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Economía de los Recursos Naturales y Desarrollo Sustentable

"PAYMENTS FOR ENVIRONMENTAL SERVICES – REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION (PES-REDD) IN MEXICO: A STRATEGY TO GUARANTEE THE PERMANENCE OF FOREST CARBON STOCKS?"

T E S I S

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Abbreviations

A/R .... Afforestation / Reforestation
AD .... Avoided Deforestation
ADDATE .... *Acta de Delimitación, Destino y Asignación de Tierras Ejidales*
AFOLU .... Agriculture, Forestry and Other Land Use
AGEB .... *Área Geo-Estadística de Base*
AICA .... *Área de Importancia para la Conservación de Aves*
ANP .... *Áreas Naturales Protegidas*
ASERCA .... *Apoyo y Servicios a la Comercialización Agropecuario*
BAU .... Business as Usual
CA .... Conjoint Analysis
CAR .... Climate Action Reserve
CDM .... Clean Development Mechanism
CENAPRED ..... *Centro Nacional de Prevención de Desastres*
CER .... Certified Emission Reduction
CICC .... *Comisión Intersecretarial de Cambio Climático*
CIDRS .... *Comisión Intersecretarial para el Desarrollo Rural Sustentable*
CO_2 .... Carbon Dioxide
CO_2-e .... Carbon Dioxide equivalent
CONAFOR ...... *Comisión Nacional Forestal*
CONAGUA ...... *Comisión Nacional de Agua*
CONANP .... *Comisión Nacional de Áreas Naturales Protegidas*
CONAPO .... *Consejo Nacional de Población*
CONEVAL .... *Consejo Nacional de Evaluación de la Política de Desarrollo Social*
COP .... Conference of the Parties
CORENA .... *Comisión de Recursos Naturales*
CTCREDD+ ..... *Comité Técnico Consultivo para REDD+*
DAF .... Development Adjustment Factor
DFID .... Departement for International Development
DNA .... Designated National Authority
DOE .... Designated Operational Entity
DOF .... *Diario Oficial de la Federación*
DRF .... Dose-Response Function
EB .... Executive Board
ENAREDD+ ..... *Estrategia Nacional REDD+*
ENCC .... *Estrategia Nacional de Cambio Climático*
ER .... Emission Reduction
ES .... Environmental Service
ETS .... Emission Trading Scheme
FANAR .... *Fondo de Apoyo para Núcleos Agrarios sin Regularizar*
FAO .... Food and Agriculture Organization of the United Nations
FCPF .... Forest Carbon Partnership Facility
FIP .... Forest Investment Program
FRA .... global Forest Resources Assessment
GCC .... Global Climate Change
GDP .... Gross Domestic Product
GEF .... Global Environment Facility
GHG .... Greenhouse Gas
GTREDD+ ...... *Grupo de Trabajo para REDD+*
HFLD .... High Forestcover Low Deforestation

IETA	*International Emissions Trading Association*
IGO	*Intergovernmental Organization*
IIEc	*Instituto de Investigaciones Económicas*
INE	*Instituto Nacional de Ecología*
INEGI	*Instituto Nacional Estadístico, Geografía e Información*
INFyS	*Inventario Nacional Forestal y de Suelos*
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
KMO	Kaiser-Meyer-Olkin
LADF	*Ley Ambiental del Distrito Federal*
LDUDF	*Ley de Desarrollo Urbano del Distrito Federal*
LGA	*Ley General Agraria*
LGDFS	*Ley General de Desarrollo Forestal Sustentable*
LGEEPA	*Ley General del Equilibrio Ecológico y la Protección al Ambiente*
LGVS	*Ley General de la Vida Silvestre*
LUC	Land-Use Change
LULUCF	Land Use, Land-Use Change and Forestry
MAoMV	Metropolitan Area of Mexico Valley
MDG	Millennium Development Goal
MRV	Monitoring/Measurement, Reporting/Registration and Verification
MRW	Magdalena River Watershed
MXN	Mexican Peso
NAFTA	North American Free Trade Agreement
NGO	Non-Governmental Organization
NTFP	Non-Timber Forest Products
ODA	Oficial Development Assistance
OECD	Organisation for Economic Co-operation and Development
PA	Protected Area
PCA	Principal Component Analysis
PCM	Pre-compliance Carbon Market
PEC	*Programa Especial Concurrente para el Desarrollo Rural Sustentable*
PECC	*Programa Especial de Cambio Climático*
PEF	*Programa Estratégico Forestal*
PES	Payment for Environmental Services
PGOEDF	*Programa General de Ordenamiento Ecológico del Distrito Federal*
PICONAFOR	*Programa Institucional de la CONAFOR*
PND	*Plan Nacional de Desarrollo*
PNMARN	*Programa Nacional de Medio Ambiente y Recursos Naturales*
ppm	Parts per million
PROCEDE	*Programa de Certificación de Derechos Ejidales y Titulación de Solares Urbanos*
PROCYMAF	*Proyecto de Conservación y Manejo Sustentable de los Recursos Forestales*
PRODEFOR	*Programa para el Desarrollo Forestal*
PRODEPLAN	*Programa para el Desarrollo de Plantaciones Forestales Comerciales*
PROFEPA	*Procuraduría Federal de Protección al Ambiente*
PRONARE	*Programa Nacional de Reforestación*
PSA	*Programa de Servicios Ambientales*
PSA-CABSA	*Programa para Desarrollar el Mercado de Servicios Ambientales por Captura de Carbono y los Derivados de la Biodiversidad y para Fomentar el Establecimiento y Mejoramiento de Sistemas Agroforestales*
PSAH	*Pagos por Servicios Ambientales Hidrológicos*
PSMARN	*Programa Sectorial de Medio Ambiente y Recursos Naturales*
RAMSAR	Convention on Wetlands of International Importance

RAN .... *Registro Agrario Nacional*
RED .... Reducing Emissions from Deforestation
REDD .... Reducing Emissions from Deforestation and Degradation
REDD+ .... Reducing Emissions from Deforestation and Degradation - plus
RHP .... *Regiones Hidrológicas Prioritarias*
RIR .... Relative Interquartile Range
RIR-V .... Variation of the Relative Interquartile Range
RPA .... *Reservas Potencial de Agua*
RTP .... *Regiones Terrestres Prioritaras*
SAGARPA .... *Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación de México*
SBSTA .... Subsidiary Body for Scientific and Technical Advice
SC .... *Suelo de Conservación*
SCT .... *Secretaría de Comunicación y Transportes*
SE .... *Secretaría de Economía*
SEDESOL .... *Secretaría de Desarrollo Social*
SEGOB .... *Secretaría de Gobernación*
SEMARNAT ..... *Secretaría del Medio Ambiente y Recursos Naturales*
SENER .... *Secretaría de Energía*
SEP .... *Secretaría de Educación Pública*
SFM .... Sustainable Forest Management
SHCP .... *Secretaría de Hacienda y Crédito Público*
SLA .... Sustainable Livelihood Approach
SMA .... *Secretaría del Medio Ambiente*
SNIF .... *Sistema Nacional de Información Forestal*
SRA .... *Secretaría de la Reforma Agraria*
SRE .... *Secretaría de Relaciones Exteriores*
SSA .... *Secretaría de Salud*
UMA .... *Unidad de Manejo y Aprovechamiento de Vida Silvestre*
UNAM .... *Universidad Nacional Autónoma de México*
UNFCCC .... United Nations Framework Convention on Climate Change
USD .... US Dollar
VCM .... Voluntary Carbon Market
VCS .... Verified Carbon Standard
VIF .... Variance Inflation Factor
VREDD+ .... *Visión de México sobre REDD+*
WCI .... Western Climate Initiative
WTA .... Willingness to Accept
WTP .... Willingness to Pay
ZPF .... *Zona Protectora Forestal*

Summary

A particular issue within global climate change mitigation strategies in the agriculture, forestry and other land use sector is the permanence of created climate benefits linked to local costs. The related policy challenge is to address these global externalities and align them with local incentives. Accordingly, this research elaborates on the policy instrument Payment for Environmental Services (PES) which may be used for Reducing Emissions from Deforestation and Degradation (REDD) to mitigate concerns of permanence. It analyzes the Mexican context of common property regimes and its influence on policy design and land-use decisions. It investigates how PES contracts may ensure permanence of emission reductions over predetermined periods of time, while maintaining necessary flexibility in dealing with changing conditions.

This dissertation is divided into two main sections. The first includes an overview of the generic components in a PES-REDD design and links them to the Mexican context. The second part reviews the application of a PES-REDD approach in the case of two communities located in the periphery of Mexico City. The underlying assumptions of this analysis is that the success of PES-REDD contracts depends on the level of asymmetric information (adverse selection and moral hazard), which is co-determined by the characteristics of the livelihoods implementing mitigation strategies on-the-ground. Therefore, the current practice of the Mexican PES program, the opinion of policy designers on critical PES-REDD design issues, and the communities' choice of land-use alternatives is analyzed in three subsequent steps.

Current PES practices are analyzed using an index assessment of livelihood dimensions in two communities, which reveal that only a limited number of community members actually recognize their active involvement in PES. This implies that the condition of voluntary and conditional participation is most likely flawed in the case of common property. It is suggested that the livelihood's capital endowment significantly influences recognized PES participation.

The Policy Delphi with experts shows that the issue of permanence in the REDD discussion is still relevant and controversial. However, this analysis suggests that the tradeoff between strict commitments ex ante and flexibility ex post can partially be achieved through limiting the responsibility of ES providers for forest carbon stocks to relatively shorter contract periods and applying a retirement solution so as to balance avoidable and unavoidable reversals.

The econometric analysis of choice-experimental data collected in two communities denotes that individuals grouped in the common property regime cannot easily agree ex ante and ensure compliance ex post of a PES contract. This is due to the heterogeneity of livelihoods within a community and the effects of external conditions such as attributes of alternatives. Therefore, case-specific and alternative-specific variables influence land-use decision-making.

Key words: Payment for environmental services; Reducing emissions from deforestation and degradation; Adverse selection; Moral hazard; Common property; Peri-urban context

Resumen

Un tema particular de las estrategias de mitigación del cambio climático global en el sector de la agricultura, la silvicultura y el uso del suelo es la permanencia de los beneficios climáticos creados. El desafío es hacer frente a estas externalidades globales y alinearlas con los incentivos a nivel local. Por consiguiente, esta investigación profundiza en el PSA-REDD para mitigar la preocupación sobre la permanencia. Este estudio analiza el contexto mexicano de los regímenes de propiedad comunal y su influencia en el diseño de políticas y decisiones sobre el uso del suelo. Se investiga cómo un contrato de PSA podría asegurar la permanencia de las reducciones de emisiones durante períodos predeterminados, manteniendo al mismo tiempo la flexibilidad necesaria para hacer frente a las condiciones cambiantes.

Esta tesis se divide en dos partes principales. En la primera, se proporciona una visión general acerca de los componentes principales en el diseño de PSA-REDD y cómo se vincula al contexto mexicano. En la segunda parte se estudian las implicaciones de un enfoque PSA-REDD en el caso de dos comunidades ubicadas en la periferia de la Ciudad de México. Este análisis se guía por la presunción de que el éxito de un contrato PSA-REDD depende del nivel de información asimétrica (selección adversa y riesgo moral), que está co-determinada por las características de los medios de vida que implementan actividades de mitigación a nivel local. Por lo tanto, se analiza en tres etapas subsiguientes la práctica actual en el programa PSA mexicano, la opinión de expertos hacia el diseño de PSA-REDD y las elecciones de las comunidades frente a alternativas de uso del suelo.

El análisis del programa PSA mexicano por índices que reflejan dimensiones de los medios de vida en dos comunidades revela que no todos los miembros de la comunidad en realidad reconocen su participación activa en el PSA. Esto indica que la condición de la participación voluntaria y condicional esté probablemente defectuosa en los casos de propiedad comunal.

El *Policy Delphi* con expertos muestra que el tema de la permanencia en el debate REDD sigue vivo y polémico. Sin embargo, el análisis sugiere que el equilibrio entre los compromisos estrictos ex ante y flexibilidad ex post se puede lograr parcialmente mediante la limitación de la responsabilidad de las communidades por contratos de períodos relativamente cortos y aplicar un *buffer pool* para reversiones evitable e inevitable.

El análisis econométrico de datos experimentales recolectados en dos comunidades indica que los individuos agrupados en régimenes de propiedad comunal no pueden lograr fácil un acuerdo ex ante y asegurar el cumplimiento de un contrato de PSA ex post. La razón es la heterogeneidad de los medios de vida dentro de una comunidad y los efectos de las condiciones externas tales como atributos de las alternativas.

Palabras claves: Pagos por servicios ambientales; Reducción de emisiones por deforestación y degradación; Selección adversa; Riesgo moral; Propiedad comunal; Contexto peri-urbano

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1. Introduction

Humanity is currently facing one of its greatest challenges - the threat of Global Climate Change (GCC). Climate change is any long-term significant change in the expected patterns of average weather in a specific region over an appropriately significant period of time (IPCC, 2007). In contemporary usage, especially in the context of environmental policy, climate change usually refers to changes in the Earth's current climate and is attributed to anthropogenic factors. Anthropogenic factors are known as human activities that change the environment (Millennium Ecosystem Assessment, 2005; Stern, 2006). In some cases, the chain of causality of human-induced climate change is direct and unambiguous, while in other instances it is less clear. Generally, the scientific debate has moved on from skepticism to a scientific consensus on GCC that human activity is the probable cause for the rapid changes in world climate in the past several decades (IPCC, 2007; Stern, 2006). Hence, the focus is now on options to mitigate further human impact and to adapt to change which has already occurred.

