as the MEA (2005) calculated, more than 45% of the 100,000 Protected Areas had more than 30% of their land area under crops. Nonetheless, although in light of political and economic realities, many recently designated PAs in several African countries explicitly permit a biodiversity friendly agriculture, usually in areas considered as category V or VI by the IUCN system (IUCN, 1994). However, agricultural activities within the PAs of the country are officially considered as illegal, and even if at all allowed, they are not biodiversity friendly.

Environmental Services (PES). PES provide financial transfers to landowners, farmers, and communities whose land use decisions may affect the biodiversity value and create incentives for the conservation of plant and animal species.

However, designing these incentives for a voluntary provision of environmental services (ES) by farmers and fishermen is not easy (Swinton et al., 2007). If in theory, PES is an economic incentive mechanism for the provision of ES, analyzing their implementation especially in agricultural and fishing sectors underlines the great dependence of their effectiveness on their social acceptability. Moreover, given the difficult task to evaluate watershed through a market mechanism, the compensation for watershed protection is usually based on the opportunity cost of changing practices or restricting use rights. However, by doing so, the amount of payments are not always sufficient to implement changes in agricultural and fishing practices accessible to farmers (Delvaux et al., 1999, Karsenty et al., 2010) and targeting the lowest cost for service providers requires an approach that reveals private information ex ante (Ajayi et al., 2012). Alternatives have been proposed, as taking into account the Willingness To Accept (WTA) of environmental services providers in the determination of the PES structure (Ajayi et al., 2012; Amigues et al., 2002; Delvaux et al., 1999) as well as the farmers' perception of the importance of forests and their conservation practices that may be of great importance to design suitable management incentive schemes (Appiah, 2001; Bessie et al., 2014).

The main objective of this chapter is to estimate the willingness to accept of farmers for providing environmental services in the watershed of Lake Barombi Mbo. This objective falls in three specific ones: firstly, a description of the provision of environmental services by farmers through improved agricultural and fishing practices in the watershed; secondly, an identification of criteria through which farmers perceive the negative effects of their practices on the environment; and thirdly the determination of variables that affect farmers' willingness to accept to provide ES through agroforestry or reforestation in their agricultural system. The chapter is organized in five sections. The next section defines and describes strategies for the provision of environmental services in sustainable agricultural systems, including the contingent valuation approach. The subsequent section discusses materials and methods used in the chapter. Results are then presented and discussed, including assessments of traditional and environmental practices, the farmers' perception, fishing activities, and results of the

analysis of WTA along with the computed average WTA. The final section concludes on the work undertaken in this chapter.

4.2 Literature Review and Theoretical Framework

4.2.1 Concept of Sustainable Agriculture and Fishery

Sustainable agriculture started to generate significant interest in the 1980s and has come to represent not just a different set of technologies to conventional agriculture, but a means to achieve sustainable development (D'Souza and Gebremedhin, 1998). Defined as agro-ecology, low-input agriculture, biological agriculture, regenerative agriculture, or organic agriculture, sustainable agriculture aims to increase agricultural productivity while reducing negative effects on the environment and providing environmental services. While improving the internalization of environmental externalities in agricultural production, an agro-ecology system increases economic returns to farmers through more efficient inputs use and enhances resource management (Scherr and McNeely, 2008). Indeed, although these environmental measures may slow agricultural outputs in the short-term, eco-efficiency gains yield long-term economic benefits (Stevens, 2011).

A number of practices and technologies have been variously developed and adopted to promote sustainable agriculture worldwide. Integrated pest management systems have used varietal crop mixes, pest monitoring, and management practices to reduce the need for pesticides (Kogan, 1998; Scherr and McNeely, 2008). Organic farming[45] relied on an organic soil fraction called *humus* to reverse the perennial problem of erosion, soil depletion, decline in crop varieties, low food quality and livestock feed, and rural poverty (Kuepper, 2010; UCS, 2009). Agroforestry is a concept of integrated land use that combines elements of agriculture and forestry in a sustainable production system and balances productivity with environmental protection (Smith, 2010). Under an agroforestry system, aquaforestry is one of accepted models for fishery today. Although good fish management systems were developed since the 1950s (Gordon, 1954) to prevent open access fishing and include limited vessel size, restrictions on which gear can be used, number of fishing days, restrictions on engine power, and limited entry to the fishery (Asche, 2011; Wilen, 2000). Aquaforestry consists in a system of riparian buffers or trees planting on the bunds of fish ponds, lakes, or reservoirs to stop

[45] Organic agriculture is a holistic production management system that avoids the use of synthetic fertilizers, pesticides, and genetically modified organisms, minimizes pollution of air, soil, and water, and optimizes the health and productivity of interdependent communities of plants, animals, and people (Müller-Lindenluf, 2009).

erosion and help fish species to be able to sustain their populations and increase the amount of oxygen they receive (Sheriff, 2012). Agro-forestry and reforestation in forested watersheds reduce the ecological footprint of farmed areas and the damage to wild species from toxics, soil disturbance, and water pollution. Increasingly agroforestry and reforestation are viewed as providing ecosystem services, environmental benefits, and economic commodities as part of a multifunctional role of agro-ecosystems (Jose, 2009; MEA, 2005; Smith, 2010).

4.2.2 Concept of Environmental Services

Whereas ecosystems services are benefits people obtain from ecosystems (MEA, 2005), Environmental Services (ES) are externalities generated by human activities that sustain the provision of ecosystems services, including watershed protection, biodiversity conservation, carbon sequestration, and landscape beauty (OECD, 1994; 2001; Pagiola et al., 2002). They are then only a part of ecosystem services and are considered as positive externalities of production and public goods. Positive externalities involve cases where the actions of one party (firm, farmer, or fishermen) directly benefit other parties (consumers or producers), but the first party receives no payment. In public goods' context, the amount of the good used by some agents cannot reduce the amount used by others and these latter cannot be excluded from using it. Economists thought of policies and incentives to internalize externalities and to create incentives for the provision of public goods. Pigou (1920) recommended that actions generating positive externalities should be subsidized, and these policies provide the context for decision-making by individuals, businesses, and government agencies that make on the ground decisions that affect ecosystems. Successfully addressing the degradation of ecosystem services requires the understanding of their provision and their value and the design of incentives for their sustainable provision (Polasky, 2011).

In the current debate on multi-functionality of agriculture, the concept of ES describes various agricultural activities that contribute to the maintenance, preservation, and improvement of the environment in its various dimensions that are landscape, natural resources, and ecosystems (Aznar et al., 2009; FAO, 2007a; Jose, 2009; Swinton et al., 2007). An important place is then given to agriculture in providing these services, especially in developing countries where agriculture is one of the main sectors of activity.

4.2.3 Sustainable Agriculture, Fishery and Environmental Services

Among Earth's major ecosystems, agriculture is the one most directly managed by humans to meet human goals. Food, fiber, and fuel production is the overwhelmingly dominant goal of

agriculture. Yet as a managed ecosystem, agriculture plays unique roles in both supplying services to and demanding services from other ecosystems. In this process, agricultural ecosystems depend upon a wide variety of supporting and regulating services, such as water, soil fertility, and pollination that determine the underlying biophysical capacity of agricultural ecosystems (Swinton et al., 2007; Zhang et al., 2007). But, on the other hand, agriculture negatively affects the environment through overuse of natural resources as inputs or through their use as a sink for waste and pollution (FAO, 2007a) as indicated in Figure 4.1 below.

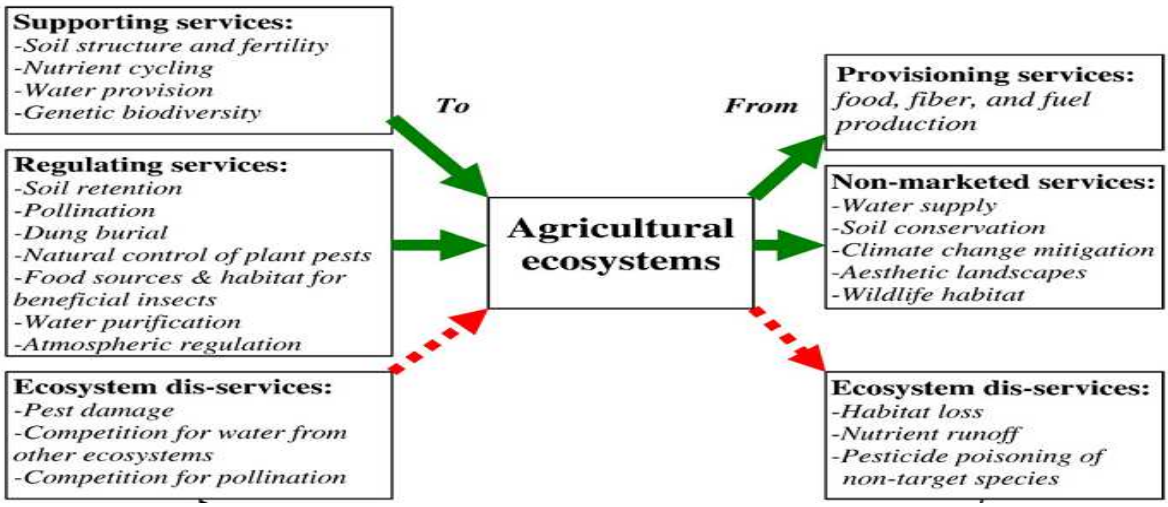


Figure 4. 1: Ecosystem services and dis-services to and from agricultural ecosystems. Adapted from Zhang et al. (2007).

Nevertheless, sustainable agricultural systems have contributed to deliver and maintain a range of valuable public goods and have been proven to be less vulnerable to shocks and stresses. Mechanisms through which sustainable agriculture systems contribute to environmental services have been examined by numberous authors (Alavalapati and Shrestha, 2003; Jose, 2009; Pretty et al., 2011; Scherr and McNeely, 2008; Van Noordwijk et al., 2007). Bonnieux and Desaigues (1998) showed that mesh-type wooded improves productivity of dairy cows and generates external benefits to consumers (amenities for walkers and wildlife protection) and firms (inputs for tourism). Moreover, OECD's works in 1994 on rural amenities and in 2001 on multi-functionality of agriculture focuses on the same ES approach. Based on this approach, positive externalities of production are supplied essentially by agents using environmental components and natural resources in their production process. Farmers and forest users are then implicitly considered as main providers of ES and these ES are thus by-products of the main production (agriculture or forestry).

In the last decade, agricultural and/or forestry ecosystems have been recognized to offer a potential to deliver four main ES that are carbon sequestration, biodiversity conservation, watershed protection, and landscape beauty (Alavalapati and Shrestha, 2003; Landell-Mills and Porras, 2002; Pagiola et al., 2002; Wunder, 2005). As emphasized by Jose (2009), trees, crops and/or animals integrated into an agro-forestry system enhance soil fertility, water quality, and biodiversity, increase aesthetic, and sequester carbon. Within the watershed context, a stream of goods and services are delivered (Postel and Thompson, 2005), and one usually encounters a bundle of services including the three others main ES described in Figure 4.2.

a. Sustainable agriculture and watershed protection

Many of the world's most important watersheds are densely populated and under predominantly agricultural use, and most of the rest are in agricultural land use mosaics where crop, livestock, and forest productions influence hydrological systems. In such regions, agriculture can be managed to maintain critical watershed functions, such as maintaining water quality, regulating water flow, recharging underground aquifers, mitigating flood risks, moderating sediment flows, and sustaining freshwater species and ecosystems (see Figure 4.2).

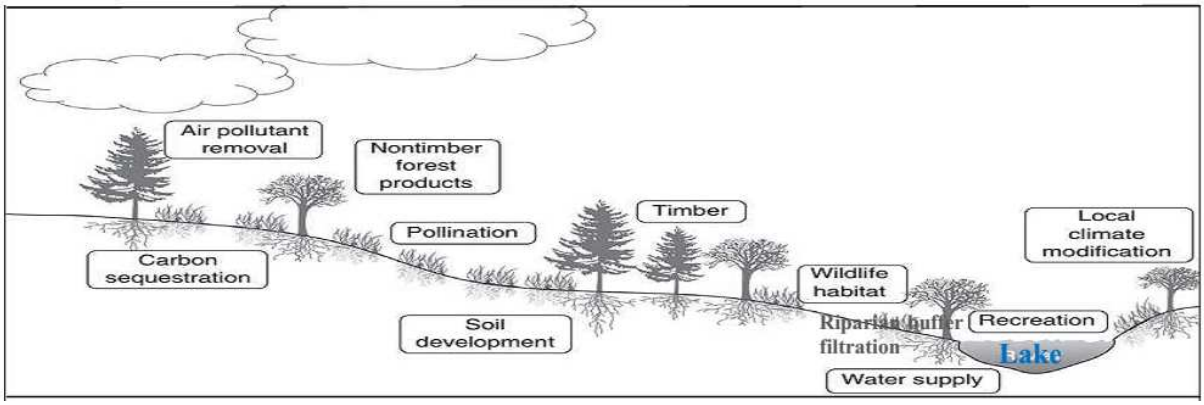


Figure 4. 2: Ecosystems services provided by watersheds. (Adapted from Brauman (2015)). In addition to hydrologic services, a watershed produces a variety of other services; examples of these are shown in the figure.

Terrestrial land, soil and vegetation management play critical roles in the hydrological cycle and this refers to the concept of "green water" (Scherr and McNeely, 2007). Protection and establishment of native vegetation buffers along streams, lakes, rivers, and riparian systems are critical for biodiversity conservation, and riparian buffers have been proposed as a means to combat non-point source pollution from agricultural fields. Riparian buffers help to clean

runoff water by reducing the velocity of runoff, thereby promoting infiltration, sediment deposition, and nutrient retention (Jose, 2009). Buffers also reduce the nutrient movement into ground water by taking up excess nutrients. According to Van Noordwijk et al. (2007), watershed functions in agricultural landscapes can be effectively provided through strategic spatial configuration of perennial natural and planted vegetation, with maintenance of continuous soil cover enhancing infiltration.

b. Sustainable agriculture and carbon sequestration within the watershed

Many of ES derived at the farm scale or landscape are enjoyed by the society at larger regional or global scales. Carbon sequestration involves the removal and storage of carbon from the atmosphere in carbon sinks (oceans, lakes, vegetation, or soil) through physical or biophysical processes. It is estimated that increasing the removal of atmosphere CO2 through carbon sequestration in soil and vegetation sinks by agriculture has the potential to offset up to 20% of global fossil fuel emissions (Stevens, 2011). However, this depends on enhanced soil management and cultivation as carbon sequestered in soils can be released back to the atmosphere through inappropriate farming practices. Investments or practices that increase soil organic matter and some trees species within the farm could both increase farm productivity and enhance carbon sequestration for climate change mitigation over the long term.

The incorporation of fruit trees, Non-Timber Forest Products (NTFPs) (Sonwa et al., 2007) and the adoption of alley farming[46] (Adesina et al., 2000) and live hedges (Ayuk, 1997) in agroforestry systems can increase the amount of carbon sequestered compared to a monoculture field of crop plants. In addition to the carbon stored in aboveground, agroforestry also stores carbon belowground (Jose, 2009). In humid tropical forest zones, the adoption of improved seeds in the agricultural system could likely mitigate climate change, in line with the underlined reduction of emissions due to deforestation and forest degradation (REDD+) mechanism. Improved seeds or the seedlings adoption lead farmers to produce more outputs from the same area of land (Pretty et al., 2011), while reducing negative environmental impacts of slash and burn and shifting cultivation system that contribute to carbon emission. Results of the alternatives to slash and burn (ASB) initiative conducted in the country

[46] Alley farming is an agroforestry technology involving the cultivation of food crops between hedgerows of nitrogen fixing leguminous hedgerow species. The leguminous species have deep roots for nutrient capture and recycling, produce substantial amounts of biomass, which are applied to the crops as mulch, and contribute to nitrogen fixation. The technology requires farmers to prune periodically the leaves of the hedgerow trees or shrubs for application as mulch. The technology has been shown to increase and sustain production of maize compared to conventional bush fallow, prevent erosion, control weeds, enhance nutrient cycling, and build up soil organic matter. For details, see Adesina et al. (2000).

regarding trade-offs faced by farmers in generating biodiversity conservation and carbon sequestration along with their implications for income and food security, compare the financial returns to various agricultural production systems with the carbon they sequester. From a carbon sequestration perspective, the largest gains are indisputably achieved through leaving the forest intact (FAO, 2007b). However, this option generates essentially no financial return. Moving from food crop/short fallow to food crop/long fallow significantly increases carbon sequestration, but reduces profitability. However, moving from food crop/short fallow to intensive cocoa (with or without fruit sales) increases yields in both carbon sequestration and agricultural profitability (Tomich et al., 2005, cited in FAO, 2007b).

c. Sustainable agriculture and biodiversity protection within the watershed

The food system must address or adapt to the collapse in harvest of wild game and wild fisheries in many regions around the world, due to overexploitation and habitat loss or pollution. Mechanisms by which a sustainable agriculture system contributes to biodiversity have been examined by various authors (Aznar and Perriet Cornet, 2003; Jose, 2009; Pretty et al., 2011; Scherr and McNeely, 2008; UCS 2009). Systems like agro-forestry plays major roles in conserving biodiversity. Agro-forestry provides habitat for species that can tolerate a certain level of disturbance and helps to reduce the rate of conversion of natural habitat by providing a more productive and sustainable alternative to traditional agricultural systems that may involve clearing of natural habitat. It also helps to conserve biodiversity by providing other ecosystem services such as erosion control and water recharge, thereby preventing the degradation and loss of surrounding habitat. As underlined by Jose (2009), multistrata cocoa agro-forestry systems that include timber, fruit, and native forest species contribute to biodiversity conservation by providing habitat for avian, mammalian, and other species, enhancing landscape connectivity and reducing edge effects between forest and agricultural land. Moreover, agroforestry practices provide improved wildlife habitat by increasing structural and compositional plants diversity in the landscape. Windbreak and riparian buffers offer the only woody habitat for wildlife in many agriculture dominated landscapes.

Reducing agrochemical use and livestock wastes in high-input production systems can also greatly benefit wildlife. The agri-environmental scheme in the EU with farmers contributed to the reduction of negative impacts of fertilizer and pesticide inputs on biodiversity and stabilized soil erosion (Kleijn et al., 2003; Stevens, 2011). Systems that use crop rotations, and green and animal manure have shown higher biodiversity by foregoing chemical

pesticides, supplying more diversed habitat, and reducing nitrogen pollution (UCS, 2009). Multi-stage agroforest systems, tree fallows, and complex home gardens are especially rich in wild biodiversity. According to Schroth and Harvey (2007), to conserve biodiversity over the long term, land management should focus on conserving native forest habitat within cocoa production landscapes, maintaining or restoring floristically diversed and structurally complex shade canopies within cocoa agroforests, and retaining other types of on-farm tree cover to enhance landscape connectivity and habitat availability.

d. Sustainable agriculture and landscape beauty within the watershed

With accelerating urbanization worldwide, the loss of natural habitats and natural features has become a central concern for planners and residents, as well as farmers operating in peri-urban areas. Agriculture can protect green spaces for aesthetic and recreation values and help to finance the maintenance of green space for wildlife habitat, recreation, and ecosystem services. As underlined Scherr and McNeely (2008), positive outcomes for human habitat and aesthetics require adequate management of crop and livestock wastes, air pollution (smoke, dust, and odours) and pollution run-offs. Furthermore, the agri-tourism sector is inclusive of farming activities, which can be linked to the tourism sector as an entrepreneurial advantage. Research by Viljoen and Tlabela (2007) showed that there is a new trend among farmers to embrace new opportunities and often farmers embrace tourism as an income generator. Moreover, agro-ecotourism can be an important alternative enterprise for small farmers, and such an enterprise typically involves charging fees for access to your property for wildlife-related recreational activities such as hiking, canoeing, camping, and photography.

However, in spite of all this potentials for sustainable agriculture to provide ES, a standing forest usually represents a potential source of income that can be accessed through logging or farming in the case of a sudden need. Moreover, holding livestock also represents a common form of insurance against possible future shocks. Farmers may thus be unwilling to introduce changes into their production systems that involve a loss of these means. Nevertheless, given that the environmental services approach leads to solutions that environmental effects of farmers' activities provide the final users with a higher welfare, then positive environmental externalities should be internalized by sending signals to farmers that emit these positive external effects. The providers of these ES should be encouraged to provide them and be paid for them, at least at the marginal social benefit procured by these ES. Since environmental public goods are not traded on conventional markets, supply and demand schedules require

some forms of non-market valuation. Thus, studies have used environmental valuation methods to measure the social benefit associated with these ES, among which travel cost, hedonic price, and contingent valuation methods.

4.2.4 The Contingent Valuation Approach

First proposed in the economic theory by Ciriacy-Wantrup (1947), the Contingent Valuation Method (CVM) is used for an ex-ante evaluation of policy implementation and is a democratic method of decision-making support, where individual preferences are the foundation (Desaigues and Point, 1993). It is a survey based on the stated preference technique where respondents are directly asked to express their Willingness To Pay (WTP) or Willingness To Accept (WTA) for a hypothetical change in a non-market good (Mitchell and Carson, 1989).

Although subject to criticisms regarding reliability and validity across the literature, CVM has emerged as a valid tool for estimating the benefits/costs of non-markets goods, particularly for direct and indirect use values (Hanemann et al., 2002). The theory of consumer behavior underlies CVM and more technically, from a benefit-cost measure, the use of WTP (compensation) and WTA (compensation) depends on the types of valuation question (Mitchell and Carson, 1989, p30). Moreover, the choice between the WTP or WTA formulation is a question of property rights, that is, does the agent have the right to sell the good in question or, if he wants to enjoy it, does it have the right to buy it? (Mitchell and Carson, 1989, p30). However, since we are dealing with public goods where rights are collectively held, this question is often not an easy one to answer. If an individual, such as a farmer, has an exclusive property or user rights over a good and is being asked to give up or restrict that entitlement in terms of exclusivity or transfer of user rights, then the correct measure within a contingent valuation framework is WTA (Carson et al., 2001). In this sense, there is some evidence that farmers through exposure to agri-environmental schemes have become familiar with the trade-off between agricultural production and provision of environmental public goods (Buckley et al., 2009; 2012).

Buckley et al. (2012) estimated the WTA for supplying ecosystem services by farmers through the adoption of riparian buffer zones in agricultural catchments. Bateman et al. (1996) used CVM for the provision of agricultural forestry trough establishment of recreational woodland. In economic terms, the measures of value they investigated were, in the case of farming experiment, farmers' WTA compensation for switching from their present activities

into the provision of recreational woodland. They found that farmers were more familiar with the concept of assessing potential compensation than households. Amigues et al. (2002) applied CVM to examine the WTA of households that own land on the banks of the Garonne River to supply a strip of riparian land for habitat preservation. The values suggested by farmers who indicated a positive WTA was consistent with revenues generated from crops. Dupraz et al. (2003) found that CVM is a reliable method to reveal the behaviors of farmers facing the invitation to participate in an agri-environmental scheme. The valuation of social benefits of ES provided by farmers has not received much attention in the country and the lack of data for the implementation of PES so as to study their profitability as well.

4.2.5 Policy Option: The promotion of Sustainable Agriculture in Cameroon

The Government has redefined its development priorities to include sustainable agriculture and protection of natural resources (soil, flora, fauna, and water). The government then requested assistance in the promotion of ecologically friendly agro-pastoral practices that would lead to the conservation of its natural resource base, including National Parks and Reserves, while improving the soil productivity. Indeed, aware of the importance of biodiversity as an essential component of its socioeconomic development and recognizing slash and burn agricultural practices as the first driver of ecosystem services degradation, the country is engaged in international financial mechanisms for biodiversity conservation and climate change mitigation. The country is committed in its 2014 report to Convention on Biodiversity to develop and implement a national Payments for Environmental Services (PES) program by 2020 to cope with the ongoing unsustainable management of its natural resources, and therefore to impute PES in the national budget. Moreover, aware of the potential negative impacts of deforestation and forest degradation for ecosystem services, Cameroon has engaged in the international Reduction of Emissions due to Deforestation and forest Degradation (REDD+) process. Several steps have been taken so far. The first step was the validation of the country's Readiness Project Idea Note (R-PIN) in 2008, the submission of Readiness Preparation Proposal (R-PP) in 2012, and the implementation of REDD pilot projects. Since then, initiatives and REDD+ pilot projects have emerged within the country. The areas of interest are the regeneration of vegetative cover in the agricultural sector of the country, while improving agricultural productivity, and the reduction of extensive agricultural lands through an intensive agricultural system. Improved seeds have been disseminated and small farm materials and/or machineries have been given to rural households. Fertilization

through the development of environmentally friendly agricultural techniques, especially the development of agro-forestry, crop rotations, and valorization of fallows under integrated watershed management are foreseen.

However, main actions undertaken until now were done without clear and systematic perceptions and expectations of farmers or communities. The effectiveness of such incentives mechanisms in promoting sustainable agricultural practices depends on the value farmers attach to ecosystem services and on their opportunity cost to switch to such sustainable practices. Furthermore, the realization of these sustainable activities around Reserves and National Parks usually faces resistance from communities. Involving farmers in such incentive schemes being designed within the country is of a fundamental importance to identify factors that determine their social acceptability. Prospective research on farmers' ability to participate in the provision of environmental services in Cameroon is necessary and indispensable. Hence, it is essential to analyze from the farmers' side their valuation of environmental services from agriculture. The willingness to accept (WTA) determines their decision to participate in a reforestation program and it is assumed that a positive WTA reveals their decision to participate. Moreover, information obtained on their socio-economic characteristics is used to test the validity of CVM.

- **Field survey**

Several types of sustainable agriculture practices have been promoted among farmers in the Meme Division by the *Ministry of Agriculture and Rural Development* (MINADER), including *farmer field school* and *farmer business school.* Through *farmer field school*, MINADER trained farmer on good agricultural practices via cooperatives. Through *farmer business school*, agriculture is considered as a source of income with the promotion of agro-forestry. The institution provided farmers with the improved corn seedlings, maize seeds, cassava cuttings, and some pesticides and fertilizers. However, difficulties encountered by farmers to adopt agro-forestry practices were the unavailability of improved agro-forestry species or nursery and the insufficient availability of land for planting. Furthermore, some villages such as Barombi Mbo and New town Barombi were not targeted since, due to their location closed to the Reserve managed by the Ministry of Forestry and wildlife (MINFOF). The lack of collaboration between these two institutions in the field leads MINADER to not giving opportunity to these village farmers to learn and benefit from agro-forestry practices.