The interaction within and among terrestrial ecosystems depends on a number of biochemical cycles. Particularly, the carbon, nutrient, and hydrological cycles may be modified by human activity (IPCC, 2000). The anthropogenic factor of most concern is the increase in levels of Carbon Dioxide (CO_2), which is a major Greenhouse Gas (GHG) contributing to global warming. Globally, CO_2 makes up of 55 percent of total GHGs emitted from the Earth's surface to the atmosphere (IPCC, 2001). According to the Intergovernmental Panel on Climate Change (IPCC, 2001), its concentration in the pre-industrial era was 280 $\pm$ 10 parts per million (ppm) and has gradually increased to 367 ppm by 1999. The principal cause of the CO_2 concentration growth is attributable to fossil fuel combustion (Kondratyev et al., 2003; Stern, 2006). It is argued that the consequences of increased GHG emissions include the increase of global temperature by 0.2 to 0.5 °C per decade, raising the sea-level by about 30 cm until 2050, and about 80 cm until 2100 (IPCC, 2001). The increase of mean global surface temperature will affect the global climate and, in consequence, harm the environment, economy and society (Millennium Ecosystem Assessment, 2005). These global trends are severe and probably threaten foremost the world's impoverished peoples, who are often exposed to a highly vulnerable environmental context.

However, fossil fuel combustion is not the only contributor to increased atmospheric GHG concentrations. Land-use change (LUC) is the second largest contributor to CO_2 emissions, with about 32 percent occurring since 1750, and approximately 60 percent of which has happened since 1959 (Stern, 2006). The Millennium Ecosystem Assessment (2005) assumes that more land was converted to cropland in the 30 years following 1950 than between the 150 year-span from 1700 to 1850. Areas of rapid change in forest cover and degradation were located in the tropical belt (Millennium Ecosystem Assessment, 2005; Steinfeld et al., 2006). Thus, the

Agriculture, Forestry and Other Land Use (AFOLU) sector has become a concern for climate policy-makers and a focus of research in order to mitigate GCC.

The same global trends observed in forest cover loss and forest degradation hold true for Mexico. CONABIO (2006) estimates that in Mexico the vegetation cover is around 141 million hectares, with about 66 million corresponding to forests. Mexico is loosing this forest resource due to high rates of deforestation triggered by LUC for agricultural and cattle grazing activities, in addition to forest fires and illegal logging (CICC, 2009). It is estimated that the rate of deforestation in Mexico reached approximately 800 thousand hectares per year between 1970 and 1990 (CONABIO, 2006). For the subsequent decade, the Secretary of the Environment and Natural Resources (SEMARNAT, for its Spanish acronym) estimates a deforestation rate of 348 thousand hectares per year (CONABIO, 2006). CONABIO (2006) projects that slash-and-burn agriculture is causing almost 48 percent of the country's forest fires. In Mexico, the tropical forest areas have suffered the most from anthropogenic transformation (CONABIO, 2006), while the forest sector is found responsible for eight percent of CO_2 emissions nationwide (CICC, 2009). Thus, it is evident that Mexico's AFOLU sector is a large factor in the increase of atmospheric CO_2 concentrations.

The degradation of Environmental or Ecosystem Services (ES) is often caused by activities which produce other (often marketable) goods or services. Ecosystem interventions (e.g., timber exploitation) may have hazardous consequences (e.g., soil erosion) although the nature of this impact depends on the characteristics of the local ecosystem (e.g., slope versus flat terrain) and the type of change (e.g., clear-cut versus selective logging). However, the total cost of the loss and degradation of these ESs are difficult to measure (Constanza et al., 1997). Available evidence indicates that they are substantial, and that their negative consequences for human well-being are growing (Braat et al., 2008; European Communities, 2008; Hughes et al., 2003; Millennium Ecosystem Assessment, 2005; Worm et al., 2006). A monetary estimate of the environmental degradation in the Mexican context between 1996 and 2003 (including natural disasters) represent an average annual cost of 10.36 percent of the Gross Domestic Product (GDP) (CONABIO, 2006). This figure contributes to the perception that immediate action in terms of adaptation and mitigation is needed.

The process of slowing down human-induced ecosystem damage is hindered by the fact that most resource management decisions are strongly influenced by ESs, such as agricultural products from slash-and-burn agriculture entering the market, while ignoring the non-marketed benefits e.g., emission avoidance from forest carbon stock conservation. However, the benefits of the latter can be high and at times superior to the first type of goods and services (Constanza et al., 1997; Millennium Ecosystem Assessment, 2005). Since they are characterized as public goods, it is often overlooked that these services are also finite and thus valuable (European Communities, 2008). Relatively few studies have compared the total economic value (non- and marketed goods and services) of ecosystems under alternate management regimes (e.g., Constanza et al., 1997). Those that do have found that the benefits of sustainably managing the ecosystem exceed those of converting it (Millennium Ecosystem Assessment, 2005). The challenge is, therefore, how to internalize these benefits in land-use decision-making when up to now these are provided for free (or lost without a penalty).

1.1. Background - Problem statement

The debate on the atmospheric build-up of GHG and its role in global warming culminated in the third session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997, in Kyoto, Japan. One of the major achievements of this conference was the signing of a protocol requesting participating countries to find ways to reduce GHG concentrations in the atmosphere through the formulation of a set of effective and efficient mitigation options. In the case of CO_2, it was determined that reduction targets could be achieved through two major processes (Albrecht and Kandji, 2003): (i) reducing anthropogenic emission of CO_2; and (ii) creating and/or enhancing carbon sinks in the biosphere. Respectively, two main global targets have been formulated by the UNFCCC (2009a): to restrict the increase in global temperature by two °C and to maintain the atmospheric concentration of CO_2 below 450 ppm.

It is hypothesized that the Land Use, Land-Use Change and Forestry (LULUCF) sector will play an important role in achieving the stipulated climate goals. The IPCC indicated that additional terrestrial uptake of atmospheric CO_2 is possible for forest ecosystems, but may gradually diminish in relative and absolute terms, and perhaps become a source of CO_2 (IPCC, 2000). However, the assumption is that LULUCF activities can provide a relatively cost-effective way of offsetting emissions, either by increasing the removal of GHGs from the atmosphere (e.g., planting and managing forests), or by reducing emissions (e.g., curbing deforestation) (UNFCCC, 2006). Stern (2006) has indicated the potential of such measures, estimating that about 18 to 25 percent of all GHG emissions stem from deforestation. The IPCC (2007) found that in 2004 forestry was the third largest sector responsible for gross GHG emissions in the world.

Despite past and current discussion, there is a growing consensus that a mechanism for Reducing Emissions from Deforestation and Degradation (REDD) is a GHG mitigation strategy which can no longer be ignored. Since the COP 11 in Montreal in 2005, the Subsidiary Body for Scientific and Technical Advice (SBSTA) has started to work through the complexities of REDD. It is expected that REDD will play a role in the post-Kyoto[1] regime with a substantial contribution to the overall targets, although concrete plans of integration have not yet been

[1]Post-Kyoto negotiations refer to high level talks attempting to address global warming by limiting GHG emissions. These talks are dealing with the period after the first "commitment period" of the Kyoto Protocol, which is due to expire at the end of 2012.

made. The COP 16 in Cancun, Mexico, produced a package of decisions, the so-called Cancun Agreement, stipulating that "governments agree to boost action to curb emissions from deforestation and forest degradation in developing countries with technological and financial support" (UNFCCC, 2010). The COP 17 held in 2011 in Durban, South Africa, further elaborated on technical aspects of a REDD mechanism. That said, it seems that there is still a long way to go until a legally binding agreement is reached.

Nevertheless, the Mexican government is in favor of a so-called REDD+ approach, including not only Emission Reductions (ER) from deforestation and degradation but also Conservation and Sustainable Forest Management (SFM). Mexico is among countries selected by the World Bank to participate in the fund scheme provided by the Forest Carbon Partnership Facility (FCPF) to strengthen the country's capacity to participate in a REDD mechanism and develop a national REDD strategy (CONAFOR, 2010b; FCPF, 2008). In consequence, the SEMARNAT has been eager to build up a national baseline and monitoring scheme which can be imbedded in a future REDD mechanism.

Although these advances are important for the further development of REDD in terms of financial assistance and technological transfer, it is rather unclear how to translate this international mitigation strategy to national circumstances, and from there to the rural context. The issue is that ecosystem degradation can rarely be reversed without actions that address the negative effects of some or all direct and indirect drivers of LUC. The indirect drivers such as population change, change in economic activity, socio-political factors, cultural factors, and technological change are especially challenging (Millennium Ecosystem Assessment, 2005). However, an effective set of responses to address drivers is often hampered by barriers. Barriers related to the indirect drivers of LUC are institutional and governance arrangements (e.g., corruption, weak regulation and accountability), market failures and misalignment of economic incentives (e.g., omission of positive and negative external effects in the primary sector), social and behavioral factors (e.g., a lack of political and economic power of groups particularly affected), underinvestment in development and diffusion of technologies (e.g., lack of ecological and sustainable management practices), and insufficient use of knowledge (e.g., lack of capacity-building programs) (Grieg-Gran et al., 2005). The accumulation and interaction of these aspects creates a challenge for policy-makers and needs to be solved.

The pattern of drivers and barriers depends on the country-specific context (Millennium Ecosystem Assessment, 2005). For instance, the property characteristics of the Mexican forest, where more than 70 percent[2] is owned by the two common property regimes *ejido* and agrarian community, is likely to have a significant impact on social and behavioral factors. The majority of the members to these communities lives in poverty and is highly dependent on its natural capital (CONABIO, 2006). But being the owner of a significant national forest

[2]This is a rather rough figure, since most of the communal land is still not distributed and registered properly (Bray and Merino-Pérez, 2002, 2004).

resource makes this group an important ES provider, capable of guaranteeing the permanence and enhancement of forest carbon stocks.

A special problem for policy-making, policy implementation and research is building a link between the benefits for the national and international climate and local costs. The question is how to design a cost-effective community involvement strategy. This present study intends to analyze design options to accommodate the concept of REDD in the rural context of Mexico. The assumption is that LUCs (additional "carbon sinks") at the local level could significantly contribute to GCC mitigation (Stern, 2006). Nevertheless, such strategies are questioned due to concerns about permanence of the created carbon benefits (Marshall and Kelly, 2010). A crucial reason is that ERs impose real costs locally, while the benefits accrue globally. Thus, policies aimed at reducing GHG emissions need to address these global externalities and align local-level incentives with global-level benefits. The economic policy instrument Payment for Environmental Services (PES) that is gaining particular attention in Latin America (Grieg-Gran et al., 2005; Pagiola et al., 2005) seeks to internalize environmental costs and/or benefits into production or consumption decisions (Engel et al., 2008). PES is seen here as an attractive policy instrument to channel available funds from an international REDD mechanism to local communities and provide the necessary framework to guarantee the permanence of forest carbon stocks.

1.2. Progress of current research

Much international discussion under the UNFCCC is concerned with financial and technological transfers to countries likely to provide mitigation benefits. Respectively, most current research is focused on the correct international mitigation strategies with which a majority of countries can agree (e.g., IPCC, 2007). Some research deals with the impact of land-use decisions on GCC (e.g., IPCC, 2000, 2001), but understanding the factors which influence the decisions of land users and policy-makers in a way that promotes sustainable development remains a major challenge for research (Engel et al., 2008; Ostrom, 1990). Little investigation is concerned as of yet with the response of agents (ES sellers/providers) that have the potential to make their natural capital availble for mitigating GCC (Cárdenas and Ramos, 2006; ETH-Zürich, 2009; Palmer and Engel, 2009). The problem is that climate-relevant land-use decisions of these landowners are difficult to predict, given that they are influenced by climate itself and other factors which change over time, such as commodity prices. The severity of impact on landowners may depend on both the social organization of the society facing GCC and the adaptation options under consideration. Given that GCC is difficult for individuals to grasp, and that the complex processes take place over a long period of time, landowner's rationality in responding to incentives to change their land-use behavior is hard to foretell (Cárdenas and Ramos, 2006; Engel et al., 2008; ETH-Zürich, 2009; Palmer and Engel, 2009). This sort of knowledge gap must be taken into consideration in the assessment in order to achieve improved information for policy and action to address consequences of ecosystem change for human welfare.

It is imperative that climate policies meet the requirements of sustainable development to assure optimal land use in agriculture and forestry. It is an issue of debate, however, whether "popular" economic methods when applied to the assessment of land-use policies can meet the admittedly divergent criteria of sustainable development (Kant, 2003; Ostrom, 1990). Core issues include framing effects and preference reversal, incommensurability and the uncertainty of impacts (ETH-Zürich, 2009). Furthermore, the nexus between climate science and climate policy-making is crucial for successful policy design in agriculture and forestry (ETH-Zürich, 2009; IPCC, 2007; Palmer and Engel, 2009). Such a nexus has to facilitate a co-production of knowledge among stakeholders that are likely to be organized according to different time-scales and priorities. Differing perspectives at the local level may lead to varying assessments of the same problem, suggesting that the relationship between landowners and relevant stakeholders should be further probed. Therefore, assessing landowners' perceptions by using both economic and social-psychological approaches becomes a promising approach.

This research suggests that exploring the strategic behavior of the agents (ES sellers/providers) managing natural resources and being able to place at the disposal this natural capital as carbon sink will provide practitioners and policy-makers with valuable insight to formulate "optimal" incentives and guarantee the permanence of natural carbon sinks. The theory on strategic behavior is vast and varied (e.g., Mas-Colell et al., 1995) but rarely applied in the context of natural resource management (Kant, 2003). Contract Theory, a sub-discipline of Game Theory (Bolton and Dewatripont, 2005), serves as a useful theoretical foundation for PES considerations (Pagiola, 2008). This theory helps to extend the scope of cost-benefit analysis which has so far only been applied to justify climate action, as seen in the Stern Review (Stern, 2006). The novelty of game-theoretic approaches is that decision-makers, such as landowning rural households, are treated as *homo sapiens* instead of *homo economicus*, permitting the articulation and incorporation of social preferences into the design of effective policy solutions.

1.3. Research objectives, questions and hypotheses

The decision-making process of landowners and other stakeholders involved in the definition and implementation of a REDD strategy is the focus of the present study. Interdependencies are to be sought out within forest owners' social and natural environment. This research elaborates on how the economic policy instrument PES can be used in the Mexican context of REDD to mitigate concerns of permanence in the land-use decision of forest owners. The study analyzes the Mexican context of common property regimes and its influence on policy design and land-use decisions. The analysis explicitly attempts to link the GCC-related decisions at the international level with those taken at the local level. It investigates how PES contracts can ensure the permanence of reductions in GHG emissions over long periods of time, while maintaining necessary flexibility when dealing with changing conditions that are featured by, for example, uncertainty, risk, and trust. In particular uncertainty and risk make up most of the vulnerability quotient for decisions made where rural livelihoods are involved. This research provides a set of policy recommendations for PES-REDD design in order to manage the context of vulnerability in local communities and guarantee the permanence of forest carbon stocks.

Three principle research objectives have been formulated and are enumerated in accordance with corresponding research questions and hypotheses.

Objectives The research objectives are as follow:

O.1 Analyze how the national PES program is designed to secure the permanence of positive externalities provided by forests in Mexico. The intention is to detect if voluntary participation under a common property regime is susceptible to adverse selection of individual ES sellers (providers) which are actively involved in the PES scheme using indexes constructed with Principal Component Analysis.

O.2 Predict those attributes of the PES-REDD contract design which guarantee the permanence of positive externalities derived from forest carbon stocks in Mexico. A survey of a panel of experts helped construct a PES-REDD contract profile based on the Delphi Method.

O.3 Elicit ES sellers' response to different PES contract profiles in order to explore how adverse selection and moral hazard of ES sellers (providers) can be avoided so as to guarantee the permanence of forest carbon stocks. Using a choice-based experimental set-up employing Conjoint Analysis helps to better understand the role of ES sellers' (providers') preference in land-use decisions, and how this might affect collective decision-making in the context of common property regimes in Mexico.

Questions The research questions are as follow:

Q.1 How is a PES contract recognized by a recipient community in practice? Does the PES scheme in Mexico match the general definition of PES and adequately address the issue of additionality and conditionality - factors which set PES apart from other environmental policy instruments?

Q.2 What are the tradeoffs between environmental integrity (accounting for permanence) and contractual flexibility to enforce such contracts (liability for reversals) in order to guarantee the permanence of forest carbon stocks through PES-REDD contracts?

Q.3 How do PES contract attributes influence the decision of the ES seller (provider) ex ante? How can PES contracts be designed to ensure ES sellers' (providers') compliance when conditions such as land-use alternatives change over time, while still assuring the permanence of forest carbon stocks desired by the ES buyer (user)?

Hypotheses Corresponding to the objectives and questions of the study, the following research hypotheses have been formulated:

H.1 The objective of Mexico's national PES program and the conditions necessary to obtain incentive payments are misunderstood and insufficiently diffused among community members. The PES program is treated as a subsidy by communities and its use is adversely selected, resulting in the lack of effective change in the management of the natural resource base. The fact that the PES program is administered by the government implies that budgetary constraints and equity concerns play a determining role. Equity concerns are likely to put the original idea of PES in danger, loading it with objectives that do not increase its effectiveness.

H.2 The resulting PES-REDD contract profile reflects the policy designers' desire to secure the permanence of the ES. The effectiveness of a PES-REDD contract will depend on the ability to avoid ES sellers' (providers') adverse selection ex ante and moral hazard ex post among other factors. It is assumed that adverse selection can be avoided with an adequate definition of additionality, stipulation of eligibility criteria for ES sellers (providers), and employment of justified time frames. As for moral hazard, it is assumed that this can be avoided by adequately accounting for environmental benefits, adjusting the payment structure for the ES and enforcing contracts by adaquate sanctions, among others.

H.3 The stated preferences for land-use alternatives reflect the inner conflict of a contracted agent (the community) who relies on collective decision-making. A voluntary PES contract has to balance strict commitment ex ante with flexibility ex post in order to successfully address the problem of individual ES sellers' (providers') adverse selection and moral hazard. It is assumed that ex ante most community members of a common property regime prefer a market-based approach compared to a command-and-control approach for forest conservation. But ex post the agent (the community) has difficulties to keep the agreed conditionality upright once LUC alternatives offer higher rents to individuals (community members).

1.4. Schematic research structure

The research design is divided into three major phases of elaboration: the preliminary, main and closure phase. Graphically the structure is depicted in Figure 1.1.

In the "preliminary phase" a review of literature provides preliminary answers for the identified research gap. It develops a conceptual framework for the research, setting the theoretical

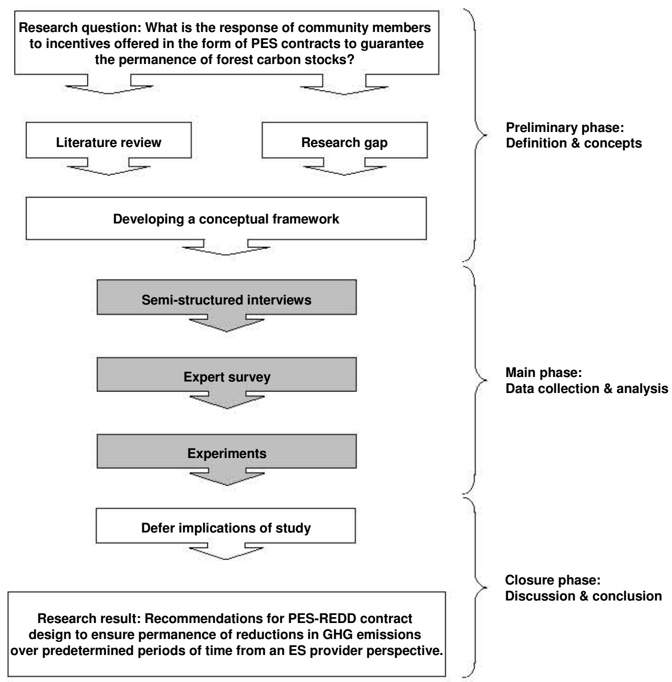


Figure 1.1.: Schematic research structure

foundation necessary to explore land-use decisions which are of relevance for permanence considerations. Encountered gaps and unanswered questions required adjustments and corrections of the initial framework.

The "main phase" comprises three studies in which data is collected and analyzed to investigate the relationship between socio-economic variables influencing land-use decisions from the perspective of an ES seller (provider) and buyer (user). Starting with semi-structured interviews in an *ejido* and agrarian community (Spanish: *comunidad agraria*), a Delphi study with experts and experiments in the same communities was carried out.

In the "closure phase", study reports from the individual studies form the basis for the final analysis. Findings are checked and clustered to defer practical implications. The abstraction of policy recommendations in light of the revealed preference statements for land-use completes the fulfillment of the research goal.

1.5. Structure of the thesis

The thesis is written in the realm of Natural Resource Economics. The respective theory employs neoclassical concepts of optimization over time, that is, the Theory of Optimal Control as well as Game Theory (Faysse, 2005). Effectively, the problems associated with the common use of natural resources involve the interaction of stakeholders to make decisions (Hardin, 1968). I.e., the actions performed by an economic agent (either a producer, consumer or environmental authority) have implications not only for the availability of the natural resource and the option to individually benefit from it but also for the community that uses the same resource (Ostrom, 1990). Specifically the reasoning of game theoretic approaches adopts the principles of neoclassical theory but appends interdependence and information.

Based on the foundations of Natural Resource Economics, this research attempts to analyze the "nuts and bolts" of PES-REDD contract design to guarantee the permanence of forest carbon stocks in Mexico. The thesis employs the research frame depicted in Figure 1.2. The research frame serves as a guide throughout the subsequent chapters to investigate the different components that are assumed to play an important role in the subject matter.

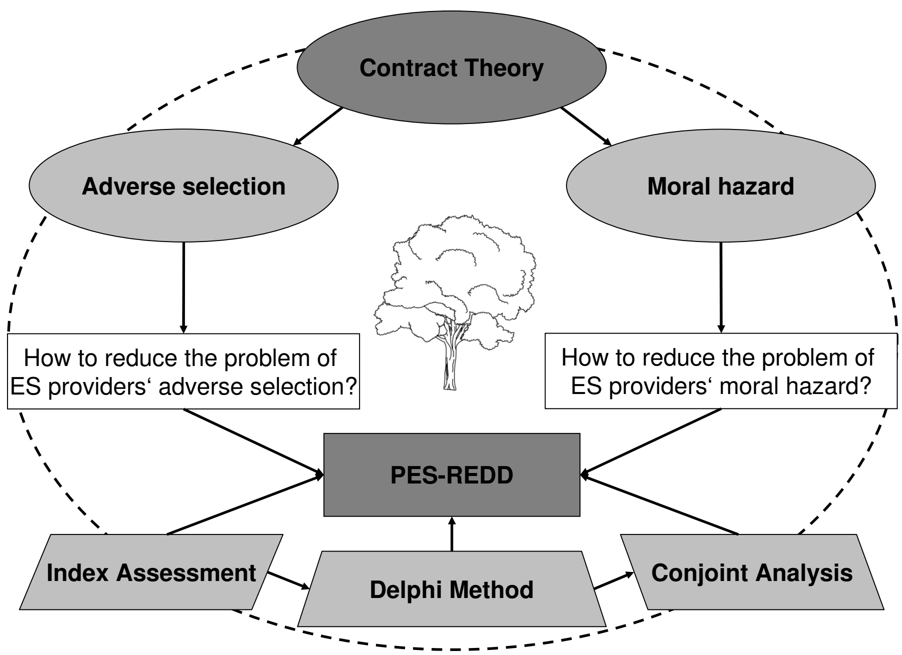


Figure 1.2.: Research frame

Chapter 2 reviews the framing conditions for PES and REDD both from a theoretical and real world perspective. The chapter starts with a review of international policy frameworks to mitigate GCC that are likely (or have already) adopted REDD as a mechanism to curb forest deterioration and avoid the emission of CO_2. The following two sections provide a review of literature of the two policy instruments (PES and REDD) and elaborates on their hypothesized power to guarantee the permanence of ES provision. Special attention is given to the permanence of climate benefits in a final section.

Chapter 3 enters into the Mexican context of forest management and conservation practices. This section provides an overview of the circumstances in which policy instruments are designed and applied. A description of PES and REDD activities currently underway in Mexico completes the chapter.

Chapter 4 provides the conceptual framework for the research in order to combine the foundations of Contract Theory with the insights of Sustainable Livelihood Approach (SLA). While the first part elaborates on the problems of adverse selection and moral hazard in environmental contracts, the second part presents the concept of the SLA to understand the livelihood context of the ES seller (provider) that may encourage hidden information and action of the same.

Chapter 5 presents the methodology (three research methods) employed to obtain data for analysis and answering the formulated research questions. The theory behind Index Assessment Tools, the Delphi Method and the Conjoint Analysis is explained in subsequent sections. With this chapter the theory and literature section is completed.

The following three chapters elaborate on the results obtained from the application of the three methods. Chapter 6 investigates current PES contracts, based on Principal Component Analysis, that are designed to secure the permanence of positive externalities. Chapter 7 explains a survey format applied to a panel of experts, based on the Delphi Method, to retrieve predictions about attributes in PES-REDD contract design. Finally, Chapter 8 explores ES sellers' (providers') response to different PES contract profiles using a choice experimental set-up based on Conjoint Analysis.

The thesis ends with Chapter 9 where overall research outcomes are discussed, implications deferred and recommendations provided for the application of PES-REDD contracts in Mexico to guarantee the permanence of forest carbon stocks.

2. Review of framing conditions

The focus of this research is how to internalize ESs into decision-making of forest owners. The challenge is that in current market settings ESs are typically treated as a positive externality where their provision is threatened by existing production patterns. Here the market fails to provide appropriate signals for efficient allocation of ESs. Therefore, it is argued that if economic considerations are the cause, instruments should be designed to regulate the use of ESs (Grieg-Gran et al., 2005), and internalize the ES of interest into decision-making (Bergen et al., 2002). Such environmental policy instruments have to balance the interests of both supply and demand where the continuous ES provision competes with its consumption in production activities. The balance of both interests is subject to environmental policy-making and demands forgoing on both sides (Bergen et al., 2002). The task of policy-makers is, therefore, to obtain information on both the maximum Willingness to Pay (WTP) for an ES and the maximum Willingness to Accept (WTA) a payment for assuring the "optimal" level of ES provision, and use this as the basis for an adequate formulation and application of policies.