4.3 Materials and Methods

The section presents the materials and methods used, including the sampling technique, the analytical and empirical models

4.3.1 Sampling Method

A population of 19,630 inhabitants was reported in March 2015, with 9,562 male and female above 15 years old by the *Programme for Sustainable Management of Natural Resources in the South West Region* (PSMNR-SWR) (Tchouto et al., 2015). The following formula: $n = \frac{N}{1 + N\varepsilon^2}$ was used to representatively select 384 farmers within the watershed, where N=9,562 is the number of inhabitants older than 15 years old and $\varepsilon = 5\%$ is the margin error. The selection of an age greater than 15 years allowed us to taken into account farms that are owned or managed by youths when both or one of their parents are not around or still alive. The proportionate stratified sample procedure was used to determine the number of farmers to be interviewed in 3 villages: Kake1, Small Ekombe, and Njurky; after fixing the number in Barombi Mbo and New Town Barombi villages since they are closer to the reserve and the lake. Structured questionnaires were used as a survey instrument and farmers were randomly selected within the village for face-to-face interviews. Questionnaires included information on socioeconomic characteristics of farmers, farm characteristics, and fishing activities in the Lake. Questionnaire also included a hypothetical scenario describing changes in the watershed due to current practices for the CVM exercise as follows: "*Studies carried out in the Barombi Mbo Forest reserve revealed that about 90% of the forest reserve is destroyed. If the current level of activities in and around the reserve continues, there won't be any trees to provide climate regulation, wildlife habitat, water quality and quantity for future generations. To regenerate the vegetation, a reforestation programme is foreseen by the Government. Your participation in this survey will help government estimate the reforestation cost.*"

Questionnaires were first pre-tested with 30 farmers. The objective was to verify its good understanding by farmers and to determine amounts to be proposed for the valuation question. To achieve this latter objective, an open valuation question was used to measure the willingness to accept (WTA) of farmers for ES provision. After the presentation of the hypothetical scenario, the open question was: "W*hat would you expect as annual compensation for trees planted in and out of the reserve?*"

After the test, the questionnaire was then revised to incorporate farmers' suggestions on the types and levels of activities carried out on farm and within the reserve and on the willingness to accept for ES. Amounts obtained from the open question allowed the determination of the distribution of WTA that was used to determine amounts or offers proposed per year for the final data collection. Rather than retain values between the 15th and 85th percentiles and out of the tail of the distribution as recommended by Kanninen (1995) for the willingness to pay, we retained the two lower amounts that were FCFA 10,000 and FCFA 15,000, due to the tendency of people to overstate their WTA as highlighted by Kahneman and Twersky (1979). Moreover, 1 or 2 amounts proposed are theoretically optimal (Terra 2010) and a smaller number of bids are preferred to a larger number of bids, as it increases the estimation efficiency and the power of statistical tests (Alberini, 1995). Each of the two amounts was then allocated to 50% of the sample to ensure the equal-distribution of the offers. A WTA question to establish the minimum amount in cash or the compensation in nature the farmer would decide to accept for changes from the current land use to a more productive agriculture in the watershed was presented using a simple close-ended format.

4.3.2 Analytical Model

A simple Tobit model (Tobin, 1958) was used to model farmers' WTA using maximum likelihood estimation procedures. The Tobit model constitutes the basic structure of models with limited dependent variable that derive from qualitative variables models, in the sense where one should model the probability of the variable to belong to the interval in which it is observed (Hurlin, 2002; Tobin, 1958). In CVM, the simultaneous presence of a substantial number of protest and zero bidders requires the use of a Tobit model, which can be a censored or a truncated model[47]. A strong assumption underlying the Tobit model is that zero bidders actually have a negative WTA, but because no amounts below zero are allowed, they are reconstituted to as a "*zero*" WTA. In other words, the latent dependent variable is assumed to contain negative values that have been censored to zero in the empirical realization of the variable. In empirical studies however, these zero values are usually considered as "*true*" or "*false zeros*" and the model used depends on the nature of the zero. The Tobit model is used in the case where only "*true zeros*" exist and the two-step Heckman method is usually used in the case where there exist "*false zeros*", that is when respondents intend to free ride or dislike the payment vehicle after expressing an interest for the good undervaluation. Indeed, in the

[47] In a censored regression model, one disposes of observations on explanatory variables at least over the overall sample, whereas in a truncated regression model, all observations of explanatory and dependent variables out of a certain range are totally lost.

well-known two-part model, the first step is a binary outcome equation, usually a Probit model that explains the decision to either participate in the hypothetical market or protest, and the second step uses a linear regression to model the contribution decision (including "*true zeros*"). The two decisions are assumed to be independent and are estimated separately. In our case, because it is question of WTA, respondents cannot free ride as compensation is received upon providing ES through reforestation. Therefore, the study deals only with "*true zeros*" values, i.e. respondents are not ready to restrict their user rights (or to set a portion of their land) to participate in reforestation or they find the amount proposed too low for participation. Thus, the Tobit model appears more relevant for analyzing our data.

From the original model of Tobin (1958), WTA belongs to the interval $[0,+\infty[$ as there exists no negative compensation and this justifies the choice of the censored regression model. The choice is dichotomous: either the individual agrees to participate ($WTA > 0$) or he does not accept ($WTA \leq 0$). The Tobit model was largely applied to the adoption of technologies or the participation in conservation programmes (Buckley et al., 2012; Delvaux et al., 1999; Terra, 2010). The conceptual model is given by the following equation:

$$WTA_i = \boldsymbol{X}_i\theta + \boldsymbol{\mu_i} = \boldsymbol{E}(WTA_i^*) + \boldsymbol{\mu_i} \qquad (4.1)$$

Where,$\boldsymbol{X}$, is a row vector of explanatory variables that determine the respondent $\boldsymbol{i}$'s WTA or to participate in the sustainable agricultural or conservation programme, θ is a column vector of parameters to be estimated, $\boldsymbol{\mu}$ an error term with a normal distribution $N(0,\sigma_\mu^2)$, and with:

$$WTA_i = \begin{cases} WTA_i^* \;\; if \;\; WTA_i^* > 0 \\ 0 \;\; if \;\; WTA_i^* \leq 0 \end{cases} \qquad (4.2)$$

WTA_i^* follows a normal distribution and is a latent variable representing the observed WTA of individual i. The Tobit model is composed of two parts: a continuous part corresponding to a linear regression and a discrete part relating to the censored point which equals to zero here. The probability that WTA_i^* takes a negative or a value equal to zero is given by:

$$Prob\,(WTA_i^* \leq 0) = \emptyset\left(-\frac{\boldsymbol{X}_i\theta}{\sigma}\right) = 1 - \emptyset\left(\frac{\boldsymbol{X}_i\theta}{\sigma}\right) \qquad (4.3)$$

And the probability for WTA_i^* to take on positive value is:

$$Prob\ (WTA_i^* > 0) = 1 - \emptyset\left(-\frac{\boldsymbol{X}_i\theta}{\sigma}\right) = \emptyset\left(\frac{\boldsymbol{X}_i\theta}{\sigma}\right) \qquad (4.4)$$

The conceptual model (1) was estimated by maximum likelihood using Stata 13, with the log likelihood function given by equation (5):

$$Log\ L = \sum_{WTA_i>0} - (\frac{1}{2}Log2\pi + \frac{1}{2}Log\ \sigma^2 + \frac{1}{2\sigma^2}(WTA_i - \boldsymbol{X}_i\theta)^2) + \sum_{WTA_i\leq 0} Log\ \left(1 - \emptyset\left(\frac{\boldsymbol{X}_i\theta}{\sigma}\right)\right) \quad (4.5)$$

4.3.3 Empirical Model

The dependent variable is WTA that takes positive values if farmer accept the proposed amount to switch to sustainable practices and a zero value if not. As far as explanatory variables are concerned, a considerable amount of empirical research has sought to explain the farmer's adoption of agricultural technologies and the participation in conservation programmes in both developed and developing countries (Adesina et al., 2000; Ayuk, 1997; Bateman et al., 1996; Buckley et al., 2012; Delvaux et al., 1999; Dupraz et al., 2003; Kosoy et al., 2008; Kwayu et al., 2013; Zbinden and Lee, 2005; Wunder, 2008). In these studies, a number of potential independent variables are selected based on prior theorization and tested logistic or Tobit regressions aimed at identifying which variables significantly correlate with the adoption of agricultural technologies or the participation in environmental conservation programmes. We use insights from these studies to explore the determinants of the farmer's participation or farmer's WTA in this study.

According to Wilson (1997) and Kosoy et al. (2008), among the variables that influence the participation of a landholder in a conservation programme are farmer and farm characteristics. Farm and farmer characteristics can clearly affect the participation in a programme or technology adoption decisions. The literature has established the role of the age (AGE), gender (GEN), education level (EDU) of the household head, the origin of the farmer (ORIGIN), the location of the farm (LOFARM), and the farm size (FA_SIZE) as important determinants of the participation (Adesina et al., 2000; Ayuk, 1997; Dupraz et al., 2003; Kosoy et al., 2008; Wunder, 2008). Kwayu et al. (2013) showed that young farmers with larger farm sizes are more apt to participate to a watershed conservation programme through the adoption of tillage due to their longer planning horizons and lower risk aversion. Moreover, Adesina et al (2000) found that younger farmers had a higher likelihood for

adopting alley cropping in the Southwest Cameroon. The education level of the household head or farmer is a key in determining the farmer's ability to obtain and process information and to implement new knowledge from intensive conservation practices and agricultural technologies (Zbinden and Lee, 2005).

Other important factors influencing the adoption of technologies and programme participation include the land opportunity cost or on-farm income (ONF_INC) (Ajayi et al., 2012; Bateman et al. 1996; Delvaux et al., 1999; Wunder, 2008). Wunder (2008) highlighted that the participation in PES is determined by the fact of owning enough "*environmentally strategic land*" and of having a low enough opportunity cost to make payments attractive. Bateman et al. (1996) showed that farms with higher profit levels from existing activities demand higher levels of compensation to entering the conservation scheme in the woodland.

Furthermore, social and cultural values such as the importance of forest for spiritual sites and non-timber forest products (NTFPs) to farm households are also important factors of adoption or participation (Kosoy et al., 2008; Kwayu et al., 2013). In Mexico for example, the appreciation of NTFPs favor forest conservation and influence the land manager's willingness to participate in payments for biodiversity conservation projects (Kosoy et al., 2008). Although reforestation with native species is often the key to restoring biodiversity, conservation professionals find it difficult to encourage landowners to use native species in restoration projects. Indeed, Garen et al. cited by Jose (2009) evaluated the experiences of farmers participating in a native species reforestation initiative in rural Panama in order to identify lessons learned that can guide future trees planting efforts. They concluded that the farmer's interest and perceptions when planning, implementing, and evaluating reforestation initiatives were critical to ensuring the success of such projects (Jose, 2009). Moreover, the perception of the outcome of practices such as the heavy use of chemical fertilizers, slash and burn (OUTCPRA) could lead to the adoption of sustainable practices such as agro-forestry that have a more positive impact on income and the environment. Ayuk (1997) highlighted the importance of such factor with the case of the profitability in adopting live hedges and Kwayu et al. (2013) with past conservation practices in the watershed. The access to information and knowledge of agro-forestry or bio-fertilizers (BIOFERT) technologies and the awareness about the payment for environmental services (AWPES) mechanisms could also be potential explanatory factors. The description of selected variables and their expected sign are given in Table 4.1 below.

The influence of the ***age of farmer*** on the decision to participate in conservation programme is not clear *a priori*. An older landowner or farmer is often considered more risk adverse and then less able to engage in a new and potentially risky contractual arrangement with either the Government or other partners. However, if reforestation is perceived as a way to decrease the scale of the farm operation, it could represent an attractive option for older farmers (Zbinden and Lee, 2005). On the other hand, the long planning horizon of young farmers could make them apt to participate in the trees planting programme (Kwayu et al., 2013). Whether ***male or female*** will be more willing to accept or to participate is not clear *a priori*. It is often hypothesized that in rural areas of developing countries where access to land are usually from inheritance, woman may lack rights to grow trees (Adesina et al., 2000). Moreover, since forest regeneration requires trees to be planted and monitored, woman may be more or less willing to participate even with secure land rights, depending on the number of trees required per individual and the history of tree planting in their own farms.

The ***origin of the farmer*** is hypothesized to positively influence its WTA. Tree planting on the farm requires the availability of enough land at the disposal of the farmer, especially land under a secure long-term control. Migrants are more likely to face land constraints that may reduce the likelihood of WTA. The ***level of education*** is expected to be positively associated with the participation. Education has many positive externalities. This hypothesis is drawn from the extensive literature on technology adoption and programme participation. In addition to enhancing the farmer's ability to acquire and process information on the potential programme, it may also be correlated with the level of information access. Indeed, if there are potential economic benefits associated with the programme, owners or users rights with a high level of education are more likely to recognize them.

The ***on-farm income*** (ONF_INC) is expected to positively influence the decision to accept trees planting in or out of the reserve. The literature suggests that higher incomes are generally associated with a willingness to enter a risky contractual arrangement with a third party or the Government. Farmers with high incomes and often with great management skills are more aware of the structure of costs and revenues of each of their production alternatives and are therefore in a better position to identify and take advantage of a programme with net economic benefits. Thus, farms with higher revenues from existing activities demand higher levels of compensation to entering the conservation or reforestation programme (Bateman et al., 1996). The ***location and size of the farm*** are expected to be positively correlated to WTA.

Farmer with a larger size of farm may be more willing to plant trees due to its large land availability for food crops. On the other hand, a farmer owning a farm closed to a specific zone to be protected such as wetland or in the vicinity of the lake is more able to recognize the importance for its farm of the programme objective.

Table 4. 1: Description of variables to be used in the regression and their expected signs

Variable	***Description***	***Expected signs***
AGE	*Age of farmer (CONTINUOUS)*	(±) Adesina et al. (2000); Kwayu et al. (2013) ; Zbinden and Lee, 2005 ;
SEX	*gender of farmer (DUMMY): 1 if male and 0 if female*	(±) Ayuk (1997) ;Adesina et al. (2000); Kwayu et al. (2013) ;
ORIGIN	*Origin of farmer (DUMMY): 1 if native and 0 if non-native*	(+) Adesina et al. (2000)
EDU	*Education level of farmer (CONTINUOUS): 0 if none, 1 if primary, and 2 if high level (secondary and high school)*	(+) Dupraz et al. (2003); Adesina et al. (2000); Zbinden and Lee (2005) ; Kwayu et al. (2013) ;
ONF_INC	*Average yearly on-farm income (CONTINUOUS)in log*	(+) Bateman et al. (1996) ; Delvaux et al. (1999); Dupraz et al. (2003) ;
LOFARM	*Location of the farm (DUMMY): 1 if out of the reserve and 0 if otherwise*	(−) Wunder (2005)
FA__SIZE	*Size of the farm (CONTINUOUS): 1 if]0-1]ha, 2 if]1-2]ha and 3 if more than 2ha*	(+) Zbinden and Lee (2005) ; Kwayu et al. (2013)
AWPES	*Awareness of PES scheme (DUMMY): 1 if yes and 0 if no*	(+) Zbinden and Lee (2005) ; Kwayu et al. (2013)
OUTCPRA	*Perception of the output of current practices by farmer (DUMMY): 1 if average (average, bad) and 0 if good (good, very good)*	(±) Ayuk (1997) ; Kwayu et al. (2013) ;
BIOFERT	*Knowledge of Bio-fertilizers (DUMMY): 1 if farmer has knowledge on and 0 otherwise*	(+)
NTFPs	*Importance of NTFPs to the farmer*	(+) Kosoy et al., 2008

Source: Author

The distribution and access to information such as the ***awareness of the PES scheme*** or ***knowledge of bio-fertilizers*** are positively correlated with the education level and are also expected to be positively associated with participation (WTA). The influence of the ***perception of the quality of output obtained with current practices*** on the farm is not clear a priori. Farmers with a good output from the farm would be less motivated to engage in new practices even though sustainable, due to the net difference in terms of output improvement and time or horizon constraint. For a farmer to engage, the net difference in profitability must be perceived to be higher to motivate the participation (Ayuk, 1997; Kwayu et al., 2013). The importance of ***non-timber forest products*** is expected to be positively associated with the decision to participate in trees planting. Trees or forests are positively correlated with NTFPs, therefore where there is more forests or trees, there is also more NTFPs. A farmer that uses NTFPs would be more likely or willing to plant trees to sustain and maintain the constant use of NTFPs.

Given these critical assumptions for participation (WTA), the model estimated from equation (1) above in this study is:

$$E(WTA_i^*) = \theta_1 + \theta_2 AGE + \theta_3 SEX + \theta_4 ORIGIN + \theta_5 EDU + \theta_6 LOFARM + \theta_7 FA\_SIZE + \theta_8 ONF\_INC + \theta_9 AWPES + \theta_{10} OUTCPRA + \theta_{11} BIOFERT + \theta_{12} NTFPs \quad (4.6)$$

The mean WTA is computed using the following formula adapted from Terra (2010) with Tobit estimate:

$$\widehat{E}\,(WTA_i^*) = \boldsymbol{x}_i \widehat{\theta} \quad (7)$$

Where $\boldsymbol{x}_i$ represent the mean of variables in equation (6) and $\widehat{\theta}$ the estimated coefficients of those variables.

4.4 Results and Discussion

The results are presented and discussed in this section and include the summary stastitics of farm and fishing activities, and the econometrics analysis of the WTA.

4.4.1 Summary Statistics

- **Traditional and environmental practices in the farm, and farmers' perception.**

Farmers have tried to improve their lands for many generations, using means available to them at the time. Traditional and environmental practices used by respondents are presented in Table 4.2. Among the 384 farmers, 87.76% indicated the use of chemicals as fertilizers and pesticides on their farm to improve soil fertility and treat cocoa. Fungicides and insecticides were the common type of pesticides used either out or in the reserve. Rotation was used by 55.47% of the respondents followed by slash and burn (38.02%) as a technique to prepare soil before sowing. Although villagers complained of not having enough land for the cultivation of their crops, approximately half (50.26%) of the respondents integrated bush fallow periods of varying lengths onto their farms. While 36.7% of the respondents had their farms located within the reserve, of which 11.46% are closed to the lake, a large majority (66.41%) thought that at least 75% of the reserve is destroyed due to the fuel wood, timber, and NTFPs exploitation coupled with farming. NTFPs such as fuel wood were collected by all respondents of which 22.40% sold them in the Kumba market. However, 40.79% of the respondents obtained their fuel wood within the reserve. The negative impact of these activities for the reserve coupled with deforestation and pesticides at the vicinity of the lake led us to identify some practices used by farmers to protect the environment.

A majority of respondents (62.24%) was practicing conservation by keeping old and big trees in their own farms. Main species of trees kept were timber and fruit trees, followed by NTFPs. Some farmers (48.18%) planted fruit trees, NTFPs, timber and other species on their farms. The number planted varied from 1 to 110 trees per year with an average of 9 trees. Seedlings were obtained mainly from their own nursery or were bought. The planting of trees do not only prevent soil erosion, but it also protects the environment. Moreover, slightly below half of the respondents (48.96%) were aware of the reforestation programme within the reserve.

Agro-forestry is not commonly implemented and this because of limited awareness regarding its importance. Only a small proportion of the respondents (29.17%) have heard about agro-forestry or bio-agriculture. Information has been obtained from various sources ranging from school, radio and newspapers, conservation agencies, and village meetings from the *farmer field school* initiative of MINADER.

Most farmers thought artificial fertilizers are the answer to the declining soil fertility. However, what they need is some enlightenment on local ways of preserving the soil from erosion and infertility. However, only 42.19% of the respondents have knowledge on bio-fertilizers and each of the respondents was invited to explain what he understands by bio-fertilizers.

Table 4. 2: Traditional and environmental practices adopted by Barombi Mbo farmers

Modality	Description or specy	Frequency of "yes"	% of the respondents
Chemical fertilizers use	Overall	337	*87.76*
	Fungicides	157	*46.59*
	Insecticides	37	*10.98*
Soil preparation techniques	Slash and burn	146	*38.02*
	Rotation	213	*55.47*
Bush fallow practice		193	*50.26*
Tree conservation	Timber	73	*30.54*
	Fruit trees	69	*28.87*
	NTFPs	60	*25.10*
Reforestation and	Fruit trees	113	*61.08*
	NTFPs	44	*23.78*
	Timber	11	*5.95*
Origin of seedlings	From own nursery	74	*40.00*
	Buy	59	*31.89*
	Donation	33	*17.84*
Agro-forestry knowledge		112	*29.17*
Biofertilizers knowledge		162	*42.19*

Source: Author's calculations from survey data

- **Farmers' perceptions**

Almost all respondents (97.14%) highlighted the importance of forests in providing ecosystem services such as climate regulation, flood control, erosion control, wildlife habitat,

landscape beauty, and the protection of cultural and spiritual sites. Almost all respondents (98.18%) perceived the role of forest to protect watershed. Moreover, most of them (97.40%) perceived a positive relationship between forest cover and water quality and 95.5% between forest and water quantity. However, only 25% of them were aware of the Payment for Environmental Services mechanisms. Nonetheless, given their ability to planting different tree species on their own farms, one could expect a full participation of communities in PES if incentives to plant and preserve trees are given to them.

- **Fishing activities in the lake**

Among the 384 farmers, 82 people (corresponding to 21.35% of the sample) undertake fishing in the lake, either everyday (35.37%) or occasionally (64.63%). These activities were practiced mainly by men (79.3%) and were done all season by 84.15% of the respondents, while 15.85% fish only during the dry season. Fishing tools commonly used are gill nets (75.61%) whose size range from 2 to 600 meters, basket traps (19.51%) as well as hooks (4.88%). Main species found by respondents were the endemic mudfish and catfish (*Clarias maclareni*) and the fishes caught were sold to retailers in the Kumba market. Besides, 46.34% of fishermen have heard about fish breeding.

- **Response rates to the offers in the contingent valuation**.

Most of the respondents (85.42%) gave a "*yes*" response to both amounts proposed for the reforestation programme in and out of the reserve and at the border of the lake as illustrated in Table 4.3 below.

Table 4. 3: Response rates to the amounts proposed

Offers	**FCFA10,000**	**FCFA15,000**	**Total**
Yes	163	165	328
No	29	27	56
Total	192	192	384
%yes	**84.90**	**85.94**	**85.42**

Source: Author from survey data

Furthermore, merits of agro-forestry were discussed with respondents during the survey and 11.46% of those who are close to the lake expressed their willingness to adopt this practice. In addition, they committed themselves to stop using chemicals within 8 meters from the lake, if seedlings for agro-forestry are given to them and training opportunities offered as well. Furthermore, 92.68% of fishermen were willing to receive fishing tools recommended to participate in a fishing programme that consists on the release of critical size and rare species once caught.

The descriptive statistics of the variables used in the empirical model are given in Table 4.4 below.

Table 4. 4: Summary statistics of variables used in the censored Tobit regression model

Variable	Mean	Standard Deviation	Min	Max
AGE	43.15365	11.36344	18	84
SEX (%)	73.958	0.43943	0	1
ORIGIN (%)	76.823	0.42251	0	1
EDU	1.22656	0.72134	0	2
LOFARM (%)	63.281	0.48267	0	1
FA__SIZE	2.66227	0.62372	0	3
ONF_INC	13.82231	1.09786	9.903487	16.1181
AWPES (%)	25	0.43358	0	1
OUTCPRA (%)	34.114	0.47471	0	1
BIOFERT (%)	42.188	0.49450	0	1
NTFPs (%)	38.281	0.48671	0	1

Source: Author's calculations from survey data

4.4.2 Results of the analysis of WTA

Table 4.5 presents results of the censored Tobit regression model. In addition to maximum likelihood estimates, their standard deviations, and their t-statistics, the table also contains the likelihood ratio statistic and the number of censored observations (left or right censored). The likelihood ratio statistic is used to test whether slope coefficients are equal to zero, i.e., whether *X* is irrelevant in the determination of $\mathrm{E}(WTA_i^*)$. The statistic for this study is of 41.09 with 11 degrees of freedom greater than the critical value of 19.67, indicating that the variation explained by the model is different from zero. That is, the coefficients for this model specification are significantly different from zero at 1% level when taken jointly. All variables have the expected sign, except for EDU and NTFPs. Four variables are significant in explaining WTA for reforestation: AGE, SEX, EDU, and BIOFERT.

The influence of ***AGE (age of the farmer)*** on WTA for reforestation was not clear *a priori*. The negative sign and significance at 1% level of its coefficient suggests that older farmers are less willing to participate in the reforestation programme. This may be because they are often less disposed to try new innovations (PES) and/or have less physical strengths and a short horizon planning to be involved in trees planting and monitoring. Moreover, regarding the statistic about tree planting on the farm, reforestation is done mostly by people of an age between 26 and 50 years old. This result corroborates that of Adesina et al. (2000) where older farmers were less willing to participate in agro-forestry technology through the adoption of alley farming and Kwayu et al. (2013) in conservation practices of tillage in the watershed.

Table 4.5: Econometric results of factors determining the farmer's WTA for reforestation programme in Barombi Mbo

Variable	Parameter estimate	Standard Error	t-values
AGE (age of farmer)	-105.6413	26.335	-4.01***
SEX (sex of farmer)	2575.053	720.499	3.57***
ORIGIN (origin of farmer)	140.1208	696.071	0.20
EDU (education level of farmer)	-1058.626	425.458	-2.49**
LOFARM (location of farm)	-376.5362	606.507	-0.62
FA__SIZE (size of farm)	545.8102	512.194	1.07
ONF_INC (yearly on-farm income)	19.12459	310.153	0.06
AWPES (awareness of PES scheme)	1028.464	667.885	1.54
OUTCPRA (output of current practices)	906.0474	608.468	1.49
BIOFERT (knowledge of bio-fertilizers)	1076.195	600.708	1.79*
NTFPs (importance of NTFPs)	-935.189	600.168	-1.56
CONSTANT	12052.44	3931.792	3.07***
LR chi2(11) = 41.09		Number of observations = 384	
Prob > chi2 = 0.0000		56 left-censored observations at WTA<=0	
Pseudo R2 = 0.0061		328 uncensored observations	
***,**, * significant respectively at 1%, 5%, 10% level		0 right-censored observations	

Source: Author's calculations from survey data

The variable ***SEX (sex or gender of the farmer)*** is significant at 1% level. The positive sign of its coefficient indicates that male are more willing to participate than female. As their number increases, WTA also increases. This is in line with summary statistics where among the 100 females of the sample, only 40% were planting trees on their farm, while 51.05% of the 284 males were involved in tree planting. These results corroborates that of Adesina et al. (2000) where the probabilities of adopting alley farming in the Southwest region of Cameroon were higher for men that for women farmers.