The problem, thus, is to identify the "optimal" level of ES provisions that are influenced by numerous variables. The four main issues regarding ES provisions are (Bergen et al., 2002): (i) quantification based on a systematization with indicators for different usage types; (ii) identification and evaluation of alternatives; (iii) determination of the environmental role and context in a Dose-Response-Function (DRF); and (iv) identification and evaluation of opportunities for protection (precautionary principle) or restoration (aftercare principle). Due to the difficulties in addressing these issues, policy-making often employs a second best yardstick based on principles. The main principles currently applied in environmental policy design are: the "polluter-pays", the "beneficiary-pays", the "precautionary" and the "cooperative or common burden" principle (Bergen et al., 2002). This investigation is particularly interested in the "beneficiary-pays" principle to correct of a market failure in the primary sector which contributes to GCC.

As already stated in the introduction, changes from forest to non-forest land categories have had an important stake in GCC and have become an essential pillar of a global mitigation strategy. In order to address the challenge of "optimal" ES provision from forests for the mitigation of GCC, policy options that are able to influence human behavior are in the focus. In this regard, Payments for Environmental Services (PES) appears as a useful economic policy instrument which assists in allocating financial resources made available through REDD at a higher international level and distribute them equitably on a local level where related positive external benefits are created, following the "beneficiary-pays" principle.

This chapter presents an overview of relevant topics which provide the basic conditions for this research and adequate policy formulation of the subject matter. The topics treated in the following four sections are: first, the three principle policy frameworks to mitigate GCC which have relevance for the Mexican context; second, the theory of the economic policy instrument PES designed to incentivize ecosystem benefits; third, the policy mechanism REDD; and fourth the implication of permanence in a carbon regime. This format aims to highlight the broader context so as to analyze the relationship between factors which influence land-use decisions.

2.1. Policy frameworks to mitigate global climate change

Humanity is confronted with a severe problem that our historic and current economic development has caused, i.e., significant negative externalities affecting the world climate. A small number of industrialized and emerging countries are responsible for this phenomenon (see Table 2.1). Their contribution to GCC is unambiguous and generally accepted. Currently, there are three main policy frameworks which attempt to directly address GCC partially through market-based approaches: (i) compliance; (ii) pre-compliance; and (iii) voluntary. They differ in a number of ways that include stakeholder participation, regional outreach, degree of legal commitment, financial architecture, and time frames. This section reviews each of the listed regimes and points out the related role of REDD.

Table 2.1.: Annual carbon dioxide emissions

Country/Region	**1,000 metric tons of CO2**	%
World	***29,319,295***	***100.0***
China	6,538,367	22.3
United States	5,838,381	19.9
European Union*	3,986,194	13.6
India	1,612,362	5.5
Russian Federation*	1,537,357	5.2
Japan*	1,254,543	4.3
Canada*	557,340	1.9
Republic of Korea	503,321	1.7
Islamic Republic of Iran	495,987	1.7
Mexico	471,459	1.6
Total Top 10	**22,795,311**	**77.7**
Rest minus Top 10	**6,523,984**	**22.3**

Source: UNSD (2007)
*Annex B Countries of the Kyoto Protocol

2.1.1. Compliance: The Kyoto Protocol

The main international platform for the discussion and negotiation on GCC mitigation and adaptation measures is the UNFCCC. The so-called Kyoto Protocol of Climate Change which was established in 1997 evolved under the UNFCCC. This protocol led to individual, legally-binding targets aimed at limiting and reducing GHG emissions of Annex I countries which became subscribers to the protocol and were thus bound by the protocol's commitments. The protocol took effect on February 16^{th}, 2005. The commitments add up to a total cut in GHG emissions of at least five percent in comparison to 1990 levels during the first commitment period of 2008-2012. In order to fulfill the ER goals of individual parties, the protocol established the use of a newly created market-based approach operating at a project level. The respective offset market opened under the Clean Development Mechanism (CDM) to enable co-operation between Annex I and non-Annex I countries, complemented by the so-called Joint Implementation (JI) which fosters co-operation among Annex I countries for the reduction of emissions.

The CDM provides the political framework for a trade market of Certified Emission Reduction (CER). CERs are generated by climate-friendly and sustainable development projects in developing countries (non-Annex I), which have been validated and verified by a Designated Operational Entity (DOE). Within this frame, industrialized countries (Annex I) have the opportunity to invest in, for instance, Afforestation/Reforestation (A/R) projects in developing countries for compliance with their emission caps. The CDM is supervised by the CDM Executive Board (EB), and is under the guidance of the COP under the UNFCCC. The purpose of the CDM was defined by Article 12 of the Kyoto Protocol. Apart from specifically helping Annex B countries to comply with their ER commitments, it must assist developing countries in achieving sustainable development, while also contributing to the stabilization of GHG concentrations in the atmosphere. This framework has a provision stating the use of CDM as "supplemental" to domestic actions to reduce emissions, in attempts to prevent industrialized countries from making unlimited use of CDM. In general, it is assumed that CDM allows net GHG emissions to be reduced to a much lower global cost by financing ER projects in developing countries where implementation costs are lower than those of industrialized countries. A crucial feature of an approved CDM carbon project is that it has demonstrated that the planned reductions would not occur without the additional incentive provided by CERs, a concept known as "additionality". Therefore, official guidelines have been designed to facilitate the uniform assessment of that eligibility condition as established by the Kyoto Protocol (UNFCCC, 2007).

REDD is still unavailable under the compliance market of CDM, since it did not enter the current protocol as a mitigation option. However, more recently progress has been made regarding the adoption of a REDD mechanism within a post-Kyoto Protocol. Although COP15 in Copenhagen has been disappointing, it provided a considerable foundation for the encouraging outcome of COP16 in Cancun. The UNFCCC (2009c), in Decision 4/CP.15, acknowledges "the importance of REDD, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries" and provides some concrete methodological guidance for activities relating to REDD+ in developing countries.

Despite this encouraging progress, two aspects need to be addressed. First, LULUCF activities as a mitigation strategy under CDM had very little acceptance in the first commitment period of the Kyoto Protocol (Keller, 2008). Between 2008 to 2012, only 62 A/R projects were registered making up 0.9 percent of all registered CDM projects, totaling only 0.8 percent of accumulated CERs as the total GHG reduction in the projects from the start or the crediting period until the end of 2012 (UNEP-RISOE, 2011), while 13 large scale and 7 small scale approved A/R methodologies exist (UNFCCC, 2011). Second, the main reason for the limited performance of A/R CERs has been the issue of permanence related to LULUCF project activities. Thus, it is of concern that if permanence is not addressed properly in the future, REDD will share the same fate as A/R in the first commitment period of the Kyoto Protocol.

2.1.2. Pre-compliance: North America

Up to now, the major contaminators (see Table 2.1), such as China, United States of America and India are not getting involved to an extent where it is possible to effectively mitigate GCC. The reason for this resistance is manifold but can probably be reduced to their individual economic and political concerns. While the USA is one of the historical polluters that initiated the problem, it is afraid of harming its already troubled economy with stricter regulations of GHG emissions, thus losing further competitiveness in the global economic arena with the Asian-Pacific nations - mainly China. On the contrary, new economic powers, such as China and India, believe they have a justified right to economic development and wealth accumulation. For them it implies a shared but differentiated responsibility to confront GCC. They believe that "old" economic powers, such as the USA, have to cut their emissions first, while emerging countries should do so at a later point in time, in order to avoid risking their economic growth.

This considerable policy problem of balancing the interests of over 190 countries worldwide makes the possibility of achieving a global and legally binding agreement extremely challenging under the UNFCCC. Consequently, we see a trend of more and more local governments and regional coalitions turning to smaller scale solutions, for example, in the form of an Emission-Trading Scheme (ETS). The introduction of legally binding cap-and-trade schemes at a lower level has become a form of a Pre-compliance Carbon Market (PCM) where participants also look at the possibility of making created carbon credits fungible in the future, in case their sectors become incorporated into the Kyoto Protocol at a later date. So far, operational and announced ETSs are: EU (operational), Regional US (operational), New Zealand (operational), Australia (operational), USA, Canada, and Japan. Of these developments, US progress is of special interest for the Mexican context given that it is a neighboring country.

The USA has indicated that it is willing to bring the Kyoto Protocol to the next level and expand the scope of action under post-Kyoto 2012 if major emerging countries agree to contribute as well. It has even announced plans for its own cap-and-trade scheme, and has agreed to partner with Mexico on a "bilateral framework" of renewable energy, energy efficiency, adaptation, market mechanisms, forestry and land use, green jobs, low carbon energy technology development and capacity building in 2009 (White House statement cited by PointCarbon, 2009). US President Barack Obama has proposed an economy-wide ETS with the aim of cutting GHG emissions by 80 percent below 1990 values by 2050. However, the US administration faces strong opposition in the US Congress. Given the current state, this political constellation makes it unlikely that either a strong international (post-Kyoto) or national commitment emerges under the US-based leadership. In the first case, the US administration has demonstrated during international climate talks under the UNFCCC that its willingness to agree to tough reduction targets is rather low, and in the latter instance, it is observed that a draft climate bill already skipped the ambitious aim of incorporating REDD. Nonetheless, a long absence of US action at the federal level has led the way for some important developments on a state, inter-state and tri-lateral level. Among the most relevant US initiatives at the moment are two PCM proposals: the Western Climate Initiative (WCI) and the Climate Action Reserve (CAR). The WCI is a regional ETS of jurisdictions consisting of seven US States and four Canadian Provinces, which proposes to also accept offset credits from other sectors that are not subject to a cap (WCI, 2012). The CAR is a California-based organization that tracks and registers projects that reduce GHG emissions in order to enter a Californian cap-and-trade scheme. So far, CAR has launched two protocols (landfill and livestock) for the design of Mexican offset projects (CAR, 2012), and it is expected that a forestry protocol for Mexico with the explicit inclusion of REDD activities will follow in 2012.

2.1.3. Voluntary: The Voluntary Carbon Market

The Voluntary Carbon Market (VCM) evolved in the shadow of the GCC debate. CDM, as the predominant market-mechanism, strongly influences the VCM (Olschewski and Benítez, 2005). The market generally derives its demand from companies, individuals, and other entities that are not subject to mandatory limitations and are interested in offseting their GHG emissions, for example, for personal persuasion or publicity. However, up to now the VCM has remained very small compared to the compliance market under the Kyoto Protocol. According to a comprehensive annual report published by Bloomberg New Energy Finance and Ecosystem Marketplace, the international carbon markets reported transactions of 6,692 Metric ton Carbon Dioxide equivalent ($MtCO_2$-e) valued at USD 124 billion in 2010 (Peters-Stanley et al., 2011). In comparison, during that same time period the VCM contributed a fraction of this total with approximately 0.02 percent of volume and less than 0.01 percent of value (Peters-Stanley et al., 2011). Thus, the VCM still represents a small niche in the carbon market, but is growing quickly and might become quite substantial with a high potential to promote REDD projects (Peters-Stanley et al., 2011). The outlook for REDD to perform in the VCM is justified because the market's demand is primarily publicity driven and LULUCF project types provide an excellent opportunity to achieve that. Therefore, one of the predominant and most promising "Standards" of voluntary carbon initiatives at the moment shall be briefly described below to identify related progress and its importance as a pioneer option and role model for future LULUCF activities in compliance and PCM regimes.

The Verified Carbon Standard (VCS) has launched a robust, new global standard and program for approval of credible voluntary offsets. The process of developing the VCS started in 2005 and lasted until 2007, involving organizations such as the International Emissions Trading Association (IETA), the World Economic Forum and the World Business Council for Sustainable Development (VCS, 2010). The VCS claims that offsets must be real, additional, measurable, permanent, independently verified and unique. To guarantee this claim the VCS pursues the objective of providing a trusted, robust and user-friendly program with quality assurance for the VCM, to pioneer innovative rules and tools that open new avenues for carbon crediting and allow businesses, non-profits and government entities to engage in climate action, and to share knowledge and encourage the uptake of best practices in carbon markets so that markets develop along coherent and compatible lines (VCS, 2012). Specifically the VCS has encouraged the development of methodologies for the sectoral scope of AFOLU and became a driving institution for early action in related project activities (Peters-Stanley et al., 2011). Since the standard accepts the A/R methodologies developed under CDM, other project types are reflected in the registered portfolio of AFOLU methodologies, which add up to 10 registered methodologies (VCS, 2011a). A sign of increased market interest and ES buyers' WTP for REDD is that six REDD and four IFM methodologies have been approved between 2010 and 2011. So far, 21 project activities within the sectoral scope of AFOLU have been registered under this standard, of which seven REDD and three IFM projects were registered by October 2011 (VCS, 2011b).

2.2. Payments for Environmental Services

Several environmental policy instruments are able to finance conservation efforts and compensate landowners that must or wish to preserve their ecosystems. The greater use of economic instruments and market-based approaches for the conservation, management and restoration of Environmental Services (ES) are particularly promising interventions (Bergen et al., 2002) and show an increased acceptance among policy-makers (Grieg-Gran et al., 2005). Economic policy instruments frequently used in practice in order to influence human behavior include subsidies, levies (or tax), labels, and certificates (Bergen et al., 2002; CONABIO, 2006; Millennium Ecosystem Assessment, 2005). More recently, the set of environmental policy instruments has been enriched by the so-called PES approach. It is a policy instrument for effectively improving the quantity and quality of ES provision where external non-marketed goods and services are translated into real financial incentives for local actors to guarantee the ES supply (CONABIO, 2006; Engel et al., 2008; Millennium Ecosystem Assessment, 2005). A variety of different PES definitions exist ranging from simple to complex formulations, and many non-pure PES-schemes have appeared due to the fact that existing conditions made it inappropriate to apply the concept *vis-à-vis*. Thus, the number of definitions reflects the level of agreement (or disagreement) among experts (Wunder et al., 2008), and the distinct conditions of application. Nonetheless, the underlying similarity is that they are all based on a "beneficiary-pays" principle (Engel et al., 2008). For this research, a formulation widely found in scientific literature and originated by Wunder (2005) is adopted. According to this definition PES contains five basic elements:

(i) Voluntary transactions;
(ii) well-defined ES or a land use likely to secure its provision;
(iii) at least one buyer;
(iv) at least one seller effectively controlling service provision; and
(v) if and only if the ES seller secures service provision (conditionality).

2.2.1. Rationale of PES

In economic terms, consumption goods are exchanged on a market based on supply and demand given a specific time, place and price. The exchange is based on services (the offering of a good) and returned services (e.g., money). According to the assumed rational behavior of a principal and agent, an exchange is only completed if both market participants (principal-agent) consider it beneficial. Thus, the counter trade depends on the characterization of the good and its monetary valuation (Bergen et al., 2002). However, different types of goods and services exist which are distinguished by their characteristics in terms of rivalry and excludability (see Figure 2.1). Particularly challenging for environmental economics are public goods (environmental services), where the demand side has actually no obligation to provide a service in return. In this context, the proof of profitability for the supplier is often missing to continue the provision, since an adequate incentive scheme is lacking (Bergen et al., 2002). The carbon benefits created by forests are such a public good.

The failure of markets to provide adequate incentive structures for maintaining public goods (externalities) frequently leads to considerable economic and social losses for individuals depending on the resource and the society as a whole (Bergen et al., 2002; Pagiola, 2003). It

	Excludable	Non-excludable
Rivalrous	**Private goods** e.g., food, cars, clothing, timber	**Common-pool resources** e.g., fish, hunting game, water, timber
Non-rivalrous	**Club goods** e.g., satellite television, golf course, swimming pools	**Public goods** e.g., air, scenic beauty, biodiversity, water

Figure 2.1.: Types of goods
Source: modified from Bergen et al. (2002)

is assumed that improper investment in the protection and unsustainable management ("free-rider" mentality) of natural resources is followed by its depletion (Grieg-Gran et al., 2005; Pagiola, 2003; Pagiola et al., 2004; Robertson and Wunder, 2005) so that positive externalities, sooner or later, become scarce and therefore obtain an economic value. External users of the service may then be interested in compensating ES providers in order to guarantee its additional or continued supply in the future (Grieg-Gran et al., 2005; Pagiola et al., 2004; Robertson and Wunder, 2005). Hence, it is possible that the provider and user of the public good have an interest to create an environmental market and become sellers and buyers in order to guarantee the provision of the ES. PES adopts this idea in order to correct the identified market failure which harms a particular ES. The rationale is to incorporate ESs into economic valorization standards so as to offer them as a product on a defined market and employ direct incentives for their preservation. This rationale follows the Coase theorem (Coase, 1960) by acknowledging that problems of external effects can, under certain conditions, be overcome through (direct or indirect) negotiation between the corresponding parties.

It is worth noting that the attraction (unique selling proposition) of PES relies on the promise that it can succeed where other concepts failed to guarantee effective and efficient allocation of ESs, such as observed under "command-and-control" approaches. The difference of PES is that it is based on a relation between supply and demand employing direct economic incentives. Here a user or buyer (demand side) is willing to buy a service from a provider (supply side) willing to sell a service, contingent upon the effective provision of the service under a contract with a price agreed upon between the two parties beforehand or by involving an intermediary (Ogonowski et al., 2009; Wunder, 2005). The explicit difference thus is the acknowledgement that trade-offs between environmental protection goals and current practices exist (Ogonowski et al., 2009). The latter activities might be profitable for single land users providing them with direct benefits, but environmentally damaging to them in different degrees (causing indirect losses) or the others (causing negative externalities). PES, therefore, strives to create adequate incentive structures for individuals to withdraw from those practices causing negative externalities.

In addition, there is a growing expectation that PES has the potential aside from delivering environmental goods and services to also offer development benefits by improving livelihood alternatives for ES providers (Grieg-Gran et al., 2005; Pagiola, 2003; Robertson and Wunder, 2005), and developing and strengthening institutions in order to monitor and enforce conservation activities (Ogonowski et al., 2009). However, given the temptation to expand the scope of PES, it seems recommendable to follow the guiding principle of simplicity in performance payments for a smaller number of well-defined activities. The risk exists that PES projects or programs are loading the instrument with too many development goals, and might fall short in achieving their main objective - in the case of REDD, avoiding CO_2 emissions and improve forest carbon stocks.

2.2.2. Conceptual framework of PES

The PES concept is commonly applied to the ecosystem of natural forests. The increase of threats, especially to tropical forests, caused by deforestation and degradation, has motivated a call for innovative instruments which guarantee the continuous ES provision (Robertson and Wunder, 2005). This is due to the fact that forests provide innumerable valuable services for humanity. Currently, commercialized forest-related ES are carbon sequestration, hydrological services, scenic beauty and biodiversity (Grieg-Gran et al., 2005). According to Pagiola (2003) the PES mechanism works if (i) characteristics of supply are understood through familiarity of the science of ESs; (ii) characteristics of demand are understood by knowing who the ES buyer is; and (iii) service providers (ES seller) are contracted where ES buyers can be sure that they get what they want (see Figure 2.2).

Scope of PES

The core of a PES contract is the well-defined ES or a land-use likely to secure the provision of the same. The scope of a PES program varies typically by the size of the available budget, which is related to the type of financing: government or user. It has been found that government-financed structures typically target various ES simultaneously, often combined with co-benefits, while user-financed programs focus more on a single, rather emblematic local ES which tends to be defined with greater precision (Wunder et al., 2008).

Environmental services The concept of environmental or ecosystem services (ES) is today a central point of departure for various disciplines concerned with natural resource manage-

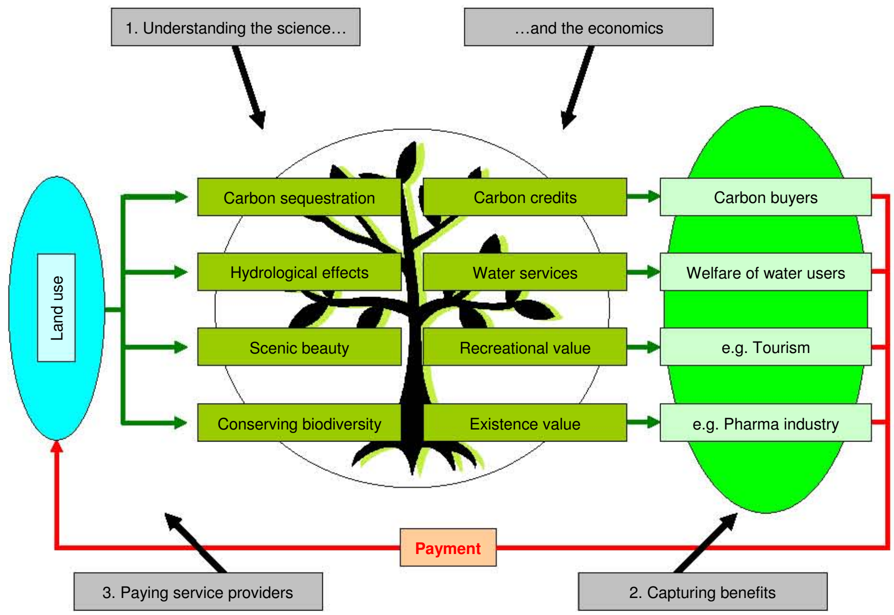


Figure 2.2.: PES mechanism
Source: modified from Pagiola (2003)

ment. However, the exact understanding of the term frequently varies. For example, an early definition proposed by Constanza et al. (1997) considers ESs as "the benefits human populations derive, directly or indirectly, from ecosystems". A more recent formulation which has also become a reference for related research due to its more differentiated description is given by the Millennium Ecosystem Assessment (2005). Their definition draws attention to four dimensions of ES: (i) support, such as nutrient cycle; (ii) provision, such as wood and timber; (iii) regulation, such as climate regulation; and (iv) culture, such as recreation.

The literature reports four principal ES that have been used in PES agreements. The most common set-up is based on hydrological services (Engel et al., 2008) of forests in form of improved water quality and stabilized water quantity. Typically, conflicts surrounding forests and water resources are of an upstream versus downstream nature, where downstream users may be impacted by land-use management of the upstream providers. In this case, PES schemes commonly direct payments to the upstream provider in order to maintain, improve, or change the current land use. The costs that have to be compensated for can be estimated by the "Increased Cost and Reduced Revenue Method" (Bergen et al., 2002; Schneider, 2005). The perceived advantage of such a PES scheme is that it is possible to establish a strong relation between individual water users (ES buyer) and water providers (ES seller) (Wunder et al., 2008). However, on the downside, it can be observed that these user-financed schemes are often limited to a certain spatial scale (Wunder et al., 2008). Furthermore, many supposed hydrological advantages of the forest depend on the specific conditions in place (Wünscher et al., 2008). Interception, infiltration, storage, runoff and evapotranspiration are properties which affect water differently, depending on total surface and groundwater yields, seasonal distribution, and quality (Bruijnzeel, 2004; Wünscher et al., 2008). It is particularly difficult to quantify responses to the impacts of LUC when extensive areas are owned or used by many individual stakeholders with a variety of land management decisions (Kabat et al., 2004; Robertson and Wunder, 2005; Wünscher et al., 2008).

Another ES that has attracted much attention recently is forest carbon stock. The UNFCCC has positioned A/R activities for carbon sequestration among the strategies under the Kyoto Protocol to mitigate GCC. The ES is provided through tree growth since plants absorb CO_2 for that purpose. This service is normally quantified in tCO_2-e per hectare. Usually inventories reveal the amount of carbon stocks in forests, but they can also be estimated by default values from IPCC (2003, 2006) or other national sources (Wünscher et al., 2008). The development of international markets attract resources from industrialized countries that have pledged to reduce their carbon emissions and use the compensation mechanisms to achieve imposed targets while developing technologies for producing low-carbon energy. The general perceived advantage of carbon sequestration through A/R activities is the possibility to implement it in almost all locations (Wunder et al., 2008), at relatively low costs (Palmer and Engel, 2009). On the other hand, it is possible that potential ES sellers face stiff competition since ES buyers might be interested in seeking out the providers who minimize their cost of paying for the ES.

Forests also play an important role for recreation and are highly appreciated for their scenic beauty. The value of the ES is based on the composition of various landscape elements that are visually attainable from specific sites by a certain number of people given their individual valuation level (Wünscher et al., 2008). Typical examples of the valuation of landscape beauty are the "Hedonic Pricing Method" and the "Travel Cost Method" (Bergen et al., 2002). The valorization of landscape protection calculated using the hedonic value is based on the real estate market. In this concept, the forest is seen as a landscape element which forms part of the real estate and co-determines the total value of the estate. The valuation concept "Travel Cost" derived its name from the expenditures that a visitor pays to reach a certain location. In addition, costs arise for entrance, for hosting and other site operations. The total amount of spending represents the local and international tourists' WTP for the beauty of the landscape. Scenic beauty is often the most important asset for developing countries (Robertson and Wunder, 2005). Local communities can be compensated directly for the conservation or rehabilitation of the landscape beauty by receiving a share of charged costs.

The last ES considered here is the intrinsic value and utility of biodiversity. The growing concern regarding its survival has motivated the public as well as the private sector to pay for its protection. Governments are normally paying for the option value of biodiversity, for example through the Global Environment Facility (GEF), which are values not yet discovered.

Others are enthusiastic supporters of global fauna and WTP for the existence of biodiversity where no explicit use of the ES buyer is foreseen. Donations to established conservation organizations represents such a WTP for existence values (Robertson and Wunder, 2005). Another private ES buyer is the pharmaceutical industry which is paying for the exploration of biodiversity in specially defined areas (Pagiola, 2003). Nevertheless, these payments are low and the explored systems are quite limited (Robertson and Wunder, 2005). Some targeting models use surrogates for helping to differentiate the value of habitat types, such as Holdrige's life zones together with a bio-corridor criterion (Wünscher et al., 2008). Yet, the form of calculating the value of the environmental resource is difficult since biodiversity, as such, has no price. The valuation of the social functions provided by the forest owner may be realized from the perspective of the enterprise (Bergen et al., 2002). Opportunity cost calculations, i.e., the "Increased Cost and Reduced Revenue Method" can be used to determine the minimum claim for compensation of the production of the public service, which is, from the perspective of the service provider, an adequate valuation method (Bartelheimer, 1993). In essence, the enterprise should provide public services, such as biodiversity, without being worse-off than without a conservation obligation.

Combination of ES The ecosystem forest, in particular, represents a large and diverse package of ESs. Thus, some PES schemes have emerged which consider ESs in combination and base payments on more than one type of ES. In general, this makes sense if the payment for one ES is not sufficient to guarantee its conservation in comparison to benefits derived from alternative uses (Asquith et al., 2008). In particular, it seems that biodiversity is an ES that is often combined with another ES, because the WTP directly for it is not sufficient (Robertson and Wunder, 2005). The combination approaches that exist are bundling, layering, piggybacking and umbrella. They are encountered when there are multiple users of a single ES and/or when multiple services are sold to different buyers.

The bundling approach is commonly referred to as the situation where one ES buyer is buying a "package" of several ESs from a defined location, thus increasing the per hectare value of the specific site. Similar to bundling is layering, except for one characteristic. While in bundling there is only one type of ES buyer demanding a set of ESs, in a layered setting ESs are supplied to different ES buyers that presumably have only an interest in one of the offered ESs. Often this has to do with separate obligations and leads to the creation of different markets.