EDU (education of the farmer) was expected to positively influence WTA. The variable is significant at 5%. The negative sign of its coefficient indicates that less educated farmers are more willing to participate than more educated ones. This could be firstly explained by the important proportion of low levels of education characterizing rural areas in developing countries, and secondly because farmers with low education levels would learn more on the advantages of agro-forestry and bio-fertilizers by participating in the PES scheme.

The influence of ***BIOFERT (knowledge of bio-fertilizers)*** was expected to be positively associated with WTA. The coefficient of the variable is positive and significant at 10%. This suggests that farmers with knowledge on bio-fertilizers are more willing to participate in the reforestation programme. This may be explained by the various advantages of bio-agriculture that are the improvement of the output and soil fertility of the farm, the prevention of erosion, and the protection of the environment. The rapid growth of agro-forestry species considerably

explains this result. This result is in line with the literature, which considers prior knowledge on the mechanism or technology as an important factor of participation.

4.4.2 Computation of the Mean WTA

It is conventional in a contingent valuation to compute the Average WTA. Based on results of the model used, the mean WTA for provision of ES was computed using the formula provided in equation 7. Besides, the constant was added due to its significance at a 1% level.

$$\text{Mean WTA} = \widehat{E}\,(WTA_i^*) = \boldsymbol{x}_i\widehat{\theta}$$

Thus, $\boldsymbol{Mean\ WTA = FCFA10,352.4844\ /year}$

As 328 respondents gave a positive WTA, the total WTA or the total cost for reforestation was then computed as:

$$\boldsymbol{Total\ WTA\ = 10,352.4844} \times 9562 \times \frac{328}{384} = \boldsymbol{FCFA\ 84,554,347.6905/year}$$

Therefore, the total cost of the reforestation programme was estimated at **FCFA 84,554,347.6905/year.**

4.5 Conclusion of the chapter

The role of sustainable agriculture and fishery in providing environmental services through the internalization of negative externalities of farm activities was explored in this chapter. Agro-forestry and forest regeneration were identified as the main sustainable agriculture practices to be promoted in the study zone. The criteria through which farmers perceive the negative effects of their practices on the environment have been identified, and the determinants of willingness to accept (WTA) have also been determined.

Almost all respondents highlighted the importance of the forest in providing ecosystem services that are climate regulation, flood control, erosion control, wildlife habitat, aesthetics, and cultural and spiritual aspects. Therefore, from the farmers' view, deforestation negatively affects the environment. Besides, a majority of respondents already practiced conservation on their own farms by keeping old and big trees and some farmers had planted fruit trees, NTFPs, and other species on their farms. Trees maintained or planted were not only to prevent soil erosion but also to protect the environment. Agro-forestry was still not common as only a

very low percent of the respondents had knowledge on agro-forestry or bio-agriculture and bio-fertilizers.

From the contingent valuation scenario, a large majority of respondents have expressed a positive WTA for a reforestation programme, while some were willing to adopt agro-forestry within 8 meters from the lake to reduce chemicals used in its vicinity. Almost all fishermen were willing to receive fishing tools that release critical sizes during fishing activities and to release rare species once caught. From the econometrics model results, age (-), gender (+), education (-), and bio-fertilizers (+) variables provide insights into necessary conditions for a programme participation. Indeed, (i) younger farmers are more likely to participate in the reforestation programme than older ones; (ii) male farmers are more likely to participate than female; (iii) the participation or WTA is higher with low educational levels and (iv) with higher knowledge on bio-fertilizers.

The contingent valuation method (CVM) therefore allows us to conclude on the potential participation of farmer communities to a payment programme for the watershed protection through reforestation and agro-forestry. The average WTA is estimated at **FCFA 10,352 per year** with a total cost for the reforestation programme at **FCFA 84,554,347 per year**.

Our estimates provide key information or insights from a field survey and farmers preferences of the cost of PES programme through agro-forestry and reforestation that could be implemented by the government. Nevertheless, in order to pay farmers for their efforts in protection the lake watershed, this amount could be derived from the demand of the watershed protection by households through their willingness to pay for the watershed ES.

Chapter five that follows focuses on the estimation of the demand of downstream' households for improved watershed management by upstream farmers. The main objective is to estimate the households' willingness to pay for the provision of environmental services in Lake Barombi Mbo watershed. The chapter contributes to the limited literature on the estimation of the demand for watersheds protection using choice experiments in combination with contingent valuation, and it is about the first time that choice experiment to value watershed is being applied in the country.

CHAPTER FIVE

Downstream Households' Demand for Improved Watershed Management: A Willingness To Pay Estimates

5.1 Introduction

An important environmental service (ES) often cited as an economic justification of conservation activities, is the watershed protection function provided by tropical forest (Aylward et al., 1995). Watersheds are among the earth's most productive ecosystems and provide a diverse array of important ecological functions and services, ranging from flood and flow control to groundwater recharge and discharge, water quality maintenance, biodiversity, carbon sequestration and other life-support functions. These ecological functions and services translate directly into economic functions and services such as flood protection, water supply, improved water quality, improved fuelwood amount, commercial and recreational fishing and hunting, and mitigation of global climate change (Barbier et al., 1997; Birol et al., 2006). However, many watersheds have been threatened and degraded, as such, from a global analysis of 106 watersheds, Revenga et al. (1998) noticed that nearly one-third of them, more than half the land area has been converted into agricultural use. Today, they are under increasing pressure from anthropogenic activities such as conversion to intense agricultural and residential uses, and pollution due to nutrient run-offs. Other factors adversely affecting the sustainability of watersheds include poverty and economic inequality, population growth, immigration and sociocultural conflicts (Birol et al., 2006; République du Cameroun, 2012; 2014). The progressive loss of these services likely harms human health and welfare through poorer water quality, increased CO_2 emissions and lower crop productivity (Postel and Thompson, 2005; MINEPAT, 2007; Chifamba, 2011; ICRAFT, 2011; Kometa and Ebot, 2012).

In the country, governance frameworks and law enforcement for water resources management are still too weak and financial means too scarce to adequately prevent pollution and ensure the sustainability of these watersheds (GWP, 2010). Most water decrees of the country have been more focused on expanding infrastructures, in particular networks of safe water supplies, with little or no focus on sustainable management of water resources (DSCE, 2009, MINEE/GWP 2009).

Furthermore, most commentators agree that command and control (CAC) institutions have successfully reduced pollution from well-defined point sources like factories and sewage treatment plants. However, they have been less successful in regulating the remaining nonpoint sources of pollution geographically diffused, numerous; and heterogeneous resource users who jointly affect the environmental quality of a watershed. Moreover, CAC institutions have difficulty in addressing problems such as habitat destruction that involve multiple environmental media (air, water, and land) (Lubell et al., 2002). This has led to an increased focus on nonpoint, unrelated sources of pollution such as agriculture, which may have lower abatement costs. Contractual arrangements and payments for water quality services from municipal water organizations to nonpoint sources represent a similar instrument (Grolleau and McCann, 2012). However, such payment mechanisms are not yet expanded in the country. Furthermore, alarmed by the accelerated rate of wetland loss and watershed degradation, in 1970, 100 countries created the Ramsar Convention on Wetlands of International importance, which provides the framework for national action and international cooperation for the 'conservation and wise use' of wetlands and their resources (Ramsar, 1996). As a signatory of the Ramsar convention in 2006, the country owns now 7 Ramsar sites of a total of 827,060 hectares, of which the Barombi Mbo Crater Lake (see appendix 5.1). Therefore, as contracting Party to the Ramsar Convention and Convention on Biological Diversity, the country intends to sustainably manage and improve the conditions of its wetlands and watersheds, which provide several important ecological functions as described above and wellbeing to local population. The country created a national Ramsar Committee and a national focal point to deal specifically with issues of wetlands. The effort to involve local population is still too low[48] (Wanzie, 2003), and setting successfully a framework for the benefits derive by local population from wetlands and watersheds requires the development of conservation tools and approaches that contribute to the sustainable development.

In addition to these international and national commitments and efforts, the growing number of valuation studies on these environmental resources also reflects the increasing recognition of the importance of wetlands and watersheds. Farber and Griner (2000), Loomis et al. (2000), Carlsson et al. (2003), Pattanayak (2004) and Birol et al. (2006) provide an extensive overview of watershed and wetlands valuation studies which include a broad variety of valuation techniques including conjoint analysis, contingent valuation method (CVM), choice

[48] Kouokam and Ngantou (IUCN Waza-Logone Project)),

experiment (CE), hedonic price, replacement value, damage avoided and production value methods. With the need to establish incentive scheme for watershed management, Shrestha and Alavalapati (2003) estimate the willingness to pay (WTP) for public goods carbon sequestration, water quality and wildlife habitat protection using CE. Leimona and Joshi (2009) develop a model based on the WTP of downstream beneficiaries (to pay upstream service providers) using the CVM. Adamowicz et al. (1998) combine information from CE and CVM to test for the difference in preferences and error variances arising from measuring passive use values through WTP estimate. Rai et al. (2014) undertake a CE to identify differences in local demand (locational differences) for watershed services and examine the possibility of using a non-monetary numeraire (labor hours) to estimate household WTP for watershed services.

This chapter contributes to the watershed valuation literature by applying CVM and CE to a case study in the country, where valuation studies are very limited (Lescuyer, 2000; Nlom, 2008; Melachio et al., 2011), and in particular in the watershed context (Ruitenbeek, 1989). Lescuyer (2000) tried to employ CVM to estimate the use and non-use values of tropical forest of the East region of Cameroon. However, no non-use values estimates could be assigned to the forest area of the villages investigated, due to their low-income and illiterate nature of respondents to value this asset. Today, most of the indigenous communities recognize the role of forest at least for spiritual and cultural site and animal habitats preservation. In Ruitenbeek's (1989) valuation of Korup project in Cameroon, the benefits from watershed protection were estimated to be almost half of the direct conservation benefits. To our knowledge, this chapter is the first application of CE in Cameroon. Besides comparing the CE and CVM estimates of WTP, the chapter investigates the issues of trust (bid vehicle bias) and controls the validity and reliability of responses recurrent in the CVM exercise through a non-monetary numéraire that is the labor contribution for reforestation in the watershed. Furthermore, the chapter will provide policy-makers with much needed information on the economic worth of benefits generated through the sustainable watershed management, or on the value of watershed protection to a downstream community.

The objectives of this chapter is to estimate the demand for improved watershed management by downstream users through households' willingness to pay. However, the variables that influence their WTP is also determined. The WTP for economic benefits generated by

improved watershed management to downstream is estimated using CVM and CE survey data from 383 respondents in Kumba municipality.

The next section of the chapter presents the relevant literature of the economic value and demand for watershed protection. Section 3 presents methods and materials used (CVM and CE design and administration, analytical and empirical models). The results and discussions are presented in section 4 and section 5 concludes the chapter.

5.2 Literature Review

The section focused on the economic value of watershed ecosystem services and their demand in the watershed

5.2.1 Economic Value for Ecosystem Services and Watershed Protection.

Ecosystem services provide many benefits to people. The dilution of wastewater, as well as erosion controls and water purification effects from riparian vegetation and wetlands, improve water quality. Enhanced ecosystems management and increased water quality reduce water treatment costs to downstream cities, increase the aesthetics of water for visitors, and support native fish and wildlife that different people like to view or harvest or simply know the existence (Gregerson et al., 1987; Loomis et al., 2000; Grolleau and McCann, 2012; Marre et al., 2015). Thus, these ecosystem services improvement through human activities that support ecosystems have therefore an economic value, and the characteristics of "public goods". Specifically, it is difficult to exclude downstream users from receiving an improved water management and air quality, and many of these services are non-rival in nature (Aylward et al., 1995; Loomis et al., 2000). Many individuals can view the same wildlife or enjoy knowing they exist without precluding others from doing so.

Given these public good characteristics of ecosystem services, it is difficult for private sector to sell them. The costs of losing them or benefits of preserving them have been broadly classified into use values (direct and indirect), option values and non-use values (Pearce et al., 1989; Pearce, 1990, Pearce and Moran, 1994). The latter are recognized to be an important component of the total economic value (TEV) of ecosystems and an important motivation for enhanced conservation (Marre et al., 2015; Pearce and Moran, 1994). Ruitenbeek's (1989) study reported no explicit non-use value (*WTP*), but has set the benefits for the creation of the Korup National Park. Non-use values have been subject of a growing economic literature since Krutilla (1967) and Krutilla and Fisher (1985) that first discussed the importance of

existence and aesthetic values to conservation. According to Pearce and Moran (1994), non-use values (NUV) are slightly more problematic in definition and estimation, but are usually divided between bequest values (BV) and existence or "passive" use values (EV). The former measures the benefit accruing to any individual from knowledge that others might benefit from the watershed in future. The latter derives simply from the existence of the watershed. An individual's concern to protect the watershed although he or she has never seen or use one and is never likely to, could be an example of EV. Thus, in total, we have in the watershed: TEV= UV+NUV= (DUV+IUV+OV) + (BV+EV), and use as well as non-use values in a lake watershed are given in Table 5.1 below.

Table 5. 1: Use and Non-Use Values in Forested Watershed

TEV in a forested Lake watershed				
Use values (UV)		Option values	Non-use values (NUV)	
Direct use values (DUV)	Indirect use values (IUV)		Bequest values (BV)	Existence values (EV)
-Food **-Timber** **-Non-timber products (medicine, nuts…)** **-Wood** **-Fuelwood** **-Commercial fisheries** **-Drinking water** **-Tourism (eco)** **-Medicine** **-Education** **-Research** **-Transport**	-Flood control --Erosion control --Nutrients recycling --Watershed protection --Carbon sequestration --Climate regulation --Natural recreation areas --windbreak -Wildlife habitat preservation **Ecological function**	**Future use as per DUV +IUV** **Value for the potential to be available and yields benefits in the future**	**Value placed on the resource as something useful for future generation**	**Value the resource has in itself :** -Traditional knowledge -Heritage and cultural values -Spiritual and ritual sites for indigenous and local people -Endemic freshwater species may exist, but are not used

Adapted from Pearce, 1990; Pearce and Moran, 1994;

While they are without prices, these services do contribute utility to individuals and therefore have value (Alpizar et al., 2001). This value is monetized as the individual's net willingness to pay (WTP) or consumer surplus, represented by the area under the individual's demand curve but above any cost to the user of the ecosystem service.

5.2.2 Demand for Use and Non-uses Values in the Watershed

Consumer's demand for a service or good is based on the utility he/she derives from consuming or using it. Since utility is not observable empirically, there is usually need of

welfare measures like WTP for the practical assessment of utility changes because they are defined in observable[49] (monetary) units (Alpizar et al., 2001). The rationale of economic valuation of ecosystem services is designed to account for all the changes in environmental services which would usually occur outside the market and therefore without economic signals regarding their contributions to social welfare (Adamowicz, 2004). Given the public goods nature of these ES, the aggregate demand is usually obtained through aggregate WTP for these services. WTP is estimated through individuals stated preference methods including Contingent valuation method (CVM) and Choice Experiment (CE).

CVM is based on two central assumptions of welfare economics, namely: individual preferences are the basis for the assessment of environmental benefits; and individuals are the best judge of their preferences (Desaigues and Point, 1993). When no market behavior can be observed, the willingness to pay of individuals is directly estimated by creating a hypothetical market (Bishop and Heberlein, 1979; Kahneman and Twersky, 1979; Hanemann, 1984; Adamowicz et al., 1998; Bateman and Willig, 1999). The hypothetical scenario describes the expected physical changes in the watershed, the benefits of improved watershed management, and the mechanism of policy choices that will be implemented. Hanemann (1984) was the first to develop a coherent framework of the analysis in CVM based on a derivative choice of utility maximization. However, some biases arise from the valuation exercise including hypothetical bias (Mitchell and Carson, 1989), information bias and strategic bias (Samuelson, 1954). According to Bishop and Heberlein (1979) and Hanley (2001), the overstatement of the WTP may be overcome by using the dichotomous choice elicitation format and close ended format, which not only provide incentives for the truthful revelation of preferences but also simplifies the cognitive task faced by respondents because of the yeah saying. With respect to information bias, a clear elicitation of the hypothetical scenario helps solve the bias. The strategic bias could be overcome with the use of CE method as underlined Hanley (2001).

Choice experiment (CE) which is a stated preference approach to elicit WTP values based on the combination of different attributes levels, was initially developed by Louviere and Henscher (1982) and Louviere and Woodworth (1983) to value environmental attributes of public goods. CEs were inspired by the Lancasterian microeconomic approach of consumer

[49] In the neoclassical economic framework, upon which environmental economics and valuation methods are based, non-use values are measured in monetary units of WTP or Willingness to accept (WTA).

choice (Lancaster, 1966), in which individual derives utility from the characteristics of the goods rather than directly from the goods themselves. It is the most promising systematic method to estimate use and non-use values of ecosystem services today (Hanley et al., 1998; 2001; Amaya et al., 2008). Indeed, under CVM, neither approach of elicitation formats is ideally suited to deal with cases where changes are multidimensional as in the watershed. In the CE method, respondents are presented with a choice card, which has (usually two) better alternatives versus a status quo (opt out) alternative and are asked to choose their most preferred one (Hanley et al., 2001; Louviere et al., 2007). The alternatives are associated with attributes and of the levels that these take. CE significantly makes probabilistic predictions about individual decision making behavior (Louviere et al., 2007; Christie et al., 2006) and allows respondent to imagine trade-offs between attributes (Adamowicz et al., 1998; Hanley et al., 1998; 2001; DeShazo and Fermo, 2002; Christie et al., 2006; Louviere et al., 2007; Hensher, 2010). CE further avoids biases associated with other stated preferences methods (Hanley et al., 2001).

Non-market valuation techniques are then one set of tools that can be used to estimate the demand and net-benefits from policy changes to different users. However, their use to identify demand for services and appropriate payment mechanisms is often limited in developing economies because of low income and the non-monetized nature of sub economies (Rai et al., 2014; Bennett and Birol, 2010). Generally, WTP for an ES is positively associated with household's income (Martínez-Alier, 1995). In region where transactions are monetized, some valuation studies have attempted to compare WTP from CVM to that from CE method and as results, CE has advantages over other environmental valuation like CVM, although many design issues remain unresolved (Hanley et al., 1998; Adamowicz et al., 1998). However, in low income economies, with informal non-monetized activities, WTP in monetary terms for service use can encounter a high proportion of protest votes (Bennett and Birol, 2010). Furthermore, in regions where many transactions are not monetized, asking people how much they are willing to pay for a good or a service can be confusing and can result in in-correct estimates of value (Alam, 2006). In order to better understand the demand for ES among cash constrained households, some valuation studies attempted to use labor time as a numéraire to determine WTP (Rai et al., 2014; O'Garra, 2009; Eom and Larson, 2006). On most small-scaled farms, labor is intensive and rudimentary tools are used. Thus, households even in the most remote rural areas understand how much their labor is worth. Hence, this makes labor

contribution a good measure for understanding rural peoples' interest in (or their willingness to) sustainably manage natural resource; mostly in a context where the demand and value of watershed to local communities are generally unknown.

5.3 Material and Methods

The section describes the survey design for CVM and experimental design of the CE used in the study. In addition, it presents the analytical and empirical models used that are based on the Random Utility Model of Mc Fadden (1974).

5.3.1 Empirical Approach

A questionnaire was used to gather information on socioeconomic characteristics, general attitudes towards water source and watershed protection, and the choice experiment scenario.

I. CVM survey design

CVM involves households being presented a hypothetical scenario of the watershed as a whole. A brief of this hypothetical scenario was as follows: [*Studies showed that* ***the adoption of improved watershed management practices…by upstream users****, increases water quality and quantity, increases fuelwood availability, fish stock and species, stabilize hydrological cycle and climate through carbon sequestration. Moreover, studies carried out in Lake Barombi Mbo have noticed that in addition to the depletion of the fish in the lake, about 90% of the Forest Reserve is destroyed and mostly the forest closed to the Lake ……that if the current level of activities in the reserve continue, there won't be any trees to provide* ***fuelwood, water quality and quantity, climate stabilization, wildlife habitat for future generation*** *as well as* ***for ecotourism*** *in the watershed. …****a Reforestation and Conservation Programme is foreseen by the Government. Your participation in this programme would help the Government estimate the demand for Lake Barombi Mbo watershed improved management"].*** Thus, in order to overcome the hypothetical bias of CVM, the study introduced the "Consequentialism" developed by Bulte et al. (2005) in the valuation scenario, which consisted of reminder the households that their participation and payment will help the government estimating the demand for the reforestation and sustainable management of the watershed. Four different amounts were determined from a pilot survey with 10 household heads, and those amounts were offered to the respondents using the close ended format. However, rather than retaining the values out of the tail of the distribution and between the 15^{th} and 85^{th} percentile of the high bid obtained with the open-ended question of the pilot survey as recommended Kanninen (1995) and Terra (2010), the following four recurrent amounts **CFA200, 300, 400, and CFA500** were retained. These four amounts were then considered for both CVM and CE exercises. But, for CVM, the total sample was divided

in four (4) sub-samples of 96 households and each bid was then randomly assigned to an equivalent sub-sample. Moreover, to overcome the bid vehicle bias and protest votes, four (4) length of time for reforestation: **2hrs, 3hrs, 4hrs, and 5hrs** were identified during the pilot survey and were applied to those who gave a "no response" to the valuation question.

II. Choice Experiment design and application

The first step in CE design is to define the good to be valued in terms of its attributes and their levels. The good valued here is the watershed, and significant watershed management attributes pertaining to the Lake Barombi Mbo watershed were identified through focus groups, existing studies in Barombi Mbo (Agbor , 2008; Tchouto et al., 2015), secondary sources and some CE studies in developing countries (Rai et al.,2014; Legesse, 2015). Focus group discussions were conducted with upstream and downstream users to determine the final attributes and their levels that are important to them or to the public. The five selected attributes, their levels and description are reported in Table 5.2 below. Four attributes with 2 levels each were selected to reflect the variety of ecological, environmental and economic benefits generated by the watershed. These were *water quality*, *fuelwood*, *air quality* (CO_2 absorption) and *fish*. The fifth attribute included in the CE was a monetary one, which is required to estimate welfare changes. The level of this monetary attribute used and the payment vehicle employed were determined through the pilot contingent valuation survey. The payment vehicle was an increase in water bill cost, although a contribution to be paid to the Council for the local development of the watershed was also feasible. Deduction from water bills was preferred over contribution to be paid since respondents may have the incentive to free-ride with the latter. Households were informed that the fees will be deducted directly from the water bills by the Water Utilities Company CDE and refunded to the council through a collaborative management strategy. The payment levels used were FCFA 200, FCFA300, FCFA400 and FCFA500.

✶ *Experimental Design*

A large number of unique watershed management profiles can be constructed from the above number of attributes and levels, that is $\mathbf{2^4x4^1 = 64}$ combinations or profiles for **4** attributes with **2** levels each and **1** attribute with **4** levels. Because respondents cannot be shown all the different choice options or profiles, the number of possible combinations was reduced to 8 optimal profiles based on an orthogonal fractional factorial design using statistical software SPSS 20 that enables the estimation of main effects. The 8 optimal profiles were used to form

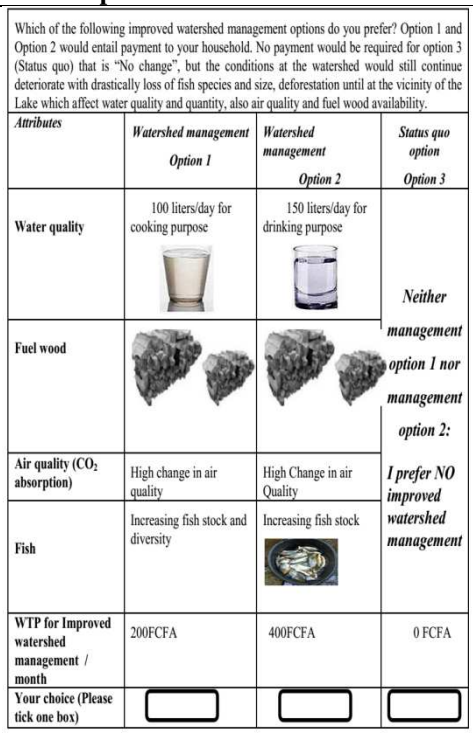
choice sets with four cards to each individual. Each card included two watershed management options and a status quo (opt out) option as it can be seen in table 5.2. The inclusion of status quo in the choice sets is instrumental to achieving welfare measures that are consistent with demand theory (Birol et al., 2006; Bateman et al., 2003; Hanley et al., 2001). Options 1 and 2 involved the improved watershed management actions that were likely to affect the future conditions of the watershed. Option 3 was the status quo, thus, "no change" and involved no improved watershed conditions and no payment or cost. The size of watershed management fees depends on the management options 1 or 2.

- ***Data collection***

The CE involved the same households than under CVM, that were presented with four choice cards with three different alternatives or options. Face to face interviews were conducted during the month of September 2015 and involved a sample of 383 household heads[50] determined using Sudman and Bradburn formula: $n = \frac{N}{1+Nd^2}$ where $N = 400{,}000$ inhabitants downstream and d= desired margin of error (0.05).