Piggybacking is a concept where the initial situation is not suitable to succeed with the establishment of a PES scheme for a certain ES "A". However, within that same area, a different ES "B" could be identified that may be less attractive, for several reasons, but might get the PES scheme started on a reliable basis. When the circumstances for marketing the ES "A" change to a later point in time and makes it preferable over ES "B", the structures built previously can be used to switch to a set-up based on the ES "A".

Finally, the umbrella approach takes advantage of circumstances where the compensation for the provision of one ES is sufficient to provide and improve a set of other ESs that are not explicitly incorporated in a PES scheme. The reasons for assuming an umbrella approach can be varied, including that the other ESs simply have no market or marketing them is causing prohibitive costs for transactions and monitoring.

Side-objectives In general, PES agreements attempt to identify ES providers (sellers) who provide a high level of ES benefits at low costs in the face of allocating scarce funds. These considerations are often strongly related to opportunity costs and additionality considerations but are, at least, equally subject to political side-objectives that undermine pure PES concepts. The most common side-objectives entering into PES explicitly or implicitly are poverty alleviation, rural development and employment creation, but tend to be less common in user-financed situations than in government-financed programs (Wunder et al., 2008). The reason is probably the necessity to create broad political acceptance in the latter instance. Poverty alleviation is an implicit target of environmental policy formulation particularly in developing countries, although the motivation can be mixed. If such policies are introduced, they usually have to fit into a political agenda to obtain votes, although the impetus can also come from cooperation agreements with other entities such as the World Bank. Treating side-objectives equally or giving them more weight than the ES provision likely undermines the effectiveness and efficiency of a PES program (Wunder et al., 2008). There has been little quantitative-empirical proof that PES is able to contribute to poverty alleviation (Engel et al., 2008; Wunder and Albán, 2008; Wunder et al., 2008). Although some studies report that low-income households participate in PES, the evidence of explicit participation is mixed (Engel et al., 2008; Pagiola, 2008; Zbinden and Lee, 2005). This might be related to the relatively short time span of program operations and an inability to compare different PES-like designs.

Stakeholders in PES

PES follows the "beneficiary-pays" principle, where the supply side (ES seller) is paid for maintaining or changing a certain land-use behavior in order to deliver the desired level of an ES to the demand side (ES buyer). Although Wunder (2005) in his definition of PES only refers explicitly to these two parties, other markets have evolved, directing considerable power to a third institution (administration) which guarantees the adequate functioning of the exchange process. However, the exact composition of market participants depends on context-specific circumstances, and is often influenced by the type of financing source (government or user) which, in turn, influences the scale on which these participants interact. It is likely that government-financed approaches demonstrate a greater geographic outreach than those user-financed based due to their "political scope" and financial endowment (Wunder et al., 2008). Thus, governmental set-ups benefit from available, more reliable, earmarked funds (e.g., from tax) (Muñoz Piña et al., 2008). Theoretically, PES can be applied on any scale: global, regional, national, jurisdictional and local.

PES administration It is often the case that neither the ES buyer nor the ES seller is the PES administrator. It is not unusual that an intermediary is created to bring both together due to the required capacity and capability. Typically, the administrator has to bear several transaction cost items such as logistics, program formulation and negotiation, submission of applications, data collection for payment targeting, processing of applications, selection and contracting of ES sellers, maintain communication between ES buyers and ES sellers, disburse payments to ES sellers, monitor compliance, and sanction non-compliance. In user-financed programs, ES buyers often create proper intermediary structures, while under government-financed schemes national agencies (existing or created) execute the task of intermediation (Wunder et al., 2008). Since government-financed programs tend to have a greater outreach, economies of scale can be significant (Wunder et al., 2008), although user-financed structures provide more flexibility, trust and encourage innovation from ES sellers to improve cost-effectiveness at the local level (Dobbs and Pretty, 2008). However, the task of intermediation is particularly complex when the program has to deal with a large number of ES sellers who own comparatively small patches (Pagiola and Platais 2007; cited in Wunder et al., 2008). The implications for transaction costs can then be considerable (Claassen et al., 2008) and may require, for example, the establishment of minimum area sizes and bundle contracts (Pagiola, 2008; Wunder and Albán, 2008).

ES buyer The ES buyer represents the financial source that makes PES operable. ES buyers can be governments, Non-Governmental Organizations (NGOs), companies, interest groups and individuals. Depending on the financial architecture (government-financed, user-financed, or an intermediary structure) the explicit ES buyer might vary (Engel et al., 2008) and is not necessarily the ES user. In user-financed PES schemes, participation is completely voluntary for both the buyer and seller, while government-financed set-ups are only voluntary for the ES seller since user fees, for example in the form of taxes, are mandatory (Wunder et al., 2008). The intermediate-financed schemes are typically cases where NGOs or similars take on the role of the buyer and use voluntary contributions (Engel et al., 2008; Wunder et al., 2008) or where programs need external funding to finance start-up costs (Wunder et al., 2008). The user-financed programs are closer to the idea of the Coase theorem (Coase, 1960) than government- or third party financed schemes (Engel et al., 2008). The associated shortcomings of the latter PES design include insufficient information about changing ES characteristics over time, no direct incentives to ensure that the program is working, and the program's obliteration by political motives (Engel et al., 2008). However, the Coase approach faces frequent problems that are hard to overcome in a user-financed set-up due to the lack of clearly defined and/or enforced property rights, the high number of ES buyers, high transaction costs, challenges to identify and delimitate correctly users, and incentives for free-riding. Thus, government-financed approaches often remain the only viable option since they bypass the problems of free-riding by obliging users to pay fees and reduce transaction costs, enabling economies of scale (Engel et al., 2008).

ES seller The ES seller must have the ability to guarantee the delivery of an ES that is subject to a PES contract. The good or service bought is "an ES or a land use likely to provide the same" (Wunder, 2005). Hence, implicitly the ES seller must be some sort of a (individual or collective) landholder. Probably for administrative simplicity and political reasons most PES programs are aimed at private landholders (Engel et al., 2008). But in theory public lands owned by the government also qualify (Engel et al., 2008) such as Protected Areas (PAs) (FAO, 2009). The identification of eligible participants who can benefit from the commercialization of an ES is a challenging task, which is mainly juridical in nature. The ex ante definition of the ES's legal ownership becomes a critical criterion and since ESs are usually provided by a forest ecosystem, it is likely that eligibility is linked to formal land titles. However, selecting the holding of a legal land title as eligibility criterion involves two sides of the same coin (Asquith et al., 2008). On the one side, this precondition compensates those who have acted legally and might strengthen forest governance (Ogonowski et al., 2009). On the flip side, reality demonstrates that informal land control is a common feature of rural societies where control is often based on accepted traditional arrangements and in some instances even appears to be more effective (Wunder et al., 2008). Effective control is associated with some key features such as excludability (ability to control access to the resource) and enforceability (ability to execute the terms of the PES contract). Given the difficulty of identifying the agent (ES seller/provider) with effective control, Schlager and Ostrom (1992; cited in Rosa et al., 2004) propose to analyze the interrelations between property rights, management of ecosystems and livelihoods through a framework which differentiates between rights of access, extraction, management, exclusion and disposal. Generally, the individual or group that has the right of disposal is the one that is considered to be the owner of the resource, since s/he is able to transfer the other rights (usually all) to a third party. However, particularly the notion of effective control over the access has important implications for the success of PES. For example, illegal logging and LUC are commonly associated with groups that may not be the formal landholders but execute the effective control over a certain area within a deficient titling system (Wunder et al., 2008). In turn, this frequently leads to the perspective that eligibility to participate in PES should be based on proof of effective control rather than on legal land-use rights (Ogonowski et al., 2009; Wunder et al., 2008). Nevertheless, a PES scheme where the eligibility criterion is effective control may cause conflict about the legitimacy of the approach since it implies that the scheme rewards only participants who have or plan to commit illegal activities, which bears the potential implication of a perverse incentive (Ogonowski et al., 2009).

Conditionality in PES

The conditionality criterion of PES is what sets this instrument apart from other environmental policy instruments such as subsidies. As Wunder (2005) defines it, an ES seller is only paid if and only if s/he secures the specified ES provision. The basic idea behind this is that the ES buyer is getting what s/he is paying for (Ogonowski et al., 2009). Thus, conditionality is closely related to additionality, where non-additionality is commonly defined as an action or situation that would have happened even without an incentive scheme, and therefore, effectively provides zero benefits compared to Business as Usual (BAU). Therefore, the baseline compared to the PES activity levels reveals additionality and amount of created ES benefits. However, the challenge in PES is to demonstrate that additionality (Wunder, 2005) and targeting contribute to achieving ES benefits efficiently (Wünscher et al., 2008). It is this idea which actually guarantees the value-added of the payment.

Performance measure Conditionality can only be guaranteed if an adequate and reliable baseline exists allowing the verification of changes attributable to the PES program. Hence, if additionality is not addressed adequately, the credibility and effectiveness of a scheme can be jeopordized severely, becoming exacerbated where financial resources are scarce. Programs with low, undifferentiated, and untargeted payments are especially likely to be exposed to this limitation (Engel et al., 2008). Baselines can only be created if cause-effect relations and spatial patterns are understood well enough for the development of verifiable proxies and indicators for hypothetical changes (Tomich et al., 2004). But frequently, the transparent and credible creation of BAU scenarios suffers from the lack of adequate capacity and capability to identify the relative threat levels of LUC, particularly in rapidly changing economies of developing countries. As most PES programs are clear about the necessity to assure conditionality in order to efficiently allocate scarce funds, the way performance is effectively measured becomes less clear. Therefore, it is important to define the specific responsibilities of the ES seller to guarantee delivery, the minimum capabilities required, and methodology to demonstrate both (Ogonowski et al., 2009). PES designers may then choose between "output- and input-based" measures of compliance (Baylis et al., 2008; Engel et al., 2008). Especially where programs are not able or willing to monitor the ES's dynamic (output) with sufficient resolution, the input approach is more frequent in practice (Tomich et al., 2004). Input-based designs draw on the formulation of Wunder (2005) that payments are made for land uses that are likely to provide the ES. Often this happens on a "per hectare", "material" or "man-hours" basis (Bennett, 2008; Engel et al., 2008). However, it is likely that these schemes create less ES benefits than output-based programs (Claassen et al., 2008; Wünscher et al., 2008), and in the worst case create no benefits at all (Baylis et al., 2008). Although, the input-based set-up is often criticized for that, it is sometimes the only way to initiate a PES scheme.

Monitoring, Reporting and Verification Conditionality can be proven when performance measures are established. Monitoring, Reporting and Verification (MRV) activities are actually the procedures that allow contracting parties to quantify created ES benefits and control for conditionality of ES provisions. Usually it is the task of the ES seller to demonstrate compliance. Depending on the ES treated and whether the design is input- or output-based for remuneration, different MRV approaches might be applied delivering the desired resolution and accuracy of measurements (Engel et al., 2008). Nevertheless, the actual implementation and intensity of MRV efforts is an issue of PES design and associated costs. For instance, in the case of input-based designs the MRV of the land use's ability to really supply the desired ES is often neglected in practice (Engel et al., 2008). Limitations are often related to the availability of funds which also impact the capability and capacity to perform MRV. Since most programs lack adequate funding, especially during the initial phase, it is not surprising that MRV is reported to be poor (Pagiola, 2008), particularly in remote areas (Wunder and Albán, 2008). But, internalizing MRV into payment structures is a prerequisite to determine if a program is fully sustainable from a financial point of view.

2.2.3. Lessons learned from PES

The innovation of PES is the direct interaction of supply and demand, and PES designers have the task to balance interests so that the voluntary ES provision is maximized. PES follows the user-pays principle where the seller (provider) only gets paid if the agreed ES is delivered (Wunder, 2005), and overcomes the problem of not internalizing external effects into land use decision-making (Wunder et al., 2008). PES breaks with the perspective that conservation of ES provision can only be guaranteed by the government through command-and-control measures. This concept assigns a greater responsibility to the actual ES buyer (user) because s/he may be more familiar with the importance of a certain ES. The lessons learned from PES provide valuable insight for translating the idea of a market-based approach to incentivize positive externalities into detailed domestic environmental policies that are more appropriate for different ES types and varying social, economic and political contexts. Analyzing existing PES schemes, therefore, helps to understand the potential benefits (environmental-effectiveness), costs (cost-efficiency) and political barriers (equity concerns) underlying its application.

Effectiveness The general enthusiasm related to PES has so far not been matched with sound guidance of how to use it effectively. It seems to be a general lesson learned that context-specific adaptations are needed, which means accommodating differences in ecology, socio-economics, institutional arrangements and political environment. In consequence, PES reviews encounter significant gaps between the basic idea of the concept and its application in reality, often leading to hybrids or PES-like schemes (e.g., Wunder et al., 2008). There is a considerable gap where the key characteristic of conditional payments is not met. It represents the outstanding difference between PES and, for example, a subsidy program (Engel et al., 2008; Wunder, 2005, 2008; Wunder et al., 2008). Different factors make it relatively challenging to adopt the definition one-to-one in order to guarantee the environmental-effectiveness in the ES provision (Engel et al., 2008; Pagiola, 2008; Wünscher et al., 2008; Wunder et al., 2008), and six factors seem to stand out in particular: (i) linkages between land use and ES; (ii) enrollment of land; (iii) conditionality; (iv) leakage; (v) perverse incentives; and (vi) permanence[1].

Land uses supported by PES must, in fact, relate to the desired levels of ES provision. The greatest obstacle is to assure that a land use truly fulfills this goal. The relationship between land use and ES, magnitude and threshold effects are frequently unknown and uncertain (Asquith et al., 2008; Bennett, 2008; Muñoz Piña et al., 2008; Pagiola, 2008; Wunder and Albán, 2008; Wunder et al., 2008). Thus, relations remain vague and programs tend to be "input-based" (Engel et al., 2008). This second-best approach induces a type of insurance against certain, but still vague, environmental risks (Wunder and Albán, 2008), which follows a "precautionary" principle (Bergen et al., 2002). This may be appropriate where preventing adverse LUC is less costly than restoration (Wunder et al., 2008), yet, the drawback is that the real incentive for ES buyers to pay decreases and does not provide a sound feedback loop of ES seller's performance. Only if the science is understood (Pagiola, 2003), can ES provision be adequately controlled through MRV in order to detect additionality and establish adequate payment levels. In this regard, user-financed PES schemes are most likely doing better due to a more direct feedback loop, often on a smaller scale with a single ES, and without side-objectives (Wunder et al., 2008).

ES sellers are required to enroll their land property in order to be accountable for created ES benefits under a PES scheme. The enrollment of a certain area enables the program to achieve a desired level of ES provision or maximize the program's effectiveness within a given budget. Although, national PES programs do not commonly suffer from a lack of seller's demand (Muñoz Piña et al., 2008; Pagiola, 2008), they usually report problems of mistrust related to skepticism of continued payments and backdoor land expropriation (Asquith et al., 2008; Wunder et al., 2008). The first aspect is easily overcome by actually making payments, but the latter issue is harder to solve (Wunder et al., 2008). Another problem is the inability to achieve the enrollment of high-valued ES areas (Muñoz Piña et al., 2008; Pagiola, 2008). It is likely that high opportunity costs exceed the uniform price structure of broad-scale (often government-financed) programs (Wunder et al., 2008) and payments are insufficient to induce socially desirable land uses. Thus, PES designers have to specifically target ES sellers who are

[1]The issue of permanence is not within this section but reviewed extensively in Section 2.4.

able to effectively deliver the desired ES quality and quantity.

The compliance (conditionality) of the ES seller with certain obligations and activities is a precondition but not necessarily sufficient to demonstrate additionality. Additionality requires the adoption of activities that would have not been implemented in the absence of a PES scheme so that the payments effectively lead to real changes in terms of ES quality and quantity distinct from the BAU scenario. The effectiveness of payments is therefore doubted in situations where programs pay, for example, for forest areas that are already officially protected[2] (Engel et al., 2008; Pagiola, 2008; Wünscher et al., 2008) and the combination of ESs provoke problems of double counting (Asquith et al., 2008; Engel et al., 2008; Wunder and Wertz-Kanounnikoff, 2009). Hence, the main challenge is to construct an accurate BAU scenario which hampers adverse selection ex ante (non-additionality) and moral hazard ex post (non-conditionality).

The concept of leakage refers to the displacement of undesired land-use practices to another location through the introduction of a PES scheme. Drivers of leakage are an eminent problem and may occur both internally and/or externally at various geographic levels (Engel et al., 2008; Pagiola, 2008; Wünscher et al., 2008). Local level leakage refers to, for example, where ES sellers enroll only parts of their land and move their BAU activities internally to another property. National or international leakage might occur due to price distortions where the reduced availability of "unprotected" land through PES increases demand of the same and puts pressure on other land not enrolled into the PES program. For Wunder et al. (2008), leakage is only relevant if a program is not covering all the area likely to provide the ES. In the case of hydrological services, this might be possible due to a delimitable watershed, but for forest-related carbon projects the scale is naturally global and makes leakage a severe challenge and difficult to quantify and mitigate.

Perverse incentives are among the key concerns of environmental policy design. However, implicitly the condition of additionality might encourage potential ES sellers to actually adopt a socially undesired behavior (e.g., threat of deforestation) in order to be eligible (Ogonowski et al., 2009; Wunder et al., 2008). Hence, it is necessary to establish and communicate rules that effectively thwart these effects such as the formulation of adequate eligibility criteria. A good example of this comes from the forest carbon market where A/R projects are only eligible if potential ES sellers are able to demonstrate in a baseline analysis that in the past no forest cover existed before a certain period of time (under CDM after 1990) prior to the activity's start in order to avoid the creation of incentives for deforestation.

Efficiency Environmental policies may be subject to two different budgetary constraints: to maximize impacts within a given budget or to minimize budgets within a given benchmark of impact. The first case is more common and likely to limit the geographic cover of the selected instrument. In this regard the hypothesized attractiveness of PES, compared to other

[2] An exception might be where PAs are not effectively conserved (FAO, 2009).

environmental policy instruments, is that the market-based approach is able to create on the supply- and demand-side efficiency gains (Wunder et al., 2008). Efficiency can be significantly improved if the selection of potential ES sellers is based on the level of ES provision, risk of ES loss in the BAU, and the ES sellers' cost of ES provision (Wünscher et al., 2008). While the first two items have already been discussed under effectiveness the focus here is on cost-efficiency.

A particular issue of cost-efficiency is the number of participants and size of the individual projects enrolled. The implication relative to economies of scale is important since program costs typically increase simultaneously with the number of participants. But if the size of individual projects increases, fixed costs per hectare can be reduced. This observation also holds true, though to a lesser extent, with an increase of participants (irrespective of their size) since some fixed costs of managing the PES scheme exist independently. Thus, PES schemes which manage a portfolio with a small number of participants and large individual project sizes (in terms of hectares and/or amount of ES provided) have a comparative cost structure advantage over a portfolio with a large number of participants and small individual project sizes. But favoring a portfolio with a small number of participants and large individual project sizes runs the risk of excluding marginalized and poor landholders, which has the potential of undermining public support (Ogonowski et al., 2009), while having a portfolio with a large number of participants and small individual project sizes requires scaling up. To convert the latter portfolio structure into a viable option, designers have consider setting a minimum project size with the option of "bundling" actors, where obtained benefits are distributed on a higher scale (Karousakis, 2007). For that approach, an aggregator capable of grouping individuals, communicating between supply and demand side, and distributing benefits is necessary. Aggregators can vary by jurisdiction, type of organization and delimited territory (Griffiths, 2007). In some instances, existing institutional infrastructure can be used, while in other circumstances it might be useful to construct new institutional arrangements.

Achieving cost-efficiency in PES programs through incremental ES provision at lower costs depends on various cost factors. Typically the literature distinguishes between opportunity, investment and transaction costs (Wunder et al., 2008). These cost items represent entry points for options to improve the cost-efficiency of PES schemes. The opportunity costs are the ES sellers' surrender of alternative benefits from the BAU land-use scenario. In a world of rational choice, it is expected that payments offered to an agent (ES seller/provider) under a PES scheme must be (at least) equal to her/his opportunity cost. However, social inefficiencies might occur if these payments are insufficient to induce the adoption of the desired land uses, and/or when the adoption of the desired land uses, likely to supply the ES, is achieved but at a cost higher than the ES value itself (Engel et al., 2008; Pagiola, 2008; Wünscher et al., 2008).

Furthermore, PES payments must absorb the investment and transaction costs attributable to the ES seller's participation in the scheme. The investment or implementation costs of the actual ES seller are the costs incurred when changing or maintaining any socially desired land use, while the transaction costs are stakeholders' costs (seller and buyer) associated with the administration of the PES program. The transaction costs are "all those costs that are not payments proper" (Wunder et al., 2008). They occur mainly for two reasons: informational needs (e.g., understanding linkages between land use and ES, creating baselines, and implementing MRV) and logistical needs (e.g., executing site visits, communication, and ground-truthing) (Wunder et al., 2008). However, the transaction costs principally influence cost-efficiency. Based on occurrence during program implementation, transaction costs can be further subdivided into start-up, periodic, and maintenance costs. PES programs typically face high start-up costs compared to other cost blocks (Wunder et al., 2008). It is argued that information procurement in order to establish adequate baselines and confirm linkages, contract design, and negotiations are time consuming and costly. These costs are similar to fixed-cost blocks which decline in relative terms with the scale, thus putting small, often user-financed programs at a disadvantage. Therefore, most PES schemes sustain these costs either by external donations (Asquith et al., 2008; Wunder and Albán, 2008) or by expected payment levels corresponding to the perceived ES value (Wunder et al., 2008). The challenge of any PES administrator is, thus, to find ways to reduce this fixed-cost block.

Periodic (e.g., ground-truthing, verification, and payments) and maintenance (e.g., monitoring, sanctioning, and technical assistance) costs tend to be lower compared to start-up costs (Wunder et al., 2008). Large-scale PES schemes, often government-financed, are theoretically in a better position due to economies of scale. Government-financed programs, in particular, can additionally draw on the pre-existence of institutions with local presence and experience. Although this might be valid, the prominent examples of national programs (Costa Rica and Mexico) reveal that their administrative cost figures are rather artificial because they are predetermined by law as a fixed percentage of the available budget (Muñoz Piña et al., 2008; Pagiola, 2008; Wunder et al., 2008). Hence, if the funding is not sufficient, inefficiencies might occur when necessary activities are postponed or executed at a lower level than optimal (Wunder et al., 2008), although PES administrations benefit directly if budgets increase. PES designers have to take targeted and differentiated payments with adequate MRV seriously as they theoretically create the ability to improve additionality in a cost-efficient manner (Dobbs and Pretty, 2008; Ferraro, 2008; Muñoz Piña et al., 2003, 2008; Wünscher et al., 2008; Wunder et al., 2008).

Equity The equity concern adds a third dimension to PES design. Higher opportunity costs, tenure insecurity, lack of land titles, technical constraints and transaction costs may be prime obstacles obstructing poorer ES seller's access to PES programs (e.g., Pagiola et al., 2005). While effectiveness and efficiency directly impact on the objective of conditional ES provision, equity is concerned with the social dimension of equitable payments. It deals, for example, with the question of whether it is correct to pay better-off, larger landowners, while poor small landowners are excluded due to cost-efficiency considerations. Since PES is, after all, a policy instrument, various interest groups are interacting and interested in incorporating side-objectives which correct such perceived inequalities but, in turn, might also affect the rigidity of conditionality. Especially government-financed schemes tend to have an unwillingness to penalize non-compliance due to the opposition of powerful political groups or out of fear of political consequences when dealing with poor groups (Wunder et al., 2008). Thus, it is likely that political considerations limit the efficiency of PES by loading it with several side-objectives, often for equity considerations, that do not explicitly improve the conditionality of ES provision and might even lead to questionable results regarding the side-objectives themselves.

A central concern of side-objectives in PES design generally refers to the possibility of contributing to poverty alleviation. However, the impact of PES on the poor has been slightly documented so far (Engel et al., 2008) and implications are mixed (Asquith et al., 2008; Engel et al., 2008; Muñoz Piña et al., 2008; Neitzel, 2007; Pagiola et al., 2005; Pagiola, 2008; Wunder and Albán, 2008; Wunder et al., 2008). Nevertheless, if poorer households participate in PES programs, the question remains as to the significance of contributing to poverty reduction. In circumstances where flat payment schemes are applied and budgets are limited, even good intended "targeting the poor" might not have an impact, or if positive the magnitude is vague. Depending on the context, even slight gain might be of importance when alternative cash-income sources are limited (Wunder et al., 2008). Moreover, it has been argued that the non-income impacts can be considerable for the poor where PES helps to improve land tenure security and property rights (Asquith et al., 2008; Engel and Palmer, 2008; Landell-Mills and Porras, 2002; Pagiola, 2008; Wunder et al., 2008). Given that PES is voluntary, participants have the option of (at least) withdrawing their participation if they perceive any disadvantage (Pagiola et al., 2005; Wunder et al., 2008). In contrast, it is possible that PES is making land more valuable and casts out poor forest dwellers by politically more powerful groups (Landell-Mills and Porras, 2002).

2.3. Reducing Emissions from Deforestation and Degradation

REDD generally refers to a financial mechanism discussed under the UNFCCC for a post-2012 Kyoto Protocol commitment. After the concept was first introduced during COP 11 in Montreal, Canada in 2005, the SBSTA was charged to work through the difficulties and analyze incoming proposals from other governments and organizations. Finally, during the COP 13 in 2007, participating countries established the Bali Action Plan which agreed to include REDD into the climate negotiations (Parker et al., 2009). Although in 2010 during the COP 16 in Cancun, Mexico, strict decisions were not made, one central point related to REDD entered the "Cancún Agreement" that deserves mention: "Governments agree to boost action to curb emissions from deforestation and forest degradation in developing countries with technological and financial support" (UNFCCC, 2010). In 2011, the COP 17 in Durban, South Africa, further elaborated on the technical aspects of a REDD mechanism with guidance for reference scenarios and safeguards. Despite this progress, the expected post-Kyoto Protocol has not yet been finalized. Instead, the commitment period of the existing protocol was extended. The deficiency of this outcome was exacerbated by the decision of Russia, Japan and Canada to exit the Protocol, and China's announcement that it would not agree to legally-binding commitments until 2020. The implication for REDD, as a possible central pillar of a mitigation strategy under the UNFCCC, is that the lack of broad consensus, acceptance and implementation at a global scale considerably limits its contribution to halt and reverse GCC.

Several definitions of REDD exist, not always referring to a potential inclusion into the compliance scheme under the Kyoto Protocol. Yet a common consensus exists that the key for REDD's success includes incentives, most likely financial in nature, designed to make the maintenance of standing forests more attractive and profitable for countries versus their conversion for agriculture, timber and other land uses (Ogonowski et al., 2009), which implicitly means that action at a lower scale is needed. Therefore, REDD refers mainly to a blueprint of ER from the LULUCF sector in developing countries and employs financial sources as incentives for the ES provision of positive externalities derived from forest carbon stocks such as emission avoidance and carbon sequestration.