Table 5. 2: Attributes, description and levels, and an example of choice card

Attributes	Description	Levels	An example of choice cards
Water quality	Amount of water availability per household for daily use.	1-As much as now **(100 liters/day for cooking purpose)** 2-Twice as much as now **(150 liters/day for drinking purpose)**	
Fuel wood	Amount of fuelwood available to household per day from LBMFR watershed, and results from an increase.	1-As much as now **(2 bundles/day)** 2-Twice as much as now **(3 bundles per day)**	
Air quality (CO2 absorption)	Change in air quality in Kumba municipality due to reforestation in the watershed, and contributes to hhd well being.	1-High change 2-Moderate change	
Fish	Quantity and species of fish available to the household per month and results from conserving the critically endangered species.	1-Increasing in fish stock and diversity 2-Increasing in fish stock	
Watershed management fee (Price)	An introduction of new monthly fee for watershed management. This fee is additional to what hhds are paying now as water bill.	1-200FCFA 2-300FCFA 3-400 FCFA 4-500 FCFA	


Which of the following improved watershed management options do you prefer? Option 1 and Option 2 would entail payment to your household. No payment would be required for option 3 (Status quo) that is "No change", but the conditions at the watershed would still continue deteriorate with drastically loss of fish species and size, deforestation until at the vicinity of the Lake which affect water quality and quantity, also air quality and fuel wood availability.

Attributes	*Watershed management Option 1*	*Watershed management Option 2*	*Status quo option Option 3*
Water quality	100 liters/day for cooking purpose	150 liters/day for drinking purpose	*Neither management option 1 nor management option 2: I prefer NO improved watershed management*
Fuel wood			
Air quality (CO_2 absorption)	High change in air quality	High Change in air Quality	
Fish	Increasing fish stock and diversity	Increasing fish stock	
WTP for Improved watershed management / month	200FCFA	400FCFA	0 FCFA
Your choice (Please tick one box)	☐	☐	☐

Source: Author construction

[50] Rather than 399 as gave the formula used, since information on the number of households were not available.

5.3.2 Analytical Model

CVM and CE methods have the same theoretical foundation which is the Random Utility Model (RUM) as explained in Mc Fadden (1974). However, as stated earlier, the attributes of the alternatives or options being valued are not identified in the CVM because either you want the entire panel or not. Under CE many options are proposed and are defined by many attributes. Attributes vary across alternatives and respondents are then required to choose their most preferred options or alternatives. In each case, the choice of an alternative (one of the three in CE or yes/no in the CVM exercise) represents a discrete choice from a set of options. Each alternative is represented with a utility function (U_{ni}) that contains a deterministic part (V_{ni}) and a stochastic component (ε_{ni}) (see Louviere, 2001; Louviere et al., 2007).

$$U_{ni} = V_{ni} + \varepsilon_{ni} = bX_{ni} + \varepsilon_{ni} \qquad (5.1)$$

where U_{ni} is an individual *n* utility from choosing alternative *i* and is specified as a linear index of the attributes X_{ni} of the *i* different alternatives (option 1, 2 and 3) being valued in the choice set, and only two alternatives (yes/no) for CVM representing the whole watershed being valued. Assuming that *i* = improved state and *j* = status-quo, the probability of an individual choosing alternative *i* over *j* is

$$P_n(i) = \Pr\,(U_{ni} > U_{nj};\ \forall j \in \emptyset, \quad i \neq j) \qquad (5.2)$$

Where, $\emptyset$ is the set of all possible alternatives. Individual *n* answers "yes" to a proposed bid if the policy change (*i* = 1) causes his utility net of the required payment, to exceed utility of the status quo (*i* = 0). The Random utility can be rewritten as:

$$U_{ni}(X_n; W_n;\ \varepsilon_{ni}) = V_{ni}(X_n; W_n) + \varepsilon_{ni}$$

$$= \theta X_{ni} + \delta W_{ni} + \varepsilon_{ni} \qquad (5.3)$$

And W_{ni} represents the socioeconomic and attitudinal characteristics of the individual *n* and δ is the vector of the coefficients associated with these characteristics. In the CVM, X_{ni} contains the bid. Assuming a type I extreme value distribution for error term ε_{ni} and independence between choice options (IIA property) and individuals (Hanley, 2001), the probability of choosing alternative *i* becomes

$$\Pr\big(U_{ni} > U_{nj};\ \forall j \in \emptyset, \quad i \neq j\big) = \frac{\exp(V_{ni})}{\sum_i \exp(V_{ni})} \qquad (5.4)$$

This probability is estimated using limited dependent variables models. Binary Logit (Maddala, 1983, Greene, 2012 p683) is used for CVM and Conditional Logit model (CL) for CE (McFadden, 1974; Green, 2012, p766).

CL model is specified so that the probability of selecting a particular improved watershed option is a function of attributes of that option and of the alternative specific constant (ASC), which is specified to equal 1 when either management option 1 or 2 is selected and to 0 when option 3 is selected. CL assumes the Independence of Irrelevant Alternatives (IIA) property, which states that the relative probabilities of two options being chosen are unaffected by introduction or removal of other alternatives. Moreover, CL assumes homogeneity between individual making the choice since parameters are not individual-specific and a single value is estimated for each attribute (Hynes et al., 2013). Hence, discrete choice model that does not require the IIA property such as Random Parameter Logit (RPL), and that accounts for individual heterogeneity by including interactions of respondent specific socioeconomic and attitudinal characteristics with choice specific attributes or with ASC in the utility function is used. This enables the RPL model to pick up preference variation in terms of both unconditional taste heterogeneity (random heterogeneity) and individual characteristics (conditional heterogeneity), and hence improve the model fit (Birol et al., 2006; Carlsson et al., 2003; Hynes et al., 2013; Rai et al., 2014).

The marginal willingness to pay (mWTP) *for CE is estimated using the formula given in the equation below (Hanley et al., 2001):*

$$mWTP = -\frac{\beta_{attribute}}{\alpha_{price}} \qquad (5.5)$$

Where β is the estimated coefficient of the management attribute and α the coefficient of the cost attribute. The Mean WTP of CVM is computed using Krinsky and Robb (1986) method (*wtpcikr* command) if Sigma is less than one (Sigma<1) or Hanemann (1989) formula below if WTP is greater than or equal to zero (as it is logical for improvement):

$$Mean\ WTP = \frac{1}{\beta_{12}} \ln\left(1 + e^{\beta_0}\right) \qquad (5.6)$$

Where β_{12} is the coefficient estimate of the bid and β_0 is either the estimated constant (if no other independent variables are included) or the grand constant calculated as the sum of the

estimated constant plus the product of the other independent variables times their respective means (Loomis et al., 2000), except the variables income (Terra, 2010).

5.3.3 Empirical Model

The socio-economic and attitudinal variables affecting WTP in the CVM and the utility of choices in the CE are derived from Loomis et al. (2000), Carlsson et al. (2003), Kosoy et al. (2007) and Rai et al. (2014) studies. Some are derived from the Water Poverty Index (WPI) which considers households access to water quality, households' capacity to manage water as well as the environmental and spatial integrity related to water resources (Sullivian et al., 2003). Table 5.3 gives their description and expected signs, and the model to estimate using maximum likelihood in CVM is given in equation 5.7 below.

$$\text{Log}\frac{(yes)}{(1-yes)} = \beta_0 - \beta_1 BID + \beta_2 AGE + \beta_3 GEND + \beta_4 EDU + \beta_5 HHINCOME + \beta_6 HHWTAP - \beta_7 WATERBILL + \beta_8 WSPROT_{PAST} + \beta_9 MBERSHIP \quad (5.7)$$

Table 5.3: Variables used in CVM logistic regression and the Random Parameter Logit (RPL) of CE

Variable	Description	Mean/Proportion	Expected sign
AGE	*Age of the household head in years*	39.4830	-
GEND	*Gender of the household head: 1 if male and 0 if female*	0.5065	+
EDU	*Education level of household head: 1 if none (never been to school), 2 if primary and 3 if secondary and high school*	2.624	+
HHINCOME	*Household head income in FCFA amount*	149,678.9	+
HHWTAP	*Proportion of household with tap-water: 1 if household has a tap and 0 if not*	0.5901	+
WATERBILL	*Average water bill cost per month in FCFA*	3,438.031	-
WSPROT_PAST	*Participation to water source protection in the past by household head: 1 if yes and 0 no*	0.2324	+
MBERSHIP	*Membership of environment protection association: 1 if yes and 0 if no*	0.1123	+

Source: Author

5.4 Results and Discussion

Data were compiled using CSPro 4.1 statistical software to avoid typing errors; STATA 13 and NLOGIT 4 for descriptive statistics and econometric analysis.

5.4.1 Descriptive Statistics

Sample characteristics are given in Table 5.4 with some characteristics related to the activities in the watershed.

Table 5. 4: Socioeconomic, demographic and attitudinal characteristics of the sample

Characteristic	Mean	Stand.Deviation	Min	Max
Share female respondents	49.35	0.5006	0	1
Average age	39.48	12.3377	18	80
Average family size	4.84	2.4911	1	12
Household income per month	149,678.9	113,238.5	7,000	600,000
Average water bill	3,438.03	2,163.25	100	25,000
Education	Never been to school (*7.83%*), Primary (*22.19%),* Secondary (*41.78%*), High school (*28.20%*).			
Nationality	Cameroonian (*91.91%),* Nigerian (*7.05%),* Ghanaian (*1.04%*)			
Marital status	Married (*65.27%*), Single (*22.98%*), Divorced (*2.87%*); Wisdower/Wisdow (*8.88%*).			
Profession	Small business (*31.59%*); Civil servant (*19.06%*); Private sector (*11.75%*); Farmer (*20.89%);* Retired (*4.96%*); Others (*25.59%*).			
	Information about water quality.			
Appreciation of water bill cost	High (*23.24%*), Affordable (*65.54%*), Cheap (*8.09%*), Costless (*3.13%*).			
Having a tap in the house	59.01%			
Obtaining drinking water:	Directly from the tap (*77.55%*); Boil (*3.13%*); Filter (*5.22%*); Buy mineral water (*3.39%*); Wait for tap water to settle (*3.39%*); Add chlorine (*4.96%*); Use solar energy (*1.57%*); Others(*0.78%*).			
Perception of positive relationship between:	*forest cover and water quality*			*99.22%*
	forest cover and water quantity			*98.17%*
Fuel wood use			*88.77%*	
Visited the Lake Barombi Mbo			*61.62%*	
Membership of environmental association/group			*11.23%*	
Having participated to protecting water source in the past			*23.24%*	
Heard about payment for environmental services (PES)			*28.20%*	

Source: Author from survey data

a) Response rates in CVM and CE

In the CVM, 70.5% of the 383 respondents were willing to pay the bid amount proposed as given in Table 5.5 below.

Table 5. 5: Response rate to each bid amount

Bid	**200 FCFA**	**300 FCFA**	**400 FCFA**	**500 FCFA**	**Total**
Yes	61	77	67	65	270
No	35	19	28	31	113
Total	96	96	95	96	383
%yes	***63.54***	***80.21***	***69.79***	***67.71***	**70.5**

Source: Author from survey data

However, given the high proportion of protest bid in the CVM and in the context were transactions are not always monetized, from the 29.5% of respondents who gave a "no response" to the bid proposed, 56.64% was willing to spent between 2hrs to 5hrs planting trees in the reserve to protect the Lake and to save fish species. The high response rate was recorded with length of 5hrs followed by 3hrs per month. The results are given in Table 5.6 below.

Table 5. 6: Labor contribution of individuals having given a "no response" to the bid amount

Duration	**2h**	**3h**	**4h**	**5h**	**Total**
Yes	16	13	12	23	64
No	19	6	16	8	49
Total	35	19	28	31	113
%yes	***47.71***	***68.42***	***42.86***	***74.19***	**56.64**

Source: Author, from survey data

In the CE, across all 1532 choice occasions, the status quo (option 3) was chosen 6.14% of the cases. However, an unequal distribution of choices was found between the two hypothetical options (1&2). The results are given in Table 5.7.

Table 5. 7: Response rate in the Choice Experiment survey

Option	**Number of choice occasions**	**Percentage**
Option 1	790	51.56%
Option 2	648	42.30%
Option 3 (Status quo)	94	6.14%
Total	1532	100%
Improved watershed management versus no change in the management		
Option 1&2	1438	**93.86%**
Status quo	94	**6.14%**

Source: Author, from survey data

b) Comparison of response rate between CVM and CE

In terms of improvement of the watershed management, the participation rate was higher in the CE than in the CVM as illustrated in Table 5.8. Therefore, CE is most appropriate in estimating use and non-use values in the watershed.

Table 5. 8: Comparison of the CVM and CE response rates in terms of improved management options

Environmental Valuation Method	**Number of favorable responses**	**Percentage**
CE	**359**	**93.73%**
CVM	**270**	**70.5%**

Source: Author, from survey data

The econometrics results of CVM and CE are presented and discussed in the next subsection.

5.4.2 Econometrics Results

The results of the Logit model of CVM are presented and discussed first and then those of CL and RPL of CE. CVM econometrics results were obtained using Stata 13 and those of CL and RPL using Stata 13 and LIMDEP 9.0 NLOGIT 4.

a- CVM Econometrics Results

The results of the logistic analysis are summarized in Table 5.9. In addition to the maximum likelihood estimates and their z-statistics, this table also contains the likelihood ratio statistic, the computed marginal effects of the explanatory variables and McFadden's pseudo R^2. Although the overall fit of the model, as measured by McFadden's R^2, is low by conventional standards used to describe probabilistic discrete choice models, the model is highly significant at less than 1%. The Probability of Chi-square is 0.0000 and the likelihood ratio statistic is 38.86 at 9 degrees of freedom, greater than the critical value 16.92. Four variables are found significant and all the signs are *a priori* as expected except those of AGE, GEND and WSPROT_PAST.

Table 5. 9: Results of logistic analysis of CVM

Variable	**Parameter estimate**	**z-values**	**Change in probability**
BID	-0.00515	-0.47	
AGE	0.03610***	3.10	0.00713
GEND	-0.22005	-0.90	
EDU	0.52394***	2.77	0.10354
HHINCOME	1.51e-06	1.30	
HHWTAP	0.62954**	2.35	0.12715
WATERBILL	-0.00011*	-1.83	-0.00002
WSPROT_PAST	-0.02632	-0.08	
MBERSHIP	0.83053	1.59	
CONSTANT	-1.81968**	-2.28	
LR chi2 (9) = 38.86		Log likelihood = -212.89767	
Prob>chi2= 0.0000		Pseudo R2 = 0.0836	
***, **, * significant respectively at 1%, 5% and 10% level.			

Source: Author, survey data

The coefficient of AGE is significant at 1%. The positive sign indicates that elderly respondents are more likely to pay for improved watershed management. Increase in age by one year increases the probability to participate by 0.00713. This also suggests that aged household heads are more conscious to leave their kids with a restored state of the watershed. This result corroborates with that of Melachio et al. (2011) for the valuation of Warda Urban Park and is in contrary with that found by Carlsson et al. (2003) and Rai et al. (20114) where elder were less likely to pay for watershed or wetland restoration.

The coefficient of EDU is significant at 1%. The positive sign indicates that respondents with high education level are more willing to pay for improved watershed management. A rise in education from one level to another increases the likelihood by 0.10354. This result corroborates with that of Rail et al. (2015) study where education has the expected sign but was not significant.

The coefficient of HHWTAP (***households with tap-water in their homes***) is significant at 5%. The positive sign indicates that respondents with tap-water in their homes, and therefore access to water are more willing to pay for the improved management of the watershed. Increase in the availability of tap-water in homes increases the likelihood by 0.12715. The finding follows the suggestion by the Water Poverty Index (WPI) that the households with access to good water quality are likely to contribute to water source management.

The coefficient of WATERBILL (***average water bill cost***) is significant at 10%. The negative sign suggests that the higher the household's average water bill the more likely they are to vote against the improved watershed management and against an increase of the water bill for this purpose. Increase water bill by FCFA1 decreases the likelihood by 0.00002. This also implies that the utility of the households decreases as the monthly water bill increases; and can be explained by the fact that water bill is negatively related to the household income, which positively affects the WTP. This result corroborates with the result of Loomis et al. (2000) and Tarfasa and Roy (2013).

Although the coefficients of variables HHINCOME, MBERSHIP and BID are not significant, they have the expected sign. The negative sign of BID's coefficient denotes that the higher the FCFA amount the respondent was asked to pay, the lower the probability that the respondent would vote for restoration of ecosystem services in the watershed.

b- Choice Experiment Econometrics Results

The results of CL and RPL analysis are given in Appendix (A, B, C) and are summarized in Table 5.10. The results of the CL estimate are reported in the first column of the table; and this model was specified so that the probability of selecting a particular watershed management option was a function of attributes of that option and the alternative specific constant (ASC).

i) CL results: The overall fit of the model, the pseudo R2 is 0.1672, and the model is highly significant at less than 1%, and all the sign are as expected a priori. All of the watershed

management attributes are significant factors in the choice of a watershed management option, except *fish*, and ceteris paribus higher levels of any of the three other attributes increase the probability that a management option is selected. Households prefer increased amount of *water* (drinking and cooking), *fuelwood* and *air quality*, while they prefer to pay less in terms of watershed management fee. As a matter of fact, the negative sign of the price coefficient and its significance at 1% level in the CL and RPL model indicate that the effect on utility of choosing a choice set with a higher price level is negative.

Table 5. 10: CL, RPL and RPL with interactions estimates for watershed management attributes

	CL model	**RPL model**	**RPL with Interactions**
Attributes and interactions	**Coefficient *(s.e)***	**Coefficient *(s.e)***	**Coefficient *(s.e)***
ASC	0.03722	0.157E-12	0.202E-12
	(0.1871)	*(0.105E+16)*	*(0.138E+16)*
WATER QUALITY	0.00631***	-0.01108***	-0.00898***
	(0.0012)	*(0.0025)*	*(0.0025)*
FUELWOOD	0.49527***	0.78148***	0.44428***
	(0.5865)	*(0.0876)*	*(0.1670)*
AIR QUALITY	0.39838***	0.77487***	0.50199***
	(0.0659)	*(0.0851)*	*(0.1032)*
FISH	0.01446	0.48760***	0.34261*
	(0.0661)	*(0.1038)*	*(0.1912)*
PRICE	-0.00185***	-0.00138***	-0.00163***
	(0.0003)	*(0.00025)*	*(0.00026)*
OPT1*MALE	----	----	0.95251***
			(0.2274)
OPT1*EDU	----	----	0.36471***
			(0.1202)
OPT2*MALE	----	----	1.13423***
			(0.2289)
OPT2*EDU	----	----	0.29972***
			(0.1111)
Log-likelihood	-1978.917	-1343.730	-1322.580
McFadden Pseudo R2	0.1672	0.201622	0.214188
LR Chi2	794.86	678.689	720.989
Prob >Chi2	0.0000	0.0000000	0.0000000
Number of Observations	4596	1532	1532

***, **, *Significance at 1%, 5%, and 10% level

Source: Author, survey data.

ii) RPL results with and without interactions: The RPL has a higher overall fit compared to the CL model with a R2 of 0.214; moreover, the difference between RPL models (without and with interactions) implies that improvement in the model fit is achieved with the inclusion of socioeconomic characteristics. Similar to the RPL model in column 2, the model with interactions in column 3 also results in the significance of all the four attributes. The results of RPL with interaction show that gender of the respondents and educational levels are significant at 1% and positively associated with selecting options or alternatives. This

suggests that male respondents are more willing to move away from the status quo (existing option) relative to female. In other words, men are likely to choose improved options. Similarly, respondents with high education levels are more willing to move away from the status quo option than the less educated ones. This highlights the heterogeneity in preferences between respondents. These results are in line with that of Birol et al. (2006) where respondents with higher level of education are likely to prefer wetland management scenarios that provide higher levels of the ecological, social and economic wetland attributes.

Furthermore, except the attribute "*water quality"* that significantly decreases the probability that a management option is selected, all the other attributes significantly increased the probability. The Attribute "*fish"* is significant at 10% level under the RPL model with interactions while it is not with the CL model. Overall, these results indicate that positive and significant economic values exist for higher level of ecological and economic attributes of the watershed. The positive sign and non significancy of the ASC coefficient in the CL and RPL models implies that a positive utility occurs in any move away from the status quo (option3).

i) Estimation of Willingness To Pay (WTP)

The CVM and CE method are consistent with utility maximization and demand theory (Bateman et al., 2003). When the parameter estimates are therefore obtained by the use of appropriate models, welfare measures in the form of mean and marginal WTP can be determined. For CE this is done by estimating the marginal rate of substitution between the changes in the four watershed management attributes in question and the marginal utility of income represented by the coefficient of price attribute. Table 5.11 reports the computed mean and marginal WTP for CVM and CE. A negative marginal WTP for *water quality* is obtained with the RPL models while implicit prices are all positive with the CL models.

Table 5. 11: WTP for CVM and CE method (Per respondent or per attribute)

	CVM (Mean)	**CE (Marginal)**		
Attributes	**Binary Logit Model**	CL model	RPL model	RPL with interactions
Water quality	---	**CFA 3.4155**	**CFA -8.017**	**CFA -5.494**
Fuel wood	---	**CFA 268.2517**	**CFA 565.302**	**CFA 271.838**
Air quality	---	**CFA 215.7750**	**CFA 560.521**	**CFA 307.155**
Fish	---	**CFA 7.83155**	**CFA 352.721**	**CFA 209.634**
---	---	---	---	---
Watershed as a whole	**CFA 247.30096**			

Source: Author

ii) Comparison of total WTP for CVM and CE, and "Net Social Benefits"

In order to estimate the total value of an environmental programme or good from a CE, as distinct from a change in one of its attributes, it is necessary to assume that the value of the whole is equal to the sum of the parts. Hanley et al. (1998) calculate the value of the Environmentally Sensitive Areas Programme as the sum of the values of its component parts. However, in economics, objections have been raised about the assumption that the value of the whole is indeed equal to the sum of its parts (Part-Whole bias). Nevertheless, to overcome this bias, Hanley et al. (2001) recommend that values of a good obtained from CE should be compared with values obtained for the same resource using some other method such as CVM, under similar circumstances. Thus, based on the fraction of the sample that gave a response in favor of the improved management in the survey (70.5% for CVM and 93.73% in the CE), the aggregate WTP to achieve ecological and economic conditions are given in Table 5.12 below. *For example, in the CVM, Total WTP= 247.3*270/383*400,000, and in CE, Total WTP for water quality = 3.4155*359/383*400,000*

Table 5. 12: Total WTP in CVM and CE exercises

	CVM (total in FCFA)	**CE (total in FCFA)**		
Attributes	**Binary Logit Model**	CL model	RPL model	RPL with interactions
Water quality	---	**1,280,327.56**	**-3,005,851.69**	**-2,059,891.39**
Fuel wood	---	**100,576,877.59**	**211,951,350.39**	**101,546,571.27**
Air quality	---	**80,901,540.47**	**210,158,787.47**	**115,163,075.72**
Fish	---	**2,936,320.05**	**132,247,351.44**	**78,599,066.32**
Watershed as a whole	**69,734,725.85**	--------	---------	---------
Total	**69,734,725.85**	**185,695,065.67**	**551,351,637.61**	**293,248,861.92**

Source: Author

From the table, the total WTP is higher with the different models under CE than under the CVM.

Cost benefits analysis.

The previous results can be used to design socially efficient watershed management policies by comparing the cost of improving the different attributes of the watershed to the benefits they generate (Carlsson et al., 2003; Birol et al., 2006). The total cost estimate for improvements in the watershed is reported in Table 5.13 below.

Table 5. 13: Cost estimates for improvement in watershed management

Management intervention	Cost in CFA francs (for 2012, 2013, 2014, 2015)
1- Improvement of water quality with installation of new water filtration equipment	15 million in 2012
2- Protection, conservation and reforestation (that improve biodiversity, fuelwood, fish and air quality in the watershed)	5 million in 2013 7 million in 2014 5 million in 2015
Total cost	**32 million**

Source: Author, from field survey with Ministry of Forestry and Wildlife (MINFOF), Kumba I Council, CDE and CAMWATER.

From Table 5.11, the aggregate welfare estimates or benefits are therefore far greater than the total cost given in the table above. More specifically, the aggregate WTP is about CFA 69.7 million, 185.7 million, and CFA293.25 million respectively for CVM, CL and RPL with interactions under CE; while the total estimated cost is FCFA32 million between 2012 and 2015 from MINFOF and CDE. Therefore the aggregate net social benefits could be estimated up to FCFA261.25 million with the involvement of local population (Households) in improved watershed management.

5.5 Conclusion of the Chapter

The chapter contributes to the limited literature on the estimation of the demand for watersheds protection using choice experiment in combination with contingent valuation, and it is in our knowledge, the first application of choice experiment to value watershed in Cameroon. The results indicate that there are positive and significant economic benefits associated with ecological, social and economic attributes of the Lake Barombi Mbo watershed, and there are also benefits for a watershed as a whole. The **mean WTP** for CVM is up to **FCFA247.003**, while the marginal WTP for each of the four attributes is up to **FCFA3.4155** for **water quality; FCFA271.838** for **fuelwood, FCFA307.155** for **air quality** and **FCFA209.634** for **fish.** The aggregate WTP varies from **FCFA 69,734,725.85** with Binary Logit estimates under CVM to **FCFA 185,695,065.67** under the Conditional Logit model, and to **FCFA 293,248,861.92**/month with Random Parameter Logit (RPL) estimates both under CE.

The impacts of these attributes, the socioeconomic and attitudinal characteristics of respondents on their valuation of watershed management attributes and options are significant and conform to economic theory. With the conditional logit and random parameter logit

(RPL) models, water quality, fuelwood, air quality and fish as watershed attributes significantly increase welfare. The results of the binary Logit indicate that age (+), education (+), availability of a tap-water in the home (+) significantly increased the probability to pay the proposed bid under the contingent valuation, while water bill (-) significantly decreased this probability. Furthermore RPL highlights preference heterogeneity among households. Moreover, households are willingness to contribute to improved watershed management in labor terms. Accounting for this heterogeneity and labor contribution enables prescription of policies that take equity concerns into consideration, and an understanding of who will be affected by a policy change in addition to the aggregate value associated with such changes in the watershed. The total benefits derived from various watershed management attributes and from the two methods used reveal the estimated values of what could be the amount of payments by downstream households to upstream farmers for environmental services provision in the watershed. The net benefits estimates reveal that high social welfare is achieved under the choice experiment method with random parameter model.

The next chapter analyzes the role of intermediaries in linking upstream users' willingness to accept and downstream willingness to pay for an effective PES scheme. The chapter contributes firstly to the analysis of the transaction costs in PES literature through an examination of the Coasian framework for Lake Barombi Mbo watershed; and secondly to the empirical analysis of the divergence between WTA and WTP in the literature. Indeed, an implicit assumption of PES has been that once a monetary value has been assigned to the environmental service (ES), a market would automatically evolve with buyers and sellers of the ES. However, this assumption has hardly worked in practice because it requires that the participation constraint of the PES scheme be met and a monitoring system to make sure that the ES is effectively provided for the payment to be made.