2.3.1. Rationale of REDD

The rationale behind REDD as a mitigation mechanism is that the loss of forest cover contributes to GCC. Deforestation and forest degradation account for up to a fifth of global GHG emissions (Stern, 2006). Tropical forests alone cover approximately 15 percent of the planet's surface (FAO, 2005c) and contain around 25 percent of the terrestrial carbon stored in the biosphere (Bonan, 2008). Approximately 13 million hectares of tropical forest are lost annually due to LUC (see Figure 2.3), which corresponds to the total area of Nicaragua (FAO, 2005c). Low-latitude forests are under particular threat and very unlikely to regenerate their natural carbon stock levels if cut, making REDD activities probably as permanent as avoiding fossil fuel emissions (Fearnside et al., 2000). REDD may thus contribute substantially to GCC, which threatens populations, the economy and the environment.

Operationalizing an international REDD mechanism on the ground is a challenge since the causes of deforestation and forest degradation are varied, complex and differ by continent, region, country and locality. Local pressure increases particularly when the forest is a major source of subsistence and revenue for communities which have access to this valuable natural capital (Parker et al., 2009; Stern, 2006). The World Bank (cited in Parker et al., 2009) points out that forest resources contribute to up to 90 percent to the subsistence sources for 1.2 billion

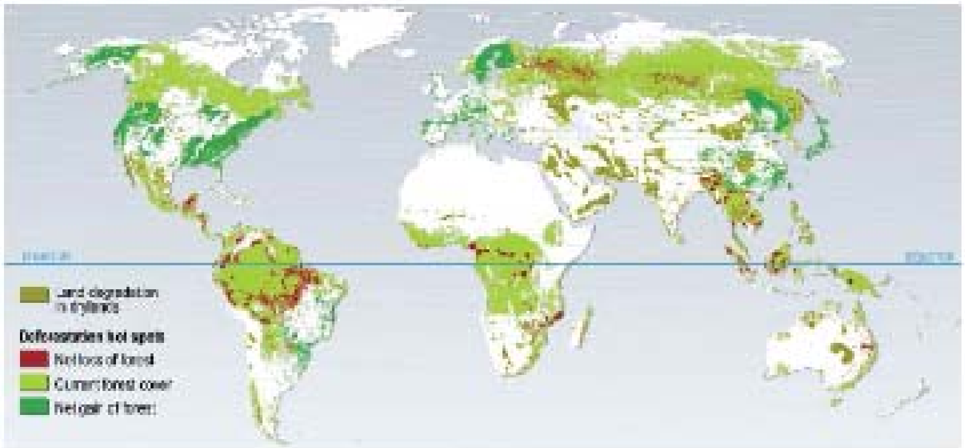


Figure 2.3.: Global trends of land cover change
Source: Millennium Ecosystem Assessment (2005)

individuals, and the loss of the natural capital threatens the poorest people who most depend on it. It is often emphasized that the inter-relationships between poverty and population pressure are the root cause of forest cover loss, provoking a vicious cycle which leads to and prevents the escape from extreme poverty (Parker et al., 2009). While a considerable group of people deforests in order to earn their daily living, others clear the forest for agriculture, livestock and (illegally or legally logged) timber fostered by consumer demand increases and because these activities are supported by the State and/or private enterprises in many countries (Parker et al., 2009; Stern, 2006). This mixture of obstacles for the adoption of REDD makes it extremely challenging to guarantee the permanence of forest carbon stocks on the ground.

2.3.2. Conceptual framework of REDD

The challenge of REDD at the conceptual level is its adoption by a considerable number of developing and developed countries in order to make a difference in current and future trends of forest cover loss on a global scale. But adoption is only the first step given that additionally avoided CO_2 emissions or improved carbon sinks require effective implementation of the REDD mechanism on the ground. A call for "making a difference" and joining together for "collective action" is synthesized into the three "Es" of effectiveness, efficiency and equity coupled with political feasibility. In order to understand how these postulates are translated into an applicable conceptual framework for REDD, four basic blocks of particular importance will be discussed below (see Figure 2.4). These segments are dealt with in general terms to find broad acceptance and allow for flexible adjustments at the level of implementation (local, sub-national, national, regional or global). The blocks presented here shape a generic REDD mechanism and are interdependent on an implementation phase (Parker et al., 2009). In the subsequent sections each block is explained and trends in current positions are highlighted at the end.

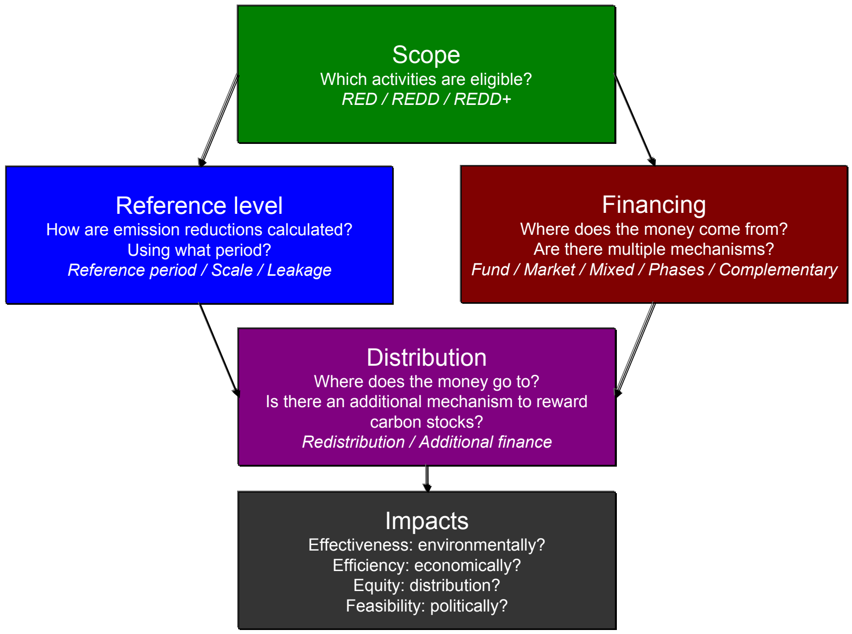


Figure 2.4.: REDD blocks
Source: modified from Parker et al. (2009)

Scope of REDD

The identification of an adequate scope for REDD is related to the aspects of eligible activities and geographic outreach. These elements can be further detailed and transformed into corresponding key policy design issues of correct activity accounting, which are complex issues in a global context with considerable differences and consequences at lower levels.

Activities In general, carbon is found both in vegetation (biomass) and soils of the terrestrial biosphere. The LULUCF sector distinguishes between above-ground biomass (stem, branches and foliage), below-ground biomass (roots), dead biomass (trunks, branches and leaves) and soil organic carbon. Furthermore, it is possible to extend these carbon pools to long-term forest products and biomass used for energy generation (IPCC, 2000). The different carbon pools imply that a full carbon accounting system consists of a complete accounting for changes in carbon stocks across all these pools within a given land area and time period (IPCC, 2000). Hence, the scope of eligible REDD activities is directly related to the flux of carbon between the terrestrial biosphere (eligible carbon pools) and the atmosphere. Although the scope has important implications for the magnitude of the mitigation potential, it also depends on the additionality (overall effectiveness) of activities and capacity with associated costs to MRV the forest carbon stock changes within different carbon pools. Thus, a number of challenges need to be solved regarding activities which could be permitted under a REDD regime in order to increase its attractiveness, while maintaining concern to minimize negative effects (Ogonowski et al., 2009) such as the degradation of enrolled forest areas through drivers that are difficult to detect, e.g., Non-Timber Forest Product (NTFP) collection and tourism. The controversy continues over which specific activities contribute to the overall aim of GCC mitigation in a way that it can be measured in an adequate and transparent manner, without creating any perverse incentives (Ogonowski et al., 2009). Examples of issues include the inclusion of enrichment planting in preserved forests, landholders in areas with little deforestation but with a rapidly approaching development frontiers, and landholders shifting from a beneficial to a more beneficial activity. As a consequence, the concept of REDD has continuously evolved in the past (New Forests Advisory Inc., 2011), and currently several broad categories are under consideration for a REDD mechanism (see Table 2.2).

Table 2.2.: Scope of REDD activities

Scope	**RED**	**REDD**	**REDD+**	**REDD++**
Deforestation	x	x	x	x
Forest degradation		x	x	x
Conservation			x	x
IFM			x	x
SFM			x	x
Improve carbon stock			x	x
Co-benefits				x

The original idea was to reduce rates of deforestation, with much of the focus on forests in tropical countries, through approaches called Avoided Deforestation (AD) or Reducing Emissions from Deforestation (RED). Deforestation, according to the Food and Agriculture Organization (FAO) of the United Nations "is the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10 percent threshold" (FRA, 2004). However, the challenge at a conceptual level has to do with the fact that the definitions of forest, forest types and forest states differ between countries and even within a country (IPCC, 2000). For example, the two commonly consulted sources for a country's forest definition are the FAO (FRA, 2004) and Designated National Authority (DNA)[3]. But if forest definitions are based on single thresholds, such as a minimum canopy cover (or minimum biomass or carbon densities), this may cause adverse effects depending on if they are high or low. I.e., establishing high thresholds may result in undetected clearing of forest-like vegetation with lower cover rates, while low thresholds may result in degradation of existing forests without implicitly contradicting the regime.

[3]Mexico defines forest as a vegetation type with a minimum tree cover of 30 percent, a land area with a minimum of one hectare, and a tree height with a minimum of four meters (DNA, 2011).

As a consequence of the limitations encountered in RED, the concept has been expanded by the idea of REDD. The approach includes reducing emissions from forest degradation. The FAO defines forest degradation "as a reduction of the canopy cover or stocking within a forest, provided that the canopy cover stays above 10 percent" (FRA, 2004). The concept of REDD is simple at first glance, as countries or sovereign units that are willing and able to reduce CO_2 emissions from deforestation and forest degradation are financially compensated (Scholz and Schmidt, 2008). However, it is argued that if degradation and/or areas deforested are allowed to re-grow in the BAU, regeneration has to be accounted for as well, because the term degradation opposes regeneration and natural growth. In principle, both effects can be estimated and included into any carbon accounting scheme, following the principle "where relevant changes result in damage to the atmosphere (e.g., forest degradation) should have obligatory adjustments, while changes that result in atmospheric benefits (e.g., forest natural growth) should be optional" (Fearnside et al., 2000). Some specialists have argued that the latter in particular may represent the major human-induced change that a country is able to provide in order to mitigate GCC.

Given the criticism encountered in the previous approach, REDD+ has emerged and refers to the improved potential of CO_2 sequestration and emission avoidance. Since the COP 13 in Bali the "+" has been added to REDD, offering the possibility of incorporating "Conservation, SFM and Enhancement of existing forest carbon stocks" (UNFCCC, 2008). Hence, this concept differs from RED and REDD since it is not limited to the mere decrease of GHG emissions and forcibly includes the maintenance and additional sequestration of CO_2 from the atmosphere. In particular, the notion of conservation produces some contradiction to previous agreements, because reserves of carbon sinks are generally different from emissions of carbon. Critics argue that including already existing, not threatened forest carbon stocks implies no change in atmospheric GHG concentration.

Despite the discussion of adequate mitigation activities, it has been hypothesized that REDD+ could provide a second "+" in the form of positive impact on, for example, the alleviation of poverty, local and regional development, rights of indigenous people, land tenure rights, biodiversity conservation and continuous provision of other ESs (Parker et al., 2009). The inclusion of co-benefits is a common feature of environmental policy instruments (e.g., PES), which can help avoid perverse environmental and social impacts (Fearnside et al., 2000) commonly referred to as environmental safeguards and social safeguards. It is proposed that respective criteria be used to screen out unacceptable project activities and to target more desirable project activities (Fearnside et al., 2000), which might also help increase acceptance of the approach (Ogonowski et al., 2009). The apparent risk is that if REDD+ is loaded with too many complex side-objectives, the probability of obtaining an effective, efficient and equal agreement on a global scale decreases (Parker et al., 2009).

Table 2.3.: Forests and carbon stocks in tropical countries

	Low forest cover (<50 %)	**High forest cover** (>50 %)
High deforestation (>0.22 %/yr)	***Quadrant I*** e.g., Guatemala, Thailand, Madagascar High potential for RED credits High potential for A/R credits Number of countries: 44 Forest area: 28 % Forest carbon (total): 22 % Deforestation carbon (annual): 48 %	***Quadrant II*** e.g., PNG, Brazil, Dem. Rep. of Congo High potential for RED credits Low potential for A/R credits Number of countries: 10 Forest area: 39 % Forest carbon (total): 48 % Deforestation carbon (annual): 47 %
Low deforestation (<0.22 %/yr)	***Quadrant III*** e.g., Dom-Rep, Angola, Vietnam Low potential for RED credits High potential for A/R credits Number of countries: 15 Forest area: 20 % Forest carbon (total): 12 % Deforestation carbon (annual): 1 %	***Quadrant IV*** e.g., Suriname, Gabon, Belize Low potential for RED credits Low potential for A/R credits Number of countries: 11 Forest area: 13 % Forest carbon (total): 18 % Deforestation carbon (annual): 3 %

Source: modified from da Fonseca et al. (2007)

Countries The geographic outreach of a REDD mechanism has considerable implications for global success in terms of created carbon benefits and the risk of introducing perverse incentives. The integration of distinct geographical and biophysical areas involves various levels