CHAPTER SIX

Market versus State Regulations in Protecting the Lake Barombi Mbo Watershed: The Role of Intermediary in Coordinating Upstream and Downstream Users' Interests in a Potential Payment Scheme.

6.1 Introduction

The governance of externalities arising from common pool resources management such as watersheds has long been a subject of debates in economics. As externalities arise because the actions of one or more economic agents cause uncompensated physical and/or economic effects (positive or negative) for others, these debates have often hinged on hierarchical (State regulation) versus autonomous (free market or contract-based) governance of externalities (Pigou, 1932; Coase 1960; 1988; Meade, 1952; Baumol and Oates, 1988; Johnson, 1973; Varian, 1995; Vatn and Bromley, 1997). Two main traditions have been considered, but both differing on the institutional mechanism involved: the Pigouvian tradition arguing for government regulation and the Coasian tradition inspiring support for private or market-driven solutions.

In the modern welfare economics, by assuming divergence between private and social net products, Pigou (1932) offers 'corrective' taxation solution or Pigouvian tax to externalities. The government then places responsibility on the agent emitting externality by imposing a tax on emissions of a magnitude equal to the divergence between social and private marginal cost. Nevertheless, what is necessary according to Coase (1960) is an approach comparing the total social product of alternative measures that gives attention to alternative specification of property rights and the transaction costs associated with different property right regimes. He rejects the Pigouvian framing of the problem in terms of "restraining the producer[51]" of negative externality and considers the problem to be of reciprocal nature: avoiding harm to B would inflict harm on A. The problem then becomes that of avoiding the most serious harm (Coase, 1960, p2). Hence, the Coasian approach stands for negotiation or bargaining between two parties involved in an externality, which will eliminate Pareto-relevant externalities and results in an efficient solution if property rights are well specified. However, economic

[51] According to Coase (1960), if we assume that the harmful effect of the pollution is that it kills fish, the question to be decided is whether the value of the fish lost is greater or less than the value of the product which the contamination of the stream makes possible (Coase, 1960, p3).

efficiency requires that to determine which party could change behavior most cheaply and from this view, the responsible party should be the one whose modified situation is cheapest for society to bear (Vatn and Bromley, 1997). Transaction cost are then key as an efficient outcome can occur through bargaining as long as costs do not outweigh gains[52].

Furthermore, while government has a crucial role to play for Coase (assigning individual property rights), the focus is rather on the limitations of government knowledge and foresight in designing effective incentives or regulations to guide individual behavior. As a matter of fact, imposing a tax is very costly as it requires to discover the appropriate level of the tax, and its information costs may exceed the benefits of implementation. Moreover, as the scope of externality affects more and more people, it becomes increasingly difficult to assign property rights, and therefore difficult to establish bargaining (Black et al., 2014). In addition, in our world of positive or high transaction costs where institutions matter, especially in delimitating property rights, Canterbery and Marvasti (1992 cited in Black et al. 2014) argued that Coase theorem borders on 'circularity' because externality arise due to transaction costs, but externalities persist because of transaction costs of removing them. Moreover, although the Coasian framework has given rise to strong views both for and against its applicability, the main weakness on the side of its supporters has been the scarcity of real-life scenarios of large number negative externalities where private Coasian bargaining resulted in externality mitigation. Coasian theorem has been better indicated for bargaining within small group or between neighbors (Njomgang, 2009, p154). Few clear cases of pollution mitigation involving large number of geographically dispersed affected parties have been considered (Hoffman and Spitzer, 1995; Black et al., 2014). This has then prompted continuing debate on policy alternatives relying on Pigouvian taxation or bargaining to correct for inefficiencies caused by such large-number externalities in the watershed. Hence, whether we should promote markets instead of government intervention is not the key question, but what optimal combination of market and hierarchical system is needed for governing externalities arising from watershed services utilization.

Interestingly, voluntary internalization of positive externalities has been developed during the last two decades and the public bargaining outcome confirms the validity of Coasian framework in large-number situations that also involves nonpoint source pollution, factors

[52] Coase argues that Pigouvian solution of taxation is not necessary if transaction costs are low or zero, allowing for an agreement that benefits all parties involved.

that have traditionally been considered hostile to its applicability. This is the case with the payments for environmental services (PES) mechanism (Pagiola et al., 2002; Kosoy et al., 2007; Wunder, 2008; Meijerink, 2008). In such solution, there is usually no need to implement taxes or fees, but rather payments to internalize positive externalities in addressing agricultural nonpoint source pollution, though a combination of fines and payments could be made possible with a PES scheme. The objective of this chapter is to examine the potential PES scheme of Lake Barombi Mbo watershed as a material example that could demonstrate the Coasian bargaining in providing solution to externality problems, with the role of the government represented by Kumba I Council as intermediary. The analysis of the power of intermediary agents, often the "dominant agents" in PES, is an important subject for research which has not yet been sufficiently addressed in the literature (Vatn, 2010; Kosoy and Corbera, 2010; Meijerink, 2008).

6.2 Design of PES Schemes and Challenges

There is an increasing interest in PES as an approach to integrate economic growth, ecological integrity and poverty reduction goals (Hope et al., 2005; Landell-Mills, 2002). However, successfully implemented PES schemes are far fewer though (Meijerink, 2008). Wunder (2005) identifies two key obstacles: firstly, a limited demand of ES and secondly, poor knowledge on the institutional requirements entailing incentive and livelihood mechanisms which so far have received comparatively little attention (Meijerink, 2008). However, although too few service users are not so confident about the mechanism that they are willing to pay for, in some cases, because the link between land use and environmental services (ES) provision is insufficiently understood or ambiguous as highlighted Wunder (2005), there is an amount of literature demonstrating that ES are in fact provided, and which establishes a biophysical link between changes in practices and the increased provision of ES (Jose, 2009; Müller-Lindenlauf, 2009; Stevens, 2011; Schroth and Harvey, 2007; Tomich et al., 2007 cited in FAO, 2007). However, developing suitable empirical methods for measuring and monitoring provision of ES remains a challenge for most PES programmes, and as Pagiola and Platais (2005) states: "if services aren't delivered, people won't pay". Meijerink (2008) highlighted that the type of monitoring that is required within PES has consequences for the institutional arrangement needed for a successful PES.

Furthermore, they are mostly reduced to PES where the 'demand side' is often the government due to the public good nature of ES (Engel et al., 2008). However, although governments have taken up responsibility of maintaining them, many PES are funded by development agencies or rural development programmes, and by urban communities or households (Kosoy et al., 2007; Engel et al., 2008; Ngo Nonga, 2015). In general, a PES scheme includes certain economic agents: resources managers/farmers or 'payees', who manage resources that provides a positive environmental externality or ES. This ES then benefits another group of people, which can be a specific group of people including households, administrations or society as a whole; and these beneficiaries can be labelled as the 'demand side' or buyers/'payers' of ES. Furthermore, from the PES literature, the most noticeable is the efforts necessary to create the market. Although the rights must be defined and the 'commodity' must be delineated, the group of users and providers must also be specified, a difficult task as 'exclusion' is often very demanding. This requires an intermediary agent (Lin and Nakamura, 2012).

Important aspects of institutional design of PES in the watershed include property rights, the necessary legal framework, transaction costs, contract type and length, and hidden information. There is a growing amount of literature devoted to this, which often make use of principal-agent theory (Hart, 2005; Ozanne et al., 2001; Fraser, 2002; Ferraro, 2008). In the Costsa Rica PES programme for example, contract length is 5 to 10 years for agroforestry and reforestation respectively. In Ugandan "Trees for Global Benefits project", the duration of agreements is typically 20 to 25 years between farmers and the environmental NGO ECOTRUST acting as intermediary for the emerging forest carbon market (AfDB, 2015).

6.2.1 Transaction Costs in PES

Transaction costs play an important role in PES schemes. Transaction cost are often underestimated and may undermine the viability of a PES scheme (Landell-Mills and Porras, 2002). Therefore, the setup of any PES scheme must aim to reduce transaction costs. This can be achieved by choosing the most appropriate institutional setup (Meijerink, 2008). Within institutional economics three sources of transaction costs can be distinguished: contact cost, contract cost and control cost (North, 1990, p.28-33):

- Contact entails the cost of measuring the valuable attributes of what is being exchanged. Individuals engaged in a transaction need to know what they are buying. In case of simple products like fruits, the cost of getting information about the product can be low. But in

the case of PES, the cost of getting this information can be high as outlined earlier from the links between land use and ES provision. But, a contingent valuation scenario that describes well the change could provide the required information.

- Contract entails the costs of protecting right. Property rights of individuals over assets consist of the rights, or the powers to consume, obtain income from and separate from these assets. Exchange involves the mutual ceding of rights; and without rights to property, market trades cannot be sustained (Inman, 1987). According to Barzel (1989 cited in Meijerink, 2008), the rights people have over asset are not constant; they are functions of their own direct efforts at protection, of other's capture attempts, and of government protection. PES schemes require the allocation of titles *de jure or de facto* on environmental externalities benefiting third parties, that is, ES. Protecting rights over ES can involve high costs because of their transient nature. But through their use rights, thus, *de facto*, landowners or farmers could supply ES through their influence on ecosystem (Ferraro, 2008).
- Control entails the costs of policing and enforcing agreements. As underlined Meijerink (2008), enforcement poses no problems when it is in the interest of the other party to live up to agreements. But without institutional constraints, self-interested behavior will exclude complex exchanges because of the uncertainty that the other party will find in his or her interest to live up to the agreement. This conflict of interest coupled with asymmetric information thus gives rise to the contract theory (Meijerink, 2008), where two sources of asymmetric information exist: moral hazard or hidden action, that is, when the *agent* can take an action unobserved by the *principal*, and adverse selection or hidden information, thus, when the *agent* has some information about the cost or valuation that is ignored by the *principal* (Hart and Holmström, 1987; Laffont and Martimort, 2002).

PES schemes intend to establish an information flow between service providers and users to facilitate the market exchange between both types of agents (FAO, 2004). However, information asymmetry arises in many PES. Ferraro (2005) notes that hidden information (adverse selection) is a problem in all PES contract settings, though Ferraro (2008) provides an amount of tools to overcome this problem. Moreover, the economic literature on moral hazard and monitoring in agri-environmental schemes bases *monitoring* and payment on the *activities* of farmers as specified in the contract (Hart, 2005; Ozanne et al., 2001; Fraser, 2002). In the Uganda case, individual payments are made in individual accounts to farmers as follow: in year 0 (30% of payment), year1 (20%), year3 (20%), year5 (10%), year10 (20%),

provided contractual conditions are fulfilled. Those conditions are: 50% of trees must be planted to get the first payment; one year later, 100% of them must be planted to get the second payment. No less than 85% of trees planted should have survived in year 3; and average tree diameter at breast height should not be less than 10 cm by year 5. Thus, monitoring explains why in PES schemes the intermediary is often the dominant agent (whether the state, NGOs of various kinds), as in addition in setting a predefined price and scheduled payment, it should monitor the farmers' activities. The chapter focuses on the issues of property rights and the transaction costs of contract through the role of intermediary (figure 6.1).

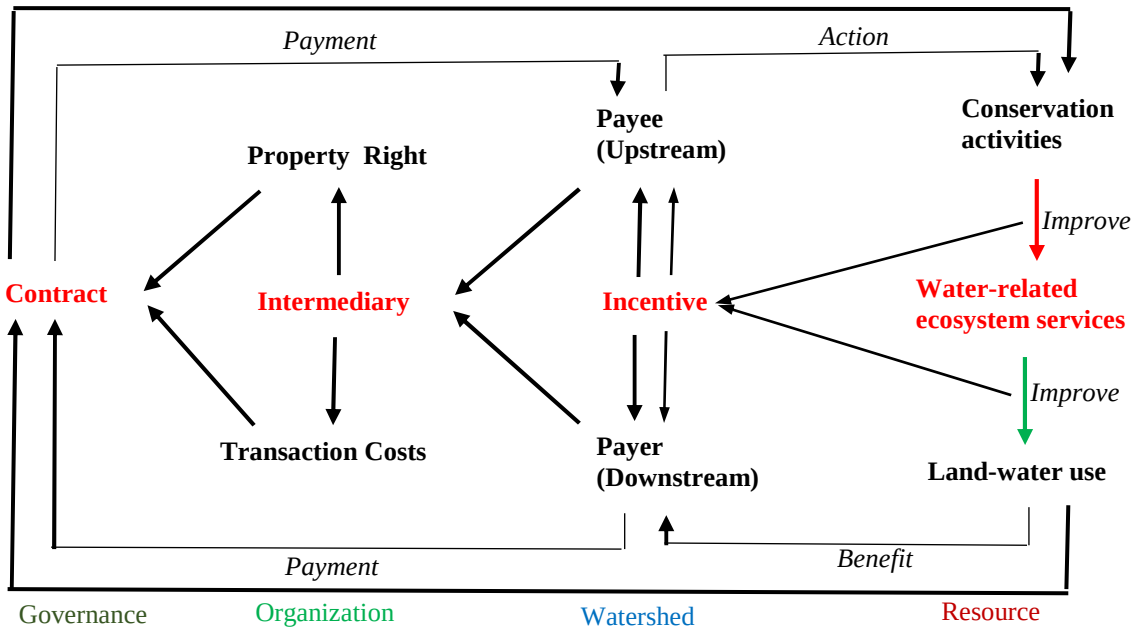


Figure 6. 1: The role of intermediary within the lake watershed governance framework. Adapted from Lin and Nakamura (2012)

From the foregoing, establishing PES systems seems to be costly. Many agents may be involved. Trust may be low and trust building becomes necessary. One must evaluate whether there is a potential gain from trade and what is an acceptable price. Moreover, when a contract is made, control is finally necessary to see whether what is contracted is also delivered.

6.3 Materials and Methods

Empirical model

Wunder (2008) highlighted the preconditions for environmental services payments in conservation including economic preconditions. Two economic preconditions have been underlined. Firstly, the key economic rationale for PES is that an "externality" exists, that is,

compensating an outside service benefit that the landowner (potentially *de facto*) provides to external beneficiaries. A minimum degree of cooperate activity is therefore required, as landowner and external beneficiaries (downstream water users) have diverging interests. Unless the latter compensate the former, the service will be lost. Secondly, the value of the service (s) at hand, which determines the environmental service user's willingness to pay (WTP) must exceed the environmental service provider's opportunity costs, thus, the profit foregone from abandoning the first-best land-use plan, which determine the ES provider's willingness to accept (WTA) PES, plus transaction costs (TC) (Wunder, 2008). However, in some situations, profits from alternative land uses may be too high for conservation to compete or transaction costs are prohibitive for PES, that is, minimum WTA+TC > maximum WTP. A way to overcome this situation is provided by Meijerink (2008), who considers the opportunity costs (OC) the agent needs to make to implement the contract as the costs of abiding or lasting the agreement for the agent. Thus, the farmer or agent gave the minimum price that will make him or her accept and last the contract, and then provide ES. This interpretation suggests that the economic precondition for PES is that maximum WTP should be greater or equal to minimum WTA or OC i.e., minimum WTA≤ maximum WTP, implying that $\frac{maximum\ WTP}{minimum\ WTA} \geq 1$. Hence, according to Wunder (2008), the economic preconditions for PES with favorable WTP/WTA ratio should then be widespread.

Furthermore, in an institutional setting as in contract theory, the solution to moral hazard has been the internalizing of incentives, via the contract terms while the solution to an adverse selection situation involves offering several alternative contracts, and the agent's choice between these alternatives reveals his private information (Laffont and Martimort, 2002). Many of these models assumed that the final outcome can be measured and can be attributed to effort (Shapiro and Stiglitz, 1984), but monitoring has often been costless in these models. However, although incorporating incentives into the contract has been the key while monitoring played a minor role, some models do not assume costless monitoring and the use of (external) auditor played a role (case with most carbon project enrolled in carbon market). According to Meijerink (2008), monitoring includes the direct supervision of the agent, that is, of the agent's actions as well as the use of output-related performance indicators, when this

is relevant, or the combination[53] of signals from various sources, taking into account the cost and informativeness of the signals.

Moreover, monitoring and enforcement have often been ignored when discussing environmental policy alternatives by policy makers and academics (Cohen, 1999). However, in economic literature on enforcement, the principal's problem is to choose the enforcement expenditures (or equivalently probability of detection through monitoring), the level of fine, the standard for imposing liability, and if relevant, the imprisonment terms. Due to the trade-off between the level of fine and enforcement expenditures as underlined Mejerink, government or the principal can reduce monitoring costs by imposing high fines. However, in PES schemes, the voluntary nature limits the range of punishment mechanisms. Either they do not exist at all (Wunder et al., 2005) or they are limited to decreasing payments or to ending the contract completely. In some PES schemes, payments are made to communities in the form of community social support, including building a new school, a road or a health Centre, given access rights or any other royalties. This undermines the conditionality of payments as these cannot be taken away when ES are not supplied. Therefore, in most cases it is assumed that payments are made conditional and that non-compliance leads to reduction or discontinuity of payments (case of Uganda). Furthermore, although a fine has often been included in agri-environmental schemes in USA and Europe (Ozanne et al., 2001), many PES in developing countries aim to enhance rural development and reduce poverty. Therefore, imposing a fine on poor resource managers in addition to withholding payments have been and might be considered inappropriate. Thus, in most PES, there is no additional fine and the punishment have consisted and consist of reducing payment, which is of limited ranged (AfDB, 2015); and Meijerink (2008) suggests that this can be modelled as "limited liability".

Empirical studies analyzing the effectiveness and efficiency of PES in contract theory traditionally used either the auctions mechanism (Vatn, 2010, Ajayi et al., 2012), or the Principal-Agent framework (Peterson et al., 2014; Meijerink, 2008). However, experiences with auctions and game theory in developing country settings are limited. In the Coasian framework and assuming the right to be *de facto*, our analysis focuses mainly on the first and last sources of transaction costs (contact and control costs), using results from valuation methods and also a principal-agent model within a basic game theory framework.

[53] When monitoring is not costless, Demougin and Fluet (cited in Meijerink) show that monitoring and incentives can be either substitutes or complements in a moral hazard situation, depending on the circumstances.

6.4 Empirical Analysis: The Coasian Framework of PES Scheme for Lake Barombi Mbo Watershed

The creation of the scheme of Lake Barombi Mbo is supported by economic valuation studies with upstream farmers and downstream households, in addition to the information from the state of the management presented above. Here, we consider three cases of transaction costs: 1) Zero transaction cost case, where it is defined as the optimal level of ES to be set; 2) Low transaction cost case corresponding to the cost of the valuation studies or contact cost (obtaining beneficiaries or households' WTP and farmers' WTA); 3) High transaction costs corresponding to the contract establishment and monitoring costs.

Case 1: Zero transaction cost case (Defining the optimal level of ES to be set)

Figure 6.2 illustrates the way of depicting benefits and costs of a contract of delivering of ES given zero transaction cost in Barombi Mbo. F and H denote farmers and downstream households respectively. In the absence of legal requirement to provide ES, farmers have an incentive to supply zero (R_F) level of ES, because at that level, profit is maximized and the OC is zero.

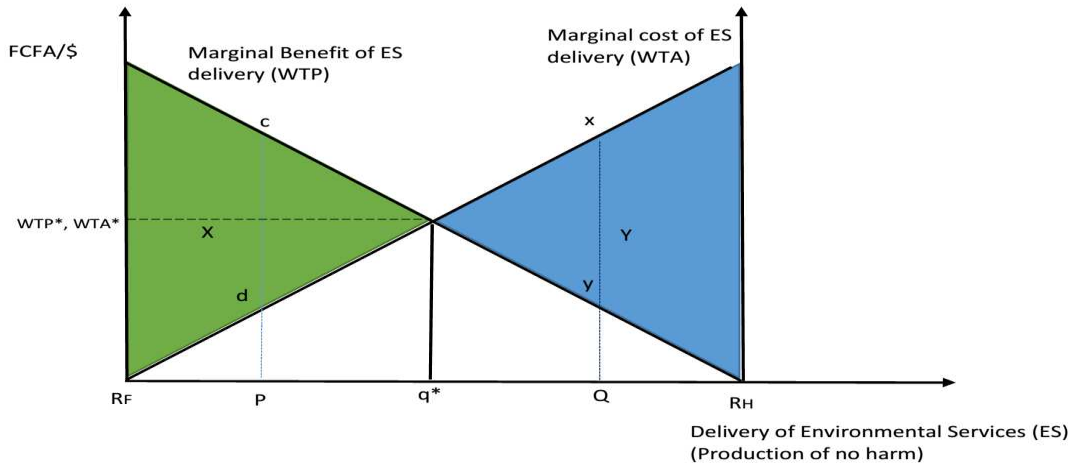


Figure 6. 2: Benefits and costs of a contract of ES provision given zero transaction cost in Barombi Mbo

When farmers have the property rights to the lake, the starting point is $R_{F,}$ because they have the right to harm and to do not integrate ES in their farm activities. The downward-sloping demand curve for ES implies that at R_F, the households' *willingness to pay* (WTP) for ES provision is initially high, but no ES is delivered. However, there is potential for trade since households' WTP for ES exceeds the farmers' OC or marginal cost of ES supply at that point.

If for example households wish to increase ES level to P, they could offer an 'amount' *cd* to farmers to induce them to supply more ES. Farmers would be willing to accept this amount because it exceeds the OC at that level. However, farmers have no incentive to provide ES beyond q* because OC exceeds the maximum payment the households are willing to offer them.

When households have the property rights on the lake, the starting point is R_H since harm is not allowed and households would like to fully enjoy ES. However, for Households to enjoy full ES, the farmers' OC is higher than households' WTP for ES provision. There is therefore a possibility for trade. At point Q for example, the maximum OC farmers are willing to supply an additional unit of ES is *x,* which is higher than the minimum compensation, *y,* that the households would offer for ES of watershed protection. In this particular case, households would be willing to offer compensation of up to *y* to farmers, to induce them to provide ES. This because even though they suffer a welfare loss from *y*, they are still enjoying more ES of level *Q,* and the payment is lower than farmers' OC in achieving that level. Thus, the move from R_H to Q is a Pareto improvement because at least one party is better off and no one is worse off. Farmers would then negotiate lower OC, which results in lesser ES. However, households would not offer payment for harm less than q* because below this level, less ES is provided and payment is higher than OC. Therefore, they will choose to pay for ES up to q*.

Therefore, the optimal level q* is the same whether the rights are with farmers (providers) or they are with downstream households (users). Gains from trade are areas in green and blue respectively. Starting from $R_{F,}$ (the typical PES starting point), there will be nothing to gain from trading if transaction costs are greater than X. However, it is certainly very difficult to define the size of X and evaluate whether transaction costs consume all potential gains. Hence, taking transaction costs into account makes it easy to understand why the intermediaries are crucial in this case as they reduce transaction costs. Certainly this goes here for the academics or the Council representing the government.

Case 2: Low transaction costs case (Analyzing economic preconditions)

The low transaction cost case corresponds to the cost of the valuation studies, thus, the cost of obtaining beneficiaries or households' WTP and suppliers or farmers' WTA by academics, or the cost to obtain the economic preconditions of the PES scheme. Therefore, drawing on our earlier results from two economic valuation methods, we verify here the economic

preconditions of the scheme using the formula: $\frac{maximum\ WTP}{minimum\ WTA} \geq 1$, adapted from Wunder (2008) and Meijerink (2008). We also examine which valuation method gives better preconditions.

❖ Results of the Economic Valuation and the Economic Precondition

As presented in the previous chapter, the application of the choice experiment method (CE), in addition to the contingent valuation method (CVM) with a sample of 383 household heads in Kumba metropolis helped determining the households or beneficiaries' WTP for ES. Their average and aggregate WTP were obtained by estimating a conditional logit and random parameter logit (RPL) models (with and without interactions). With interaction between attributes and socioeconomic characteristics, the RPL model highlighted heterogeneity in the preferences among respondents. The **mean WTP** for CVM and the **marginal WTP per month** that were obtained for each of the four attributes used are recalled in table 6.1. The **aggregate WTP** per month are reminded in Table 6.2. In upstream part of the watershed, a CVM study was also conducted with 384 farmers to determine their WTA or the compensation level they would be willing to accept to provide ES through reforestation and agroforestry. Farmers' WTA was obtained by estimating a Tobit model. The **mean WTA** and **aggregate WTA per year** are also recalled in Table 6.1 and Table 6.2 respectively.

Table 6. 1: MeanWTA/year and MeanWTP/month in CVM, and marginalWTP/month for CE method

	CVM (Mean)		**CE (Marginal WTP)**	
Attributes	Tobit Model **(WTA)**	Binary Logit **(WTP)**	CL model	RPL with interactions
Water quality		---	**FCFA 3.4155**	**FCFA -5.494**
Fuel wood		---	**FCFA 268.2517**	**FCFA 271.838**
Air quality		---	**FCFA 215.7750**	**FCFA 307.155**
Fish		---	**FCFA 7.83155**	**FCFA 209.634**
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Watershed as a whole	**FCFA10,352.48**	**CFA 247.30096**	--------	---------

Source: Author calculations from survey data

Table 6. 2: Aggregate WTA/year in CVM, aggregate WTP/month for CVM and CE method

	CVM (total in FCFA)		**CE (total in FCFA) (WTP)**	
Attributes	Tobit model **(WTA)**	Binary Logit **(WTP)**	CL model	RPL with interactions
Water quality	---------	---	**1,280,327.56**	**-2,059,891.39**
Fuel wood	---------	---	**100,576,877.59**	**101,546,571.27**
Air quality	---------	---	**80,901,540.47**	**115,163,075.72**
Fish	---------	---	**2,936,320.05**	**78,599,066.32**
Watershed as a whole	**84,554,347.69**	**69,734,725.85**	--------	---------
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Total	**84,554,347.69**	**69,734,725.85**	**185,695,065.67**	**293,248,861.92**

Source: Author calculations from survey data

From the results of valuation, the *aggregate WTP per year* could be computed by adding the total WTP per month twelve times. Thus, by assuming that the aggregate WTA per year represents *the minimum WTA* of farmers and the aggregate WTP per year, the *maximum WTP* of households for ES, the economic preconditions are presented in Table 6.3.

Table 6. 3: Economic Preconditions of Barombi Mbo scheme

	CVM (Total in FCFA)		***CE (Total in FCFA)***	
	Tobit model **(WTA)** ***(1)***	Binary Logit **(WTP)** **(2)**	CL model **(WTP)** ***(3)***	RPL with interactions **(WTP)** ***(4)***
Total per year	**84,554,347.7**	**836,816,710**	**2,228,340,788**	**3,518,986,343**
$\frac{maxWTP}{minWTA}$		$\frac{(2)}{(1)}$	$\frac{(3)}{(1)}$	$\frac{(4)}{(1)}$
		9.89	**26.35**	**41.62**
Decision		**> 1**	**> 1**	**> 1**

Source: Author calculations from the economic valuation studies results

From Table 6.3 above, the economic preconditions for Watershed payment are largely met with the two valuation methods, since all of the computed ratios are greater than one. These results therefore suggest that farmers could abide by a payment scheme with households and be paid per year at their minWTA for ES. However, with the CE method, the *maxWTP* is 41 times larger than the *minWTA* , while this is only 9 times in the CVM. Therefore, the CE is the better method to obtain the economic precondition of the payment scheme. This result could be explained by the advantages of CE to account for the different attributes of watershed management including water quality, air quality, fuelwood and fish.

Nevertheless, how this amount will be collected should be specified. To address this concern, in the valuation exercise with households, the WTP was supposed to be an additional fee to the actual water bill paid per month which varied from FCFA100 to FCFA25,000 with an average of FCFA3,438; which bill most of the households found to be affordable (65.54%) and cheap (6.08%). This additional fee has to be collected by CAMWATER and CDE, and be refunded to the Council through a collaborative agreement. In turn, the council is supposed to transfer this money or financial resource to farmers that would be involved in tree planting activities[54]. Therefore, the Council has a central role in the scheme in terms of collecting and transferring cash, and in ensuring the control of tree planting to make sure that what money is transferred for is being provided. Kumba I council should act then as intermediary in establishing the contract and monitoring the farmers' activities.

Case 3: High transaction cost case (Monitoring of the Scheme)

In considering this case of high transaction cost, we followed the principal-agent theory on how the council should monitor the contribution of farmers. For simplicity, the 'agents' are "farmers" who provide the ES, and the "Council" is the 'principal', which is the demand side, as she represents the interests of households who are the beneficiaries of ES. We therefore assumed that there is only one principal (council), and that agents (farmers) face the same opportunity costs and are symmetric over the production of the ES. The agents (farmers) and the principal (council) agreed on a contract which specifies the actions that farmers should take and the payments terms. The council (principal) expects actions of the farmer (agent) such as tree planting to lead to certain level of ES in the watershed, for which she is prepared to pay. The payments cover at least the opportunity costs of the actions implemented by the farmer, that is, reforestation, satisfying the participation constraint WTP/WTA≥1. Two cases are considered.

a) Farmers monitor each other, council monitors the group

A possible way to reduce transaction costs of monitoring could be for the council to establish a contract with a group of farmers. The council can then monitor the group and leaves farmers to monitor each others within the group. By doing so, the council transfer a part of monitoring costs to farmers. This is appropriate if monitoring costs are high for the council and lower for farmers, and farmers are neighbors and can easily observe each other activities. In addition, Council may choose a leader of the group, who will report farmers' actions to him. This latter

[54] Some of the farmers gave the average tree they would plant and monitor per year.

situation is equivalent in hiring an external auditor who can monitor farmers and report their actions to the council. Nevertheless, this first case brings us to a situation where the group can be considered as one agent that the council should monitors. From this and as argued by Meijerink (2008), the establishment of a contract with a group of agents has a fundamental difference with the principal-agent relationship in the sense that group relationships entail the problem of free riding since the effect of a reduction on effort (the council punishes the whole group) is shared by all agents. Therefore, as the council cannot detect who is free-riding, the payment he made to the group is according to the group outcome and this is shared equally between members of the group. This brings us to the case of direct supervision of farmers by the council.

b) Council monitors the farmers

By assuming that the council inspects farmers, this situation leads to a form of asymmetric information about the form and the type of monitoring. Indeed, the council for example may know when he will inspect the farmer, but the farmer does not. Hence, we illustrate and analyze this problem by game theory, by describing an inspection game adapted from Meijerink (2008) and Fudenberg and Tirole (1991). We assume there are two players an agent (farmer) and principal (council). The farmer can play two strategies: cooperate, thus, stick to the agreement by planting trees and denoted by C, or shirk (S) (do not plant tree). The council has the choice to monitor and inspect the farmer (I), or not to inspect (NI). The pay-offs to the farmer and the council depend on the costs of abiding by the agreement for the farmer (*minWTA*) (interpreted as the opportunity costs the farmer needs to make to implement the contract), the cost that the council needs to make for monitoring (*mc*), the value of the ES (*v*) and the payment the farmer receives when he/she abides by the agreement (*maxWTP*). Thus described, if the farmer shirks and is detected by the council, he/she receives no payment. Moreover, satisfying the participation constraint means that *maxWTP>minWTA*, otherwise the farmer would not enter the contract. In fact, in many PES schemes, agents (farmers) are paid only for their opportunity costs, which would imply that $maxWTP - minWTA = 0$. This means that a farmer is indifferent between entering the contract or not. However, to ensure participation, we assume that *maxWTP* is *slightly higher than minWTA.* Moreover, we assume that the value of ES *(v)* is *always greater than what people are willing to pay ie v>maxWTP* Table 6.4 shows the pay-offs matrix between farmers and council.

Table 6. 4: Pay-offs matrix of PES contract between farmers and council

Farmer (Agent)	**Council (Principal)**	
	I	NI
S	*0, mc*	*maxWTP, -maxWTP*
C	*maxWTP-minWTA, v-maxWTP-mc*	*maxWTP-minWTA, v-maxWTP*

Source: Author's construction

The above game can be interpreted as a two move or sequential game according to Meijerink (2008), in which the farmer moves first, deciding whether to cooperate (plant trees) or shirk (do not plant tree). The decision is made on the farmer's expectation about being inspected by the council. The move made by farmer is not observed by the council, who decides after the move of farmer to inspect or not. Council does not know whether farmer has cooperated or shirked. If the farmer is found to shirk, the council needs only to bear the monitoring cost (*mc*) because the farmer is not paid (*0*). If a farmer is found to cooperate, council needs to pay a reward plus bearing the *mc*, and receives the ES (*v-maxWTP-mc)*, while farmer receives (*maxWTP-minWTA)*. However, if the council does not inspect and the farmer shirks, the council transfers a payment (*-maxWTP)* which one farmer receives *(maxWTP)*, but there is no ES provided (*0*). If the council does not inspect and farmer does cooperate, the target level of ES is achieved, council receives (*v-maxWTP)* and a reward is made to the farmer who receives the payment minus cost made (*maxWTP-minWTA)*.

Discussion: The preferred strategies of the council and farmer depend on the monitoring costs (*mc*), payment (*maxWTP*), opportunity cost (*minWTA*) and the value of ES (*v*). If we assume that the monitoring costs are very high, and larger than the payment made to the farmer, that is, *mc>maxWTP*, then council would prefer not to inspect. If the farmer is aware of this, he will choose to shirk, and the **equilibrium outcome is (S, NI)**. However, this would undermine the PES scheme. If we assume now that monitoring costs is not very large (at least smaller than the payments made to the agents, that is, $mc \leq maxWTP$). Then, we could examine two cases:

1- ***No possible pure strategy equilibrium exists***.

In fact, when $mc \leq maxWTP$, if the council does not monitor, farmer would prefer to shirk and receives (*maxWTP)*. Therefore, the council is better off by monitoring (*v-maxWTP-mc)*. But if

farmer knows that the council is guaranteed to monitor, farmer will therefore choose to cooperate and receives (*maxWTP-minWTA)*. However, in this later case, the council is better off by not inspecting *(v-maxWTP)*, thus saving monitoring costs. Therefore, no pure strategy equilibrium exists. The council could randomize so that the probability of monitoring lies between 0 and 1, and farmer must randomize too so that the probability of cooperating lies between 0and 1. There is therefore a possibility for a mixed strategy. However, mixed strategies are not intuitive as pure strategies because people do not take random actions.

2- *A pure strategy equilibrium exists under certain conditions*

The equilibrium that would not undermine the PES scheme will depend on the difference between (*v-maxWTP)* and *mc*, since *(v-maxWTP)>0* by assumption. As a matter of fact, in a PES scheme, one must make sure the ES is being provided. Thus, for a pure strategy equilibrium to exist which favors an effective PES scheme where the council monitors and the farmer does cooperate (the equilibrium outcome (C, I)), *v-maxWTP* must be greater than *mc, i.e., **(v-maxWTP)>mc***, which implies that ***mc< (v-maxWTP)***. Hence, the **equilibrium outcome (C, I)**, which is the optimal solution for this PES scheme requires that *the value of the ES received minus the payment made be greater than the monitoring costs*. Therefore, this implies that *the level of monitoring cost required should be less than the difference between the value of ES and payment made*. The scheme would be efficient and equitable if this condition is met. Moreover, given the difficulty to quantify ES we really benefit when making a monetary valuation, and that the maxWTP represented the value of these ES for households, the true value (*v*) of ES could be estimated by making some assumptions. For example, that the maxWTP could represent at least 75% of *v. this implies that* $\boldsymbol{v \geq \frac{100 * maxWTP}{75}}$. From this, the value of the monitoring costs *(mc)* can be determined.

6.5 Conclusion of the chapter

Economic costs of shifting to more desirable or equitable watersheds management behaviors may be in the form of economic losses associated with the shift to alternative management arrangements, or in the form of transaction costs. PES has then been proposed as a framework of solutions to these watershed management challenges. By considering the reciprocal nature of “social cost” in the governance of externalities proposed by Coase 1960, the optimal level of ES between upstream and downstream users has been set in this study. The economic preconditions for environmental services payment were verified, and were largely met.

Therefore, farmers could abide to a payment scheme with households. Since the transaction costs could consume all the potential gains from trade, the role of the council as intermediary in coordinating upstream farmers and downstream households' interests has been shown. From the principal-agent model developed within the basic game theoretic approach described, the council would make the PES scheme efficient and equitable if and only if the difference between the value of the ES minus the payment made is greater than the monitoring costs implied. However, this condition required to make some assumptions on the relationship between the payment made and the value of the ES. Therefore, this assumption could be to consider the maxWTP as a proportion of the value of ES (v)

The next and last chapter presents the general conclusion. It includes the implications of the entire study.

CHAPTER SEVEN

General Conclusion

7.1 Conclusion

Watersheds are important component of rural development and natural resources management strategies in many countries. A watershed is a special kind of common pool resource due to the hydrological system that link its resources. The management of this natural asset has been shown to be difficult due to the multiple conflicting uses of the system as well as the irreversibility nature of most watershed ecosystem services. Efforts to protect watersheds have been jeopardized by the complex nature of the externalities involved that have hindered the development of sustainable watershed protection programmes. Hence, building incentive systems that solve market, policy and institutional failures impeding watershed protection has remained a challenge for policy-makers, scientists and communities. Typically, command-and-control institutions and policies have been effective in controlling pollution from well-defined point source, but they were less effective in regulating non-point source pollution that occur downstream as a result of the combination of individual actions carried out by geographically dispersed and heterogeneous upstream providers.

However, by means of market transactions between downstream and upstream economic agents, the payments for environmental services (PES) schemes have induced upstream stakeholders to take downstream effects into account when making decisions about their own land use. But, for PES schemes to work as a multipurpose instrument that improve the conditions of different types of natural resources (forest, water, and fish) in the watershed at the same time, they should raise awareness about the economic worth of ecosystems services, while contributing to economic development. Hence, organized in seven chapters with three empirical ones (four, five, and six), this thesis *analyzed the conditions to be met ex-ante for an effective payment scheme for watershed protection in Lake Barombi Mbo Watershed in the Mount Cameroon region.* This analyze is divided into three levels. Indeed, typical to Lake Barombi Mbo watershed, many of the world's most important watersheds are densely populated and predominantly under agricultural land use where crop and forest productions have influence on the hydrological systems. As this negatively affects water quality, sediment flows, freshwater species, and ecosystems, the multi-functionality of agriculture may be

managed through the provision of environmental services to maintain these critical watershed functions. But encouraging farmers to supply these environmental public goods at an optimal level requires some form of non-market valuations. Thus, *the study first estimated the Willingness To Accept (WTA) compensation of the upstream users (farmers and fishermen) to participate in reforestation, conservation and agro-forestry activities in Lake Barombi Mbo watershed.*

Furthermore, watershed degradation is shown to increase the cost of water purification and shortage of tap-water to households, the scarcity of freshwater species, fuelwood, and non-timber forest products. This degradation also reduces environmental quality which in turn, results to adverse modification of the local climate. However, although valuation exercises have been applied to estimate the demand for these ecosystem services, the value of watershed protection is still unknown in Cameroon. The values depend largely on the design and models as well as whether one wants to value a watershed as a whole or its different attributes. In both cases, policy makers need information about the value of different options to make decisions. Thus, *the study secondly estimated the Willingness To Pay (WTP) of downstream households for watershed protection activities by upstream users.*

Thirdly and finally, *the study built a framework to coordinate the downstream and upstream users' interest (WTA and WTP) in the watershed through the role of intermediaries.* The development of this framework is motivated by the observation that, externalities mitigation involving large numbers of geographically dispersed affected parties prompted debate on policy alternatives relying on Pigouvian taxation or Coasian bargaining to correct for these inefficiencies. Therefore, given the increasing PES mechanism, the key question relies on the optimal combination of market and hierarchical system needed for governing such externalities arising from watershed services utilization.

In estimating the WTA compensation of upstream users to protect this lake watershed, the study has examined the perception and ability of farmers to provide watershed protection through agro-forestry and reforestation by using the Contingent Valuation Method (CVM) with a survey of 384 farmers in Lake Barombi Mbo watershed. Results show that almost all farmers perceive the importance of the forests for climate regulation, flood control, erosion control, wildlife habitat, and aesthetics as well as for cultural and spiritual aspects. 85.42% of farmers in total express a positive Willingness to Accept (WTA) for a reforestation program, while some are willing to adopt agro-forestry. Furthermore, 21.35% of farmers do fishing in

the Lake and 92.68% of these fishermen are willing to receive fishing tools recommended for sustainable fishing activities. Results of the Tobit model reveal that age (-), gender (+), education (-), and knowledge of bio-fertilizers (+) are significant determinants of WTA. The Average WTA for the provision of environmental services is FCFA 10,352.48 per year, with a total cost of the reforestation programme of FCFA 84,554,347.69 per year in the watershed.

With appropriate policy incentives, farmers and fishermen would adopt these practices and contribute to the improvement of the environment in its various dimensions. Our estimates provide key information to government agencies and policy-makers for designing incentives such as Payment for Environmental Services to encourage agro-forestry and reforestation with local species, and also to protect the twelve endemic fish species of the Lake, particularly the *stomatepia mongo* species considered in the IUCN Red List. However, this amount could also be derived from the demand for watershed protection by households through their willingness to pay for these environmental services.

With the application of choice experiment method in addition to the contingent valuation one, and based on a sample of 383 household heads in Kumba metropolis, the study determined the aggregate households' WTP, and identified the attributes and socioeconomic characteristics that increase and decrease households perceived value of watershed protection. Results from conditional logit and random parameter logit (RPL) models indicate that water quality, fuelwood, air quality and fish as watershed attributes significantly increased households' WTP, and hence welfare. The results from binary logit indicate that age (+), education (+), availability of a tap-water in home (+) significantly increased the probability to pay the proposed bid under the contingent valuation, while water bill (-) significantly decreased this probability. Moreover, the RPL model highlights heterogeneity in the preferences among respondents. The mean WTP for CVM is FCFA247.003, while the marginal WTP for each of the four attributes are FCFA3.4155 for water quality, FCFA271.838 for fuelwood, FCFA307.155 for air quality and FCFA209.634 for fish. The aggregate WTP varies from FCFA 69,734,725.85 with Binary Logit estimates under CVM to FCFA 185,695,065.67 under the Conditional Logit model, and to FCFA 293,248,861.92/month with Random Parameter Logit (RPL) estimates both under CE.

Policies aimed at increasing the level of education, and access to a tap-water per household could greatly promote the valuation of watershed protection by households in Lake Barombi Mbo watershed. Moreover, the total benefits derived from these various watershed

management attributes and the CVM reveal an estimated value of what could be the amount of payments by downstream households to upstream farmers for the provision of environmental services in the watershed.

Furthermore, the implicit assumption of PES has been that once a monetary value has been assigned to environmental service (ES), a market would automatically evolve with buyers and sellers of the ES. Nevertheless, this assumption has hardly worked in practice because it requires that the participation constraint in the PES scheme be met as well as a monitoring system to make sure that the ES, which implies a payment, is effectively provided. Thus, using the Lake Barombi Mbo watershed as a material example, this study also demonstrated how the Coasian bargaining between upstream farmers and downstream households, with the role of the Council as intermediary representing the government, provides solution to an externality problem in watershed. The study used the outcomes from the two valuation methods CVM and CE, and a Principal-Agent model with a basic game theoretic approach. The results show that the economic preconditions for environmental services payment are largely met, that is, maxWTP/minWTA is about 41 and thus largely greater than 1. The equilibrium outcome of PES contract between farmers and council exists only when the level of monitoring costs should be less than the difference between the value of the ES and payment made. Hence, the scheme would be efficient and equitable under this condition which requires the true value of the ES to be greater than what households are willing to pay for these ES.

7.2 Policy Implications of the study and Recommendations

Results presented in this study have important implications for policy-makers and further research.

- It provides insights from a field survey on farmers' preferences and the cost of a PES programme that could be implemented by the Government. Indeed, as stated in the 2014 report of the country to the Convention on Biodiversity Conservation, the involvement of communities and farmers in PES schemes is of fundamental importance for such incentive mechanisms to lead to the adoption of sustainable agricultural practices. The study is therefore prospective of PES suitability.
- Besides the estimated cost to the Government, the study provides key information for a successful and effective initiative. Indeed, the main approaches for biodiversity

conservation, including PES are often combined without a clear and systematic understanding of the perceptions and expectations of stakeholders. Therefore, the implementation of such economic incentive mechanism that is socially acceptable from the farmers' point of view should be encouraged.

- The field survey and farmers' responses (see, Table 4.2 reforestation and conservation practices on farm) suggest that there is a need to provide training and good seeds or seedlings materials for those species that are of interest to farmers. The constraint to the adoption of agro-forestry promoted by the Ministry of Agriculture and Rural Development (MINADER) and tree planting, highlights the lack of knowledge and seeds as well as an absence of collaboration between the Ministry of Forestry and Wildlife (MINFOF) and MINADER on the field. Moreover, the government through the Ministry of Livestock, Fishery and Animal Industry (MINEPIA) should provide fishermen with gill nets that save critical sizes and monitor fishing activities to save endemic species of the lake such as *Claris Maclareni*. This could be done, for example, by reducing the number of fishing day per week and regulating the fishing season. Furthermore, policies with a focus on young male farmers, and aiming at improving the level of sensitization on bio-fertilizers advantages could promote the provision of ES that sustain agricultural production and natural resources management in Cameroon and in particular, in the Lake Barombi Mbo watershed.
- The study provides researchers with information on criteria farmers use to evaluate the effects of their practices on the environment. The study expanded the range of explanatory variables used in participation programmes by including knowledge of bio-fertilizers (advantage of the agro-forestry) as an independent variable. The positive sign and significance of this variable at a 10% level provides some insights into necessary conditions for the participation in agro-forestry technology. This information can therefore be used by other research in the selection of their variables.
- The households' willingness to pay computed, represent the amount they are ready to spend for watershed protection by upstream users or farmers. Moreover, achieving a higher social welfare requires to consider the choice experiment method with Random parameter model. Thus, given the obligations of the RAMSAR Convention and the current commitment to manage the natural resources of the country through PES mechanism, further studies could apply the choice experiment method or use the benefits

transfer method to provide policy-makers with information on the value and demand for improved management of other similar watersheds in the country.

- The government, represented by the council should first sensitize and involve farmers and households, and then collaborate with CAMWATER and CDE to implement this potential PES scheme to sustainably manage Lake Barombi Mbo watershed. Besides, the PES scheme should be considered in the management plan of the Lake Barombi Mbo Forest Reserve

The results of this study further provide significant insights for the environmental, socio-economic and political perspectives in the country.

✶ **Policy Recommendations**

- It has been and it is still difficult to consider that there exist a real water policy in Cameroon, taken from the perspective of "public policy". The treatment of water resources or watersheds related problems has remained marginal in the country, despite the importance of the watershed services and the existence of a department that is dedicated to them. Certainly, there is relatively dense regulatory framework and institutional bodies that governs the management of water resources. But these should be structured around a real strategy that considers watersheds or water *as a resource that must be preserved and be used in a rational way, as an environmental resource that can cause social conflicts if it is not well managed, a public health and development issue above all*.
- Furthermore, watersheds/water management in the country still remained an affair of the State, public authority, and its implementing agencies CAMWATER and CDE. The involvement of private operators, local and traditional authorities and citizens that could raise the scarce financial resources needed for their sustainable management remained weak. At this level, we recommend that:

  - Collective responsibility of all actors. The responsibility of municipalities or councils should be reconsidered. Yet, they are positioning themselves as genuine actors of local development and should therefore be committed to the development of the locality.
  - A PES policy should be developed and implemented. Such a policy could either be developed separately from the existing laws (water, environmental, forestry), or mainstreamed into them.

- **Recommendations for Environmental Management:** The following recommendations are made:

On the challenges of providing tap-water or drinking water in the country. Two great challenges faced in providing tap water and sanitation services to people in the country have been identified: the first challenge was to complete the supply of water for household services and secondly to increase and improve the sanitations facilities (DSCE, p.182-183). Therefore, we recommend that the government should change the focus from supply driven, subsidized programmes to ones in which users are provided the services they want and are willing to pay for. The private sector (CDE and others), both for profit and non-profit purpose have to play a much larger role, for reasons of both service quality and the payment of watershed ecosystem services. This would also address the challenge of managing water resources or watersheds sustainably.

The need of valuation of watershed management, its sustainable financing and the methodology that could be used. We recommend that, if rural water projects and programmes would have to be both sustainable and replicable in the country, an improved planning methodology would be required that includes a procedure for eliciting information on the value placed on different service levels, and tariffs should be designed so that at least the operation and maintenance costs can be recovery. A key concept in such an improved planning methodology could be that of willingness to pay (WTP) from an experimental choice analysis. People that would be willing to pay for the full costs of a particular service indicate that the service is valued, and therefore will likely be used and maintained. Hence, it would be possible to generate the funds required to sustain and even replicate the project or programme.

7.3 Further research Area

Further research should focus on the framework for the implementation of other PES (for example carbon sequestration PES) in the country. In this case, it would examine how the land and resource tenure issues could be clarified, provide specific rules and transaction mechanisms, and determine compliance and enforcement mechanisms in the case a separate legal policy would be desired for PES.

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1. Law No. 94-01 of 20 January 1994 to Law down Forestry, Wildlife and Fisheries Regulations
2. Law No. 74-1 of 6th July 1974 to Establish Rules Governing Land Tenure
3. Law No. 96/12 of 5th August 1996 Relating to Environmental Management in Cameroon
4. Law No. 98/005 of 14 April 1998 on the Water Regime (Loi No. 98/005 Du 14 Avril 1998 portant regime de L'eau)

ANNEXES

Annexes of Chapter 1

Villages and activities carried out upstream of the watershed.

Table A1.1: Village and location of the farm

Farm location	**Village**					**Total**
	Barombi Mbo	Kake1	Njurky	New Tow Barombi	Small Ekombe	
In the reserve closed to the lake	17	13	14	0	0	44
In the reserve	13	23	8	2	5	51
Out of the reserve	150	48	19	0	26	243
In and out of the reserve	20	9	8	0	9	46
Total	200	93	49	2	40	384

Source, Author, from survey data

Table A1.2: Village and collection of fuel wood

Fuel wood collection	**Village**					**Total**
	Barombi Mbo	Kake1	Njurky	New Tow Barombi	Small Ekombe	
In the reserve	25	26	24	1	8	84
Out of the reserve	130	36	13	0	14	193
In and out of the reserve	45	31	12	1	18	107
Total	200	93	49	2	40	384

Source, Author, from survey data

Table A1.3: Village and timber exploitation

Exploitation of timber in the reserve	**Village**					**Total**
	Barombi Mbo	Kake1	Njurky	New Tow Barombi	Small Ekombe	
Yes	9	14	2	0	9	34
No	191	79	47	2	31	350
Total	200	93	49	2	40	384

Source, Author, from survey data

Table A1.4: Village and collection of NTFPs

Collection of NTFPs in the reserve	**Village**					**Total**
	Barombi Mbo	Kake1	Njurky	New Tow Barombi	Small Ekombe	
Yes	78	42	13	0	14	147
No	122	51	36	2	26	237
Total	200	93	49	2	40	384

Source, Author, from survey data

Table A1.5: Village and fishing activities

Fishing activities in the Lake	**Village**					**Total**
	Barombi Mbo	Kake1	Njurky	New Tow Barombi	Small Ekombe	
Yes	81	0	1	0	0	82
No	119	93	48	2	40	302
Total	200	93	49	2	40	384

Source, Author, from survey data

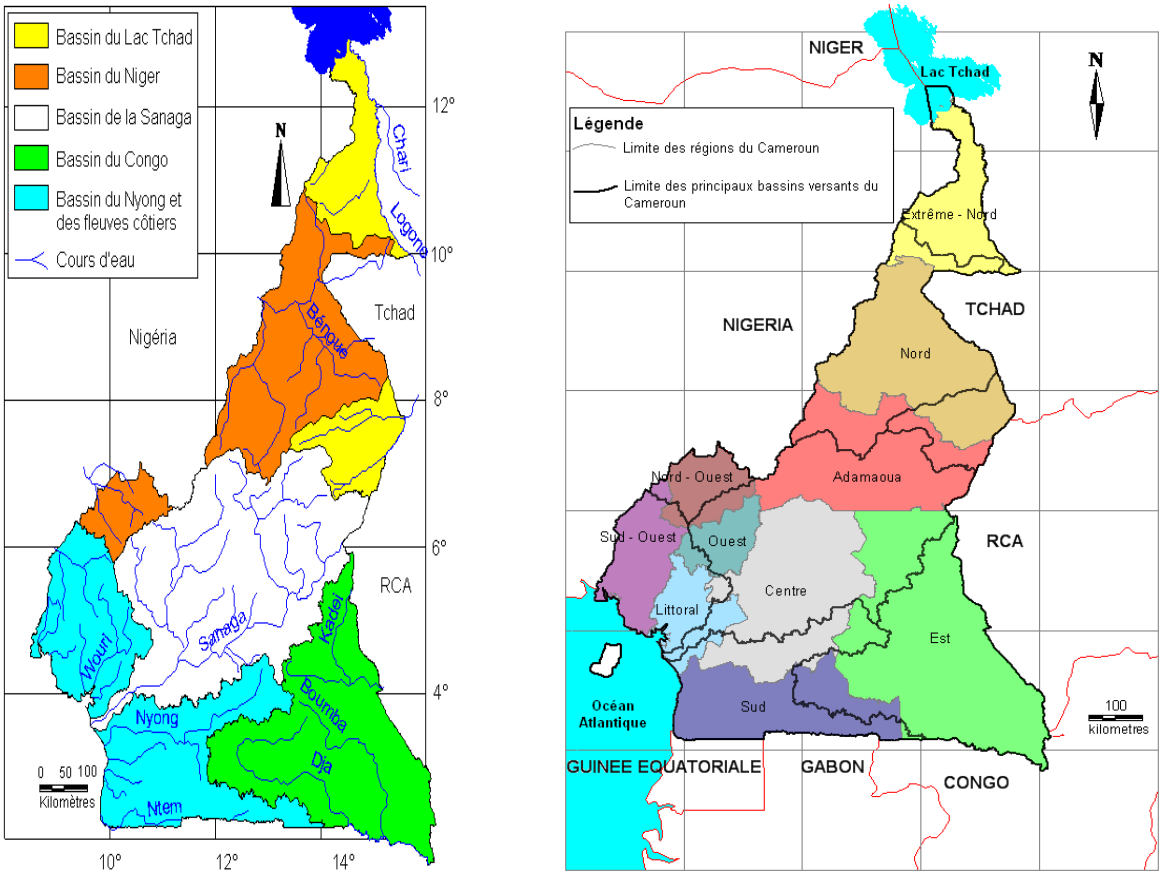
Annexes of Chapter 2

- **Annex: Water Quality Standards**

		WUC
VARIABLE		Recommended Maximum Limit
PHYSICAL REQUIREMENTS		(mg /l)
Turbidity	NTU	0.5
Color	TCU	15
Taste & Odour		Non-objectionable,
CHEMICAL REQUIREMENTS		(mg /l)
Chlorine residual	Cl_2	0.3-0.6
pH value		6.5-8.5
Total dissolved solids	TDS	450
Total harness	(as CaCo3)	20
Sulphate	So4	200
Calcium	Ca	80
Nitrite	No2	3
Potassium	K	0.25
Chloride	Cl	100
Sodium	Na	100
Magnesium	Mg	30
Iron	Fe	0.3
Manganese	Mn	0.5
Ammonium	Nh4	1.0
Aluminium	Al	0.1
Copper	Cu	1.0
Zing	Zn	3.0
TOXIC SUBSTANCES		(mg /l)
Nitrate	No3	45
Fluride	F	0.7
Lead	Pb	0.01
Cadmium	Cd	0.03
Cyanide	CN	0.7

Source, Sesi JFE notes

Annex A2.1: The Hydrographic Network (left) and Macro Watersheds (right) of Cameroon



Source: MINEE/GWP, 2009 a and b

Annex A2.2: African Main Offset Suppliers

African Offset Suppliers	Website
BioCarbon Partners	www.biocarbonpartners.com
Carbon Africa Ltd	www.carbonafrica.co.ke
Carbon Green Africa	www.carbongreenafrica.net
Carbon Tanzania	www.carbontanzania.com
CookClean Ghana Limited	www.cookclean.net
Credible Carbon	www.crediblecarbon.com
DelAgua Health	www.delagua.org
Ecosur Afrique	www.ecosurafrique.com
Hestian	www.hestian.com
HIBB & CO.TOGO	www.hibbcotogo.com
Natural Balance (Pty) Ltd	www.nb-wonderbag.com
Uganda Carbon Bureau	www.ugandacarbon.org
Vi Agroforestry	www.viagroforestry.org

Source, Author from Ecosystem Marketplace's report 2014

Annexes of Chapter 3

A3.1: Measure of Choice Design Efficiency

A measure of efficiency is choice design is derived from the well-known MNL (McFadden, 1974). This model assumes that consumers make choices among alternatives that minimize their perceived utility, *u*, given by

$$u = x_i\beta + e \qquad (1)$$

Where x_i is a row vector of attributes characterizing alternative *i*, β is a column vector of *K* associated with these attributes, and e is an error term that captures unobserved variations in utility. Suppose that there are *N* choice sets, C_n, indexed by *n=1,2,…,N*, where each choice set is characterized by a set of alternatives $C_n = \{x_{1n},\ K,\ x_{J_n n}\}$. If the errors, e, are independently and identically Gumbel distributed, then it can be shown that the probability of choosing an alternative *i* from a choice set C_n is

$$P_{in}(X_n, \beta) = \frac{e^{x_n\beta}}{\sum_{j=1}^{J_n} e^{x_{jn}\beta}} \qquad (2)$$

Where X_n is a matrix that consists of J_n row vectors, each describing the characteristics of the alternatives, x_{jn}. The vertical concatenation of the X_n matrices is called a choice design matrix *X*. The task of the analyst is to find a parameter estimate for β in Equation (2) that maximizes the likelihood given the data. Under very general conditions, the maximum likelihood estimator is consistent and asymptotically normal with covariance matrix

$$\Sigma = (Z'PZ)^{-1} = [\sum_{n=1}^{N}\sum_{j=1}^{J_m} Z'_{J_n} P_{J_n} Z_{J_n}]^{-1} \qquad (3)$$

Where $Z_{J_n} = X_{J_n} - \sum_{i=1}^{J_n} X_{in}\, P_{in}$

Equation (3) reveals some important properties of (nonlinear) choice models. In linear models centering occurs across all profiles whereas in choice models, centering occurs within choice sets. This shows that in choice designs both the profile selection and the assignment of profiles to choice sets affects the covariance matrix. Moreover, in linear models, the covariance matrix does not depend on the true parameter vector, whereas in choice models the probabilities, P_{jn} are functions of β and hence the covariance matrix. Assuming $\beta = 0$ simplifies the design problem, however, Huber and Zwerina (1996) recently demonstrated that this assumption may be costly. They showed that incorrectly assuming that $\beta = 0$ may require from 10% to 50% more respondents than those built from reasonably anticipated parameters.

The goal is choice designs is to define a group of choice sets, given anticipated β that minimizes the 'size" of the covariance matrix, Σ, defined in Equation (3). There are various summary measures of error size that can be derived from the covariance matrix (see, e.g., Raktoe, Hedayat, and Federer, 1981). Perhaps the most intuitive summary measure is the average variance around the estimated parameters of a model. This measure is referred to in the literature as A-efficiency or its inversely related counterpart,

Annexes of Chapter 4

- Results of estimation.

```
. tobit WTA AGE SEX ORIGIN EDU LOFARM FA__SIZE ONF_INC AWPES OUTCPRA BIOFERT NTFPs, ll

Tobit regression                                  Number of obs   =        384
                                                  LR chi2(11)     =      41.09
                                                  Prob > chi2     =     0.0000
Log likelihood = -3360.8678                       Pseudo R2       =     0.0061
------------------------------------------------------------------------------
         WTA |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         AGE |  -105.6413    26.3354    -4.01   0.000    -157.4258   -53.85688
         SEX |   2575.053   720.4989     3.57   0.000     1158.304    3991.802
      ORIGIN |   140.1208   696.0714     0.20   0.841    -1228.595    1508.837
         EDU |  -1058.626    425.458    -2.49   0.013    -1895.223   -222.0288
      LOFARM |  -376.5362   606.5072    -0.62   0.535    -1569.138    816.0657
    FA__SIZE |   545.8102   512.1936     1.07   0.287    -461.3388    1552.959
     ONF_INC |   19.12459   310.1529     0.06   0.951    -590.7427    628.9919
       AWPES |   1028.464   667.8845     1.54   0.124    -284.8272    2341.754
     OUTCPRA |   906.0474   608.4683     1.49   0.137    -290.4108    2102.506
     BIOFERT |   1076.195   600.7079     1.79   0.074    -105.0036    2257.393
       NTFPs |   -935.189   600.1679    -1.56   0.120    -2115.326    244.9477
       _cons |   12052.44   3931.792     3.07   0.002     4321.182     19783.7
-------------+----------------------------------------------------------------
      /sigma |   5469.276   224.8973                      5027.051    5911.502
------------------------------------------------------------------------------
  Obs. summary:         56  left-censored observations at WTA<=0
                       328     uncensored observations
                         0 right-censored observations


. summarize AGE SEX ORIGIN EDU LOFARM FA__SIZE ONF_INC AWPES OUTCPRA BIOFERT NTFPs

    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
         AGE |       384    43.15365    11.36344         18         84
         SEX |       384    .7395833    .4394345          0          1
      ORIGIN |       384    .7682292    .4225139          0          1
         EDU |       384    1.226563    .7213439          0          2
      LOFARM |       384    .6328125    .4826671          0          1
-------------+--------------------------------------------------------
    FA__SIZE |       384    2.669271    .6237204          1          3
     ONF_INC |       384    13.82231    1.097861   9.903487    16.1181
       AWPES |       384         .25    .4335776          0          1
     OUTCPRA |       384    .3411458    .4747128          0          1
```

```
     BIOFERT |       384     .421875    .4945031          0          1
-------------+---------------------------------------------------------
       NTFPs |       384    .3828125    .4867073          0          1
```

Annexes of Chapter 5

- **Annex A5.1: List of the Ramsar sites in Cameroon and total areas**

Name	**Area (ha)**
Barombi Mbo Crater Lake	415
Rio Del Rey Estuary	165,000
Camerooninan portion of River Ntem	39,848
Cameroonian part of River Sangha	6,200
Cameroonian Portion of Lake Chad	12,500
Waza Logone Floodplain	600,000
Ebogo Wetland	3097

Annex A5.2: Results of Binary Logit and CL model with Stata 13

- **A5.2.1 Binary Logit results**

```
. logit WTP BID AGE GEND EDU HHINCOME HHWTAP WATERBILL WSPROT_PAST MBERSHIP


Iteration 0:   log likelihood = -232.32865
Iteration 1:   log likelihood = -213.51865
Iteration 2:   log likelihood = -212.89951
Iteration 3:   log likelihood = -212.89767
Iteration 4:   log likelihood = -212.89767

Logistic regression                             Number of obs   =        383
                                                LR chi2(9)      =      38.86
                                                Prob > chi2     =     0.0000
Log likelihood = -212.89767                     Pseudo R2       =     0.0836

------------------------------------------------------------------------------
         WTP |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         BID |  -.0005155   .0011027    -0.47   0.640    -.0026768    .0016458
         AGE |   .0361023   .0116377     3.10   0.002     .0132929    .0589118
        GEND |  -.2200555   .2442181    -0.90   0.368    -.6987142    .2586033
         EDU |   .5239393   .1892578     2.77   0.006     .1530008    .8948777
```

```
    HHINCOME |   1.51e-06   1.16e-06     1.30   0.192    -7.61e-07    3.79e-06
      HHWTAP |   .6295449   .2677089     2.35   0.019     .1048452    1.154245
   WATERBILL |  -.0001117    .000061    -1.83   0.067    -.0002313    7.90e-06
 WSPROT_PAST |  -.0263196   .3252461    -0.08   0.936    -.6637902    .6111511
    MBERSHIP |   .8305322   .5229541     1.59   0.112     -.194439    1.855503
       _cons |  -1.819681   .7975436    -2.28   0.023    -3.382838   -.2565244
------------------------------------------------------------------------------

. summarize BID AGE GEND EDU HHINCOME HHWTAP WATERBILL WSPROT_PAST MBERSHIP


    Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
         BID |       383    349.8695    112.0664        200        500
         AGE |       383    39.48303     12.3377         18         80
        GEND |       383    .5065274    .5006114          0          1
         EDU |       383     2.62141    .6268521          1          3
    HHINCOME |       383    149678.9    113238.5       7000     600000
-------------+--------------------------------------------------------
      HHWTAP |       383    .5900783    .4924623          0          1
   WATERBILL |       383    3438.031    2163.248        100      25000
 WSPROT_PAST |       383     .232376    .4228999          0          1
    MBERSHIP |       383    .1122715    .3161132          0          1
```

Marginal effects after logit

```
      y  = Pr(WTP) (predict)
         =  .72884882
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
     BID |  -.0001019      .00022   -0.47   0.640  -.000529  .000325   349.869
     AGE |   .0071348      .00226    3.16   0.002   .002709  .011561    39.483
    GEND*|  -.0434443      .04814   -0.90   0.367  -.137794  .050905   .506527
     EDU |   .1035452      .03719    2.78   0.005   .030662  .176428   2.62141
HHINCOME |   2.99e-07      .00000    1.31   0.191  -1.5e-07  7.5e-07    149679
  HHWTAP*|   .1271485      .05476    2.32   0.020   .019818  .234479   .590078
WATERB~L |  -.0000221      .00001   -1.83   0.067  -.000046  1.5e-06   3438.03
WSPROT~T*|  -.0052182      .06469   -0.08   0.936  -.132003  .121567   .232376
MBERSHIP*|   .1388769      .07098    1.96   0.050  -.000236   .27799   .112272
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

- **A5.2.2 CL model results with Stata 13**

```
. clogit CHOICE ASC WTERQLTY FUELWOOD AIRQLTY FISH PRICE, group(ID)

note: multiple positive outcomes within groups encountered.


Iteration 0:   log likelihood = -1981.1676
Iteration 1:   log likelihood = -1978.9228
Iteration 2:   log likelihood =  -1978.917
Iteration 3:   log likelihood =  -1978.917

Conditional (fixed-effects) logistic regression   Number of obs   =       4596
                                                  LR chi2(6)      =     794.86
                                                  Prob > chi2     =     0.0000
Log likelihood =  -1978.917                       Pseudo R2       =     0.1672

------------------------------------------------------------------------------
      CHOICE |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ASC |     .03722   .1871259     0.20   0.842    -.3295399      .40398
    WTERQLTY |   .0063061   .0011714     5.38   0.000     .0040102    .0086019
    FUELWOOD |   .4952731   .0586536     8.44   0.000     .3803141    .6102321
     AIRQLTY |   .3983854   .0659107     6.04   0.000     .2692029    .5275679
        FISH |   .0144594   .0661236     0.22   0.827    -.1151406    .1440593
       PRICE |  -.0018463   .0003047    -6.06   0.000    -.0024435   -.0012492
------------------------------------------------------------------------------
```

Annex A5.2.3 for Random Parameter Logit (RPL) models estimation:

A5.2.3.1: Random Parameter Logit results with LIMDEP 9.0 NLOGIT4

```
-->NLOGIT;Lhs=CHOICE;Choices=1, 2, 3;Rhs=ASC,WTERQLTY,FUELWOOD,AIRQLTY,FISH
    ,PRICE;RPL;Fcn=PRICE(n)$
+---------------------------------------------+
| Random Parameters Logit Model               |
| Maximum Likelihood Estimates                |
| Model estimated: May 02, 2016 at 01:44:48PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1532     |
| Iterations completed                  8     |
| Log likelihood function       -1343.730     |
| Number of parameters                  7     |
| Info. Criterion: AIC =          1.76335     |
|   Finite Sample: AIC =          1.76340     |
| Info. Criterion: BIC =          1.78773     |
| Info. Criterion:HQIC =          1.77242     |
| Restricted log likelihood     -1683.074     |
| McFadden Pseudo R-squared      .2016218     |
| Chi squared                   678.6890     |
```

```
| Degrees of freedom                    7     |
| Prob[ChiSqd > value] =         .0000000     |
| R2=1-LogL/LogL*  Log-L fncn  R-sqrd  RsqAdj |
| No coefficients  -1683.0740  .20162  .19979 |
| Constants only   -1343.1357 -.00044 -.00273 |
| At start values  -1343.7517  .00002 -.00227 |
| Response data are given as ind. choice.     |
+---------------------------------------------+
+---------------------------------------------+
| Notes No coefficients=> P(i,j)=1/J(i).      |
|       Constants only => P(i,j) uses ASCs    |
|         only. N(j)/N if fixed choice set.   |
|         N(j) = total sample frequency for j |
|         N    = total sample frequency.      |
|       These 2 models are simple MNL models. |
|       R-sqrd = 1 - LogL(model)/logL(other)  |
|       RsqAdj=1-[nJ/(nJ-nparm)]*(1-R-sqrd)   |
|         nJ   = sum over i, choice set sizes |
+---------------------------------------------+

+---------------------------------------------+
| Random Parameters Logit Model               |
| Replications for simulated probs. = 500     |
| Number of obs.=  1532, skipped   0 bad obs. |
+---------------------------------------------+
+--------+-------------+----------------+--------+--------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]|
+--------+-------------+----------------+--------+--------+
---------+Random parameters in utility functions
 PRICE   |    -.00138241       .00025004    -5.529   .0000
---------+Nonrandom parameters in utility functions
 ASC     |    .157027D-12    .105125D+16       .000  1.0000
 WTERQLTY|    -.01108282       .00250950    -4.416   .0000
 FUELWOOD|     .78147864       .08755723     8.925   .0000
 AIRQLTY |     .77486985       .08509710     9.106   .0000
 FISH    |     .48760470       .10382571     4.696   .0000
---------+Derived standard deviations of parameter distributions
 NsPRICE |     .00020833       .00100898      .206   .8364
```

A5.2.3.2: Random Parameter Logit results with interaction, from LIMDEP 9.0 NLOGIT4

```
-->NLOGIT;Lhs=CHOICE;Choices=1, 2, 3;Rhs=ASC,WTERQLTY,FUELWOOD,AIRQLTY,FISH
    ,PRICE;Rh2=MALE,ED;RPL;Fcn=PRICE(n)$
```

```
+---------------------------------------------+
| Random Parameters Logit Model               |
| Maximum Likelihood Estimates                |
| Model estimated: May 02, 2016 at 01:51:47PM.|
| Dependent variable               CHOICE     |
| Weighting variable                 None     |
| Number of observations             1532     |
| Iterations completed                 12     |
| Log likelihood function       -1322.580     |
| Number of parameters                 11     |
| Info. Criterion: AIC =          1.74097     |
|   Finite Sample: AIC =          1.74108     |
| Info. Criterion: BIC =          1.77927     |
| Info. Criterion:HQIC =          1.75522     |
| Restricted log likelihood     -1683.074     |
| McFadden Pseudo R-squared      .2141880     |
| Chi squared                   720.9886     |
| Degrees of freedom                   11     |
| Prob[ChiSqd > value] =         .0000000     |
```

```
| R2=1-LogL/LogL*  Log-L fncn  R-sqrd  RsqAdj |
| No coefficients  -1683.0740  .21419  .21136 |
| Constants only   -1343.1357  .01530  .01176 |
| At start values  -1322.5825  .00000 -.00360 |
| Response data are given as ind. choice.     |
+---------------------------------------------+
+---------------------------------------------+
| Notes No coefficients=> P(i,j)=1/J(i).      |
|       Constants only => P(i,j) uses ASCs    |
|         only. N(j)/N if fixed choice set.   |
|         N(j) = total sample frequency for j |
|         N    = total sample frequency.      |
|       These 2 models are simple MNL models. |
|       R-sqrd = 1 - LogL(model)/logL(other)  |
|       RsqAdj=1-[nJ/(nJ-nparm)]*(1-R-sqrd)   |
|         nJ   = sum over i, choice set sizes |
+---------------------------------------------+

+---------------------------------------------+
| Random Parameters Logit Model               |
| Replications for simulated probs. = 500     |
| Number of obs.=  1532, skipped   0 bad obs. |
+---------------------------------------------+
+--------+-------------+----------------+--------+--------+
|Variable| Coefficient  | Standard Error |b/St.Er.|P[|Z|>z]|
+--------+-------------+----------------+--------+--------+
---------+Random parameters in utility functions
 PRICE   |    -.00163435       .00026139    -6.253   .0000
---------+Nonrandom parameters in utility functions
 ASC     |    .202408D-12    .138636D+16      .000  1.0000
 WTERQLTY|    -.00897962       .00245521    -3.657   .0003
 FUELWOOD|     .44427969       .16700346     2.660   .0078
 AIRQLTY |     .50199808       .10317048     4.866   .0000
 FISH    |     .34261479       .19121270     1.792   .0732
 1_MAL1  |     .95251168       .22738044     4.189   .0000
 1_ED1   |     .36470712       .12023889     3.033   .0024
 2_MAL2  |    1.13423391       .22899990     4.953   .0000
 2_ED2   |     .29972028       .11105952     2.699   .0070
---------+Derived standard deviations of parameter distributions
 NsPRICE |    .966604D-04      .00129563      .075   .9405
```

Annex of Questionnaires

Survey Questionnaire on the Conditions required for implementing an effective Payment for Environmental Services (PES) to sustainably manage the Lake Barombi Mbo Forest Reserve watershed in the Mount Cameroon region.

I- <u>PREAMBLE</u>

<u>Objet</u>: Good morning/Afternoon Sir/Madam. I am **Ms. Claudiane Yanick Moukam, PhD Student** at the University of Yaounde II. One of the key research priorities of the Faculty of Economics and Management is to determine **the conditions required for an effective Payment for Watershed Protection in Cameroon in general and in Lake Barombi Mbo Forest Reserve in particular.** Within the framework of this research, we will be very grateful if you can provide answers to questions in the following questionnaire. Your answers will help collect baseline information necessary for an effective payment for watershed protection that will help to ensure the sustainable management of Lake Barombi Mbo watershed, thus contributing to the improvement of the local communities' livelihoods.

Confidentiality Clause*: The information obtained from this survey keep a confidential character with respect to law N° 91/023 on the censuses and statistic surveys in Cameroon. These information cannot be used for economic repressions purpose. Thank you in advance*

II- QUESTIONNAIRE FOR DOWNSTREAM USERS

Q01 –Area name _____

Q02- Enumerator's name_____ Date |__|__||__||__|__||__|

II-1. Household Head Characteristics

Questions	Codes	Go to
Q1.1 – Age ***(In year)***	|__||__|	
Q1.2 – Sex	1- Male 2- Female |__|	
Q1.3– Marital Status	1-Married 2-Single 3-Divorced 4- Wisdower/Widow |__|	
Q1.4– Nationality of the household head	1-Cameroonian 2- Nigerian 3-Other_____ |__|	
Q1.5– Occupation	1-Small Business man/woman (Buyam Sellam) 1- Yes 2- No 2- Civil servant 1- Yes 2- No 3- Private sector employee 1- Yes 2- No 4- Farmer 1- Yes 2- No 5- Retired 1- Yes 2- No 6-Others _____	
Q.1.5.1- If farmer, where is your farm located?	1-In the reserve 2- in kumba close to the reserve 3-Others_____	
Q1.6 Family Size	|__|__|	
Q1.7– Education Level	1-Primary 2-Secondary 3-High School 4-Never been to School	|__|
Q1.8– Total household head income	|__|__|__||__|__|__|CFA	
Q1.9-Household Spending per month in CFA francs ***Put the amount or the number corresponding to the spending***	|__|__|__||__|__|__| or |__| 1- [0 30000[2- [30 000, 60 000[3- [60 000, 90 000[4-[90 000, 120 000[5- [120 000, 140 000[6- 140 000 and more	
Q1.10- Water source for household activities ***tick the source(s) to the household***	1-Tap 1-Yes |__| 2- No |__| ; 2-Stream 1-Yes |__| 2- No |__| 3-Pipe Borne 1-Yes |__| 2- No |__| ; 4-Well 1-Yes |__| 2- No Others____	

II.2. Household perceptions of Tap water quality

Q2.0- Do you have a tap in your house?	1- Yes 2- No	
Q2.1 – Do you appreciate the quality of water from the tap?	1- Yes 2- No |_	
Q2.4– How do you appreciate the risk to fall ill by using water directly from the tap?	1-Highly risky 2-Risky 3-Riskless |__|	
Q2.5- How to do obtain drinking water?	1-I drink directly from the tap 2-I boil 3-I filter |__|__| 4-I buy mineral water 5-I wait for the tap water to settle 6-I add chlorine 7-I use solar energy others_____	
Q2.5.1– How much does it cost to the household to threat water per month?	|__|__|__|__|CFA **Total water treatment cost or abatement cost of the household that will be compared to the WTP.**	
Q2.5.2- What energy source do you use to threat drinking water?	1-Firewood 2- Domestic gas 3-Charcoal |__| 4- Electricity 5- Others_____	

Q2.6– What is the average cost of your water bill per month?	|__|__||__|__|__|CFA	
Q2.7- How do you appreciate the cost of your monthly water bill?	1-High 2-Affordable 3-Cheap 4-Costless |__|	
Q2.7-Why? (Explain)	_____	
Q2.14- How do you appreciate the water availability from the tap?	1-Acceptable frequency 2-Available 3-Scarce 4- Very Scarce |__|	

II.3. Wood and fuel wood information

Q3.1 – Did you use wood these last two years for construction purpose?	1-Yes 2- No |__|	If no, go to **Q3.2**
Q3.1.1 Where did the wood come from?	1-Reserve 2-Njurky 3-Kake 4-Ekombe 5-I don't know	|__|
Q3.2– Do you use Fuel wood?	1- Yes 2- No |__|	If no, go to **Q3.3.**
Q3.2.1-Where do you collect firewood?	1- In the reserve 2- others_____	
Q3.2.1. If you buy firewood, how many Pack of 100CFA do you buy per week?	|__|__|__|Number of packs/week Cost per week |__|__|__|__|CFA Monthly cost |__|__|__|__|__|__|CFA	
Q.3.3- How much to you paid to the Council for you activities? ***(This question helps determining the payment vehicle)***	1- |__|__|__|__|__|CFA 2- None	

II.4. Household head environmental sensitivity and its perceptions about water nature and relationship between forest cover and water quality.

Q4.1 – Have you ever participate to a water source protection or to natural resource sustainable management programme?	1- Yes 2- No |__|	
Q.4.2.1- In the case the participation required financial contribution, how much have you contributed?	1-|__|__||__|__|__|CFA 2- None	
Q4.3 Are you member of an environmental association or group?	1- Yes 2- No |__|	
Q4.4– What idea do you have about "water as a resource"? ***(Please tick your choices)***	1- Water is a resource that its quality must be protected 2- Water is a resource that its quantity must be preserved 3- Water is a resource that does not need to be polluted 4- Water is a resource that should not be protected 5- Water is a resource that is abundant and illimited	
Q4.5- Perception of the relationship between forest cover and water quality	1- More forest leads to better water quality 2- More forest leads to more water quantity 3- Less forest cover leads to better water quality 4- Less forest cover leads to more water quantity 5- No relationship between forest cover and water quality 6- No relationship between forest cover and water quantity	
Q4.6-Awareness about the importance of	1-forest for fresh water provision 1-Yes 2-No 2-forest for watershed protection 1-Yes 2-No 3-forest for Biodiversity protection Y 1- Yes 2- No 4-forest for Nature/Environmental protection 1-Yes 2-No 5-forest for Climate stabilization or carbon sequestration1-yes 2-No 6-forest as cultural and spiritual sites 1-Yes 2-No	
Q4.7- Have you ever visited the Lake Barombi Mbo Forest Reserve?	1-Yes 2-No |__|	
Q4.7.1- If yes, how much did you pay?	|__|__|__|__|CFA	

Q4.8-Awareness about Payments for Environmental Services such as biodiversity protection, watershed protection, carbon sequestration and landscape beauty)	1-Yes 2-No |__| ***For instance,*** *for watershed protection, it is a compensation scheme where downstream users pay upstream users in a watershed for their efforts in regulating activities to ensure water quality and often water quantity?*	
Information on household's Willingness to Pay (WTP) for reforestation and conservation practices in the Lake Barombi Forest Reserve to benefit to a good water quality and availability, fuel wood, improvement in air quality and fish species.		
Hypothetical scenario of the Contingent Valuation*:** The review of surveys of valuation studies reveal that economic benefits of protected watersheds are rarely quantified, and that forests are an important component of watershed protection. Furthermore, studies have showed that ***the adoption of improved watershed management practices in the Forest Reserve and around the Lake increases water quality and quantity, increases fuel wood availability, fish stock, stabilizes climate through carbon sequestration. Moreover, Studies carried out in Lake Barombi Mbo Forest Reserve have noticed that about 90% of the forest reserve is destroyed and mostly the forest closed to the Lake as well as the fishes in the Lake, and that, if the current level of activities in the reserve continue, there won't be any trees to provide ***fuel wood, wood, water quality and quantity, climate stabilization, wildlife habitat for future generation as well as ecotourism in the watershed***. ***To regenerate the forest reserve, a Reforestation and Conservation Programme is foreseen by the Government. Your participation in this programme will help the Government estimate the demand for reforestation and conservation in the Lake Barombi Mbo Forest Reserve. Thus,***		
QI- If such a policy was to be implemented by **Kumba I council with the support of CAMWATER and CDE,** would you be willing to participate in this reforestation programme?	1- Yes 2- No |__|	If no, go to Q2
QI.1- If yes, would you be willing to pay |__|__|__|CFA/per month as your contribution to the programme? **The payment vehicle could be a slightly increase in water bill.**	1- Yes 2- No **The different amounts to be proposed were determined during the pilot survey. These amounts are 200, 300, 400 and 500 in monetary term and 2h, 3h, 4h, and 5h per months in labor contribution to plant trees in the reserve. Each of the amount was affected to 96 individuals in the sample.**	
QI.2-If no, would you be willing to spend |__|__|hrs/month planting trees as your contribution to the programme?	1- Yes 2- No	
Q2- Which of the following options in the choice cards below do you prefer? Please tick your choice in each card.		

II. Choice Experiment Method

Choice cards to elicit downstream WTP for improved watershed management

Card 1 **Card 2**

Which of the following improved watershed management options do you prefer? Option 1 and Option 2 would entail payment to your household. No payment would be required for option 3 (Status quo) that is "No change", but the conditions at the watershed would still continue deteriorate with drastically loss of fish species and size, deforestation until at the vicinity of the Lake which affect water quality and quantity, also air quality and fuel wood availability.

Attributes	*Watershed management Option 1*	*Watershed management Option 2*	*Status quo option Option 3*
Water quality	100 liters/day for cooking purpose 	150 liters/day for drinking purpose 	*Neither management option 1 nor management option 2: I prefer NO improved watershed management*
Fuel wood			
Air quality (CO_2 absorption)	High change in air quality	High Change in air Quality	
Fish	Increasing fish stock and diversity	Increasing fish stock 	
WTP for Improved watershed management / month	200FCFA	400FCFA	0 FCFA
Your choice (Please tick one box)	☐	☐	☐

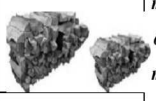
Card 3

Which of the following improved watershed management options do you prefer? Option 1 and Option 2 would entail payment to your household. No payment would be required for option 3 (Status quo) that is "No change", but the conditions at the watershed would still continue deteriorate with drastically loss of fish species and size, deforestation until at the vicinity of the Lake which affect water quality and quantity, also air quality and fuel wood availability.

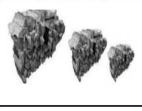
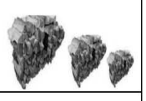
Attributes	*Watershed management Option 1*	*Watershed management Option 2*	*Status quo option Option 3*
Water quality	150 liters/day for drinking purpose 	100 liters/day for cooking purpose 	*Neither management option 1 nor management option 2: I prefer NO improved watershed management*
Fuel wood			
Air quality (CO_2 absorption)	Moderate change in air quality	Moderate Change in air Quality	
Fish	Increasing fish stock 	Increasing fish stock 	
WTP for Improved watershed management / month	200FCFA	500FCFA	0 FCFA
Your choice (Please tick one box)	☐	☐	☐

Card 4

Which of the following improved watershed management options do you prefer? Option 1 and Option 2 would entail payment to your household. No payment would be required for option 3 (Status quo) that is "No change", but the conditions at the watershed would still continue deteriorate with drastically loss of fish species and size, deforestation until at the vicinity of the Lake which affect water quality and quantity, also air quality and fuel wood availability.

Attributes	*Watershed management Option 1*	*Watershed management Option 2*	*Status quo option Option 3*
Water quality	150 liters/day for drinking purpose	150 liters/day for drinking purpose 	*Neither management option 1 nor management option 2: I prefer NO improved watershed management*
Fuel wood			
Air quality (CO_2 absorption)	High change in air quality	Moderate Change in air Quality	
Fish	Increasing fish stock and diversity	Increasing fish stock and diversity	
WTP for Improved watershed management / month	500FCFA	300FCFA	0 FCFA
Your choice (Please tick one box)	☐	☐	☐

Which of the following improved watershed management options do you prefer? Option 1 and Option 2 would entail payment to your household. No payment would be required for option 3 (Status quo) that is "No change", but the conditions at the watershed would still continue deteriorate with drastically loss of fish species and size, deforestation until at the vicinity of the Lake which affect water quality and quantity, also air quality and fuel wood availability.

Attributes	*Watershed management Option 1*	*Watershed management Option 2*	*Status quo option Option 3*
Water quality	100 liters/day for cooking purpose 	100 liters/day for cooking purpose 	*Neither management option 1 nor management option 2: I prefer NO improved watershed management*
Fuel wood			
Air quality (CO_2 absorption)	Moderate change in air quality	High Change in air Quality	
Fish	Increasing fish stock and diversity	Increasing fish stock 	
WTP for Improved watershed management / month	400FCFA	300FCFA	0 FCFA
Your choice (Please tick one box)	☐	☐	☐

Thank you for all your time spent answering our questions. Thank you so much!

Survey Questionnaire on the Conditions required for implementing an effective Payment for Environmental Services (PES) to sustainably manage the Lake Barombi Mbo Forest Reserve watershed in the Mount Cameroon Region.

III- PREAMBLE

Objet: Good morning/Afternoon Sir/Madam. I am **Ms Claudiane Yanick Moukam, PhD Student** at the University of Yaounde II. One of the key research priorities of the Faculty of Economics and Management, is to determine **the conditions required for an effective Payment for Watershed Protection in Cameroon in general and in Lake Barombi Mbo Forest Reserve in particular.** Within the framework of this research, we will be very grateful if you can provide answers to questions in the following questionnaire. Your answers will help collect baseline information necessary for an effective payment for watershed protection that will help to ensure the sustainable management of Lake Barombi Mbo Forest Reserve watershed, thus contributing to the improvement of the local communities' livelihoods.

Confidentiality Clause*: The information obtained from this survey keep a confidential character with respect to law N° 91/023 on the censuses and statistic surveys in Cameroon. This information cannot be used for economic repressions purpose. Thank you in advance.*

IV- QUESTIONNAIRE FOR UPSTREAM USERS

Q01- Village Name _____ |__|

Date |__|__||__||__|__||__|

Q02- Respondent's Name_____

II-1. Farmer's Characteristics and Perceptions

Questions	Codes	Go to
Q1.1 – Age (***in years)***	|__||__|	
Q1.2 – Sex	1-Male |__| 2- Female |__|	
Q1.3– Marital Status	1-Married 2- Single 3-Divorced 4-Wisdower/Widow	|__|
Q1.4– Status of the farmer in the village	1- Native 2- Non-Native |__|	
Q1.4.1- Number of years of residency	|__||__|	
Q1.5– Occupation	Agriculture 1- yes |__| 2- No |__| Fishing 1- yes |__| 2- No |__| Timber exploter 1- yes |__| 2- No |__| Non-Timber Forest Products (NTFPs) Collector 1- yes |__| 2- No |__| Hunting 1-Yes 2-No Other__	
Q1.6 Family Size	|__|__|	
Q1.7– Education Level	1-Primary 2- Secondary 3- High School |__| 4-Never been to school	
Q1.8- Farmer Spending per month in CFA francs ***Put the amount or the number corresponding to the spending***	|__|__|__||__|__|__| or |__| 2- [0 20000[3- [20 000, 40 000[4- [40 000, 60 000[5- [60 000, 80 000[6- [80 000, 100 000[**7-** 100 000 and more	
Q1.9- Livestock units own	Goat: 1-Yes |__| 2- No |__| Pig 1-Yes 2-No Chicken 1-Yes |__| 2- No |__| Sheep 1-Yes 2-No Others_____	
Q1.10- Type of house own	1-Traditional house (mud) |__| 2- Modern house (made with block/plank)	
Q1.11- Drinking water source to the household	Tap 1-Yes |__| 2- No |__| Stream 1-Yes |__| 2- No |__| Lake 1-Yes |__| 2- No |__| Pipe Borne 1-Yes |__| 2- No |__| Others____	
Q1.12- Perception of the relationship between forest cover and water quality	1-More forest leads to better water quality 2-More forest leads to more water quantity 3-Less forest cover leads to better water quality	

Please tick your choices	4-Less forest cover leads to more water quantity 5-No relationship between forest cover and water quality 6-No relationship between forest cover and water quantity	
Q1.13. Awareness about the importance of forest for:	1- Watershed protection Yes/No 2- Biodiversity conservation Yes/No 3- Nature/Environmental protection Yes/No 5-Climate regulation or Carbon sequestration Yes/No 6-cultural and spiritual site Yes/No	
Q1.14- Awareness about Payments for Environmental Services such as biodiversity protection, watershed protection, carbon sequestration and landscape beauty.	1-Yes 2-No	

II.2. Farm Characteristics. (Necessary to understand the types and levels of activities carried out by farmer in the Reserve and Lake, and the access modalities)

Q2.1- Do you have farm in the Village?	1-Yes 2- No |__|	
Q2.1.1- How did you obtain it?	1- Inheritance 2- Rent 3- Buy |__| 4- Donation 5- Others	
Q2.2- Location of the farm ***Closed to the lake can be understood as 3m, 5m or 8m from the Lake border/***	1-In the Reserve closed to lake 2-In the Reserve |__| 3- Out of the Reserve 4- In and out of the reserve	
Q2.2.1- If in the reserve, were you aware it is forbidden to do farming in the reserve?	1- Yes 2- No |__|	
Q2.2-2- Size of the farm	A-]0-1]ha B-]1-2]ha C-]2-5] ha |__| D-]5-10]ha E-More than 10ha	
Q2.3– Types of Crops most cultivated	1-Food crops 2-Cash Crops 3-Foods and Cash Crops	|__|
Q2.3.1- which ones?	1-Cocoa 2- Palm oil 3- Rubber 4-Others_____ |__|	
Q2.4- What system of production do you use?	1-Mix cropping 2-Mono Cropping |__| 3-Shifting cropping	
Q2.5– In which markets do you sell your agricultural products?	1-Village market 2-Kumba market |__| 3-Village and Kumba markets 4-Others _____	
Q.2.6- Average yearly on farm Income	Food crops |__|__|__|__|__|__|__| CFA Cash Crops|__|__|__|__|__|__|__| CFA Total: |__|__|__||__|__|__|	
Environmental practices in the farm or Traditional farm management practices and knowledge on technology adoption		
Q2.7- Are you using chemicals?	1- Yes 2- No |__|	If 2, go to **Q2.8**
Q2.7.1- Which one?	A-Fungicides B-Herbicides C-Insecticides |__| D-At least one of them E- Others_____	
Q2.7.2. How much did they cost per crops season?	|__|__|__||__|__|__|CFA	
Q2.8- What techniques do you use for soil preparation before sowing?	1-Slash and burn 2-Rotation 3-Others_____ |__|	
Q2.9–Do you practice bush fallow?	1-Yes 2-No |__|	If 2, go to **Q2.10**
Q2.9.1- For how long do you practice bush fallow?	a-1 year b- 2years c-3years d-More than 3years |__|	
Q2.10- How do you judge the outputs of your crops produced with the practices you use? **(*soil fertility)***	1-Very Good 2- Good 3- Average 4- Bad |__|	
Conservation Modality		
Q2.11-Do you still have big old trees in your farm?	1- Yes 2- No |__|	If 2 go to **Q2.13**
Q2.12- Which types of trees do you still have in the farm?	1-Timber 2- NTFPs 3-Fruit trees 4-Wood |__| 5- Fuel wood 6- Others_____	
Reforestation modality		

Q2.13- Do you plant trees in your farm?	1- Yes 2- No	
Q2.13.1-Which types of trees do you plant in your farm?	1-Timber 2- NTFPs 3-Fruit trees 4-Wood 5- Fuel wood 6- Others_____ |__|	
Q2.13.2- Number of trees planted per year?	|__|__|__|trees	
Q2.13.3- Frequency of trees planting	1-Every year 2- After 2 years 3-Other_____ |__|	
Q2.14.4-Do you hire people to plant trees in your farm?	1-Yes 2-No	
Q2.14.5- Number of hours spent planting trees in your farm	|__|__|hrs	
Q2.14.6- Where do you obtain your seedlings?	1-From your nursery 2- Donation 3-Buy 4-Others_ |__|	
Q2.15- Is there any reforestation Programme in the reserve?	1- Yes 2- No |__|	
Q2.16- Which percentages of forest in the reserve do you think is destroyed?	1- 90% 2- 80% 3- 75% 4- 50% |__|	
Timber exploitation, Fuel wood and Non Timber Forest Products collection activities in the reserve		
Q3.1. Do you exploit timber in the reserve?	1- Yes 2- No |__|	If no, go to **Q.3.2**
Q3.1.1- What are the more exploited species?	1-Mahogany 2- Iroko 3-Sapelli 4-Bosinga 5-Other	
Q3.1.2- Where do you obtain the exploitation title?	_____	
Q3.1.3- How much do you gain in exploiting timber?	|__||__||__||__||__||__||__|CFA	
Q3.2- Where do you collect fuel wood?	1-In the reserve 2-Out of the reserve 3-In and out of the reserve |__|	If2, go to **Q3.3**
Q3.2.1- Do you sell fuel wood collected?	1- Yes 2- No |__|	If2, go to **Q3.3**
Q.3.2.2- Where do you sell them?	1-Village 2-Kumba market 3-Village and Kumba markets 4- Others _____ |__|	
Q3.2.3- How much do you gain selling fuel wood?	|__|__|__|__||__|__|CFA	
Q3.3- Do you collect NTFPs in the reserve?	1- Yes 2-No |__|	If2, go to **Q4**
Q3.3.1- Where do you sell them?	1-Village market 2-Kumba 3-Village and Kumba markets 4- Others _____ |__|	
Q3.3.2- How much in average do you gain selling them?	|__|__|__|__|__|__|CFA	
Agroforestry information		
Q4- Have you ever hear about AGROFORESTRY or BIOAGRICULTURE? ***Agroforestry technology combines trees and forages with livestock operation, and provides environmental benefits such as water quality improvement, soil conservation, carbon sequestration, wildlife habitat protection, and aesthetic value.***	1- Yes 2- No |__|	
Q4.1.1- How did you hear about Agro-forestry?	Explain_____ _____	
Q4.1.2- Do you ever hear about BIOFERTILIZERS?	1-Yes 2- No |__|	(if no, go to **QII)**
Information on farmer's Willingness to Accept (WTA) compensation for reforestation and agro-forestry practices		
Hypothetical scenarios of the Contingent Valuation: Studies carried out in Barombi Mbo forest reserve have noticed that about 90% of the forest reserve is destroyed and mostly the forest closed to the Lake and that, if the current level of activities in the reserve continue, there won't be any trees to provide *fuel wood, wood, climate stabilization, wildlife habitat, water quality and quantity for future generation as well as for ecotourism in the watershed*. To regenerate the forest reserve, a ***Reforestation Programme is foreseen by the Governmen*t**. Your participation in this Programme will help the Government estimate the *Reforestation Cost*. Thus,		
QII- ***Would you be willing to participate in this trees planting Programme in the reserve and at the border of the lake or in any other programme?***	1- Yes 2- No |__|	If 2, go to **QII.3**
QII.2. How many trees will you be willing to plant and control per year?	|__|__|__|trees	

QII.2.1. ***Would you be willing to receive*** **|__|__|__|__|__|*per year for your participation in the reforestation programme?***	1- Yes 2- No |__| **From the pilot survey, we retained two amount 10000 CFA and 15000, of which each will be affected to 50% of individual after printing out the questionnaires**	If no, go to **QII.2.1**
QII.2.2- Would you be willing to just receive seedlings and training to participate to the programme?	1-Yes 2- No |__|	
QII.3- ***Would you stop using chemical from at least 8 meters of the lake border for consecutive 10 years if you receive seedlings of agro-forestry species and training?*** **(Agroforestry practices: associate reduction in chemical use with fruit trees planting)**	1- Yes 2- No |__|	

II. 3. Fishing activities in the Lake

Q5.1-Do you fish in the Lake?	1- Yes 2- No |__|	If no, go to **QIV**
Q5.1.1- Which periods do you fish in year?	1-Every season 2-only dry season	
Q5.1.2- How many days do you fish per week?	1-Everyday 2-Sometimes	
Q5.1.3. Which fishing tools do you use?	1-Basket traps 2- Hooks 3- Gill nets |__| 4-Others___	
Q5.1.4.What is the size of the Gill nets?	|__|__|__|__|Meters	
Q5.1.5-Where do you buy them?	1-Locally made 2-Village market 3-Kumba market Other__	|__|
Q5.1.6- Which fish species do you find rare in the lake? ***(Local names and commercial names)***	_____	
Q5.1.7- Where do you sell them?	1-Village market 2-Kumba market 3-Village and Kumba markets 4-Others_____ |__|	
Q5.1.8- What is the nature of your customers?	1-Retailers 2-Others_____ |__|	
Q5.1.9- How much do you gain in fishing activities per month?	|__[__|__|__|__|__|CFA/per month	
Q5.2- Have you ever heard about fish breeding?	1- Yes 2- No	

Information on Willingness to Accept (WTA) compensation for conservation practices

Hypothetical Scenario of the Contingent Valuation: The International Union of Conservation of the Nature has noted that most of the endemic fish species in the Lake such as *cichlid Stomatepia mongo* are critically in danger and that if the current level of fishing activities continue, there won't be available fish for future generation in the Lake as well as not opportunity for visitors and scientists coming for research. To save these endemic fish species, a *Conservation Programme is foreseen by the Governme*nt. Your participation in this Programme will help the Govenrment estimate the *conservation cost*. Thus,

Q4.2. ***Would you be willing to participate in this sustainable fishing programme?***	1- Yes 2-No |__|	If no,go to **Q.1**
Q4.2.1-Would you be willing to receive fishing tools recommended *(gill nets types and size*) **for sustainable fishing activities?**	1- Yes 2-No |__|	
Q4.2.2- Would you be willing to participate to a reforestation programme protecting the Lake Border and saving fishes?	1- Yes 2-No |__|	

Q.1- According to the reforestation, conservation activities in the reserve and the lake, would *you be willing to participate in a sustainable integrated watershed management practices so as it benefits to future generation if you receive*\|__\|__\|__\|__\|\|__\| *per year? 1-Yes 2- No* \|__\|

If No, why? _____

Thank you for all your time spent answering our questions. Thank you so much!

End notes

[i]An estimated rate of 0.48% per year. Also, a forest monitoring realized over a period of ten years (1990 - 2010) in an forest area of 50 hectare in Mount Cameroon watershed for individuals size reaching at least 10 cm indicates that the forest is declining (Chuyong et al. unpub. datacit.MINEPDED, 2013). Moreover, between 1990 and 2000, the country lost an average of 220,000 ha of forest per year, amounting to an average annual deforestation rate of 0.90%. Between 2000 and 2005, the rate of forest change increased to 0.98% per annum. In total, between 1990 and 2005, Cameroon lost 13.3% of its forest cover (or around 3.3million ha); and measuring the total rate of habitat conversion for the 1990-2005 interval, the country lost 8.4% of its forest and woodland habitat. In Cameroon, agriculture is allegedly responsible for the lion's share of deforestation, and this agriculture's share is commonly cited as 90%.
http://rainforests.mongabay.com/deforestation/archive/Cameroon.htm

[ii] In 1798, Thomas Robert Malthus in his book, *An Essay on the Principle of Population* set the tone for the current debate about the sustainability of the economic growth. Malthus reasoned that there is a tendency for population to increase at a geometric rate, whereas its subsistence (food production) increase at an arithmetic rate. Thus, Malthus emphasizes an eventual steady state for the economy with a growing population. For Malthus, a fixed land quantity and an assumed tendency for continual positive population growth, and diminishing returns in agriculture implies a tendency for output per capita to fall over time.
In 1820, David Ricardo formalized and extended this notion of steady state by including the concept of *diminishing marginal productivity*, particularly in his *Principles of Political Economy and Taxation.* Malthus's assumption of a fixed stock of land was replaced by a conception in which land was available in parcels of varying quality. Agricultural output could be expanded by increasing the intensive margin (i.e. exploiting a given parcel of land more intensively) or by increasing the extensive margin (i.e. bringing previously uncultivated land into productive use). In other words, that is, as population increased, people would be forced to not only cultivate existing land more intensively but also extend production into inferior land. However, in either case, returns to the land input were taken to be diminishing. Economic development then proceeds in such a way that the economic surplus is appropriated increasingly in the form of rent, the return to land, and development again converges toward a Malthusian stationary state. Nevertheless, the Ricardian view was more optimist in terms of allowing for mitigation of the Malthusian fate through technological advancement.
In 1857, John Stuart Mill's work utilizes the idea of diminishing returns, but recognizes the countervailing influence of the growth of knowledge and technical progress in agriculture and in production more generally. Writing in Britain when output per person was apparently rising, not falling, he placed less emphasis on diminishing returns, reflecting the relaxation of the constraints of the extensive margin as colonial exploitation opened up new tranches of land, as fossil fuels were increasingly exploited, and as innovation rapidly increased agricultural productivity. The concept of a steady state was not abandoned, but it was thought to be one in which a relatively high level of material prosperity would be attained.

[iii] Simon (1981) took an extremely optimistic view of population growth in contrary to Malthus. According to Simon, population growth is a positive thing because the larger the world's population the more minds there would be and therefore the greater would be the growth of knowledge. This expansion in knowledge would overcome the resource constraint to population growth. Other optimists used the power of technology as a basis for their assessments.

[iv] Since public funds are insufficient to ensure the continued growth of forest cover, FONAFIFO has tried to find new financing sources to compensate forest owners for their efforts and secure the benefit for all of us. This gave rise to the idea of the Environmental Services Certificate (ESC), a financial instrument that preserves the existing forests and regenerates new ecosystems and guarantees environmental services to an increasing population. Both individuals and companies may invest in ***Environmental Services Certificate*** for the protection of one or more regions determined according to their interests. The amount to be invested will depend on the number of hectares he/she/it is willing to protect. The minimum area to invest for an ESC is one hectare. In 2010, the average value of ESC per hectare is $57 per year and contracts are made for five-year terms. FONAFIFO has developed a second new way to raise economic resources from the private sector, institutions and friendly governments to protect and reforest the land, mainly in watersheds where important water resources are generated for human consumption and hydroelectric energy production, as well as for the protection of regions wherein large variety of biodiversity is present. Such instruments consist of entering into ***agreements;*** through these agreements, the private sector, institutions, or Governments contribute certain amounts of money, complemented by funds from FONAFIFO's programs, in order to execute the Environmental Services Payments under ESP in a particular region. FONAFIFO has subscribed agreements with local, national, international, public and private entities to generate funds for the fulfillment of its objectives

[v] According to IUCN, in the 1990s, Environmental Funds (EFs) have emerged as promising long-term mechanisms for providing financial support to biodiversity conservation and sustainable development activities. Environmental Funds vary greatly in terms of their funding, governance, structure, purpose and funding priorities. They operate at the local, national and sometimes, regional level. Yet, there are some common threads, both in terms of lessons learned and features contributing to success. For instance, the most successful funds tend to operate like independent foundations, investing their assets and using the interest to fund programs. They tend to be governed by mixed public-private sector boards, often with NGOs as "majority stakeholders", helping manage the capital, invest the funds, and determine which projects will receive funding. Clearly environmental funds can provide a useful and sustainable source of funds for biodiversity conservation. But beyond

the money, the funds can also help build a culture of philanthropy in the countries concerned and serve as increasingly important actors in national policy arenas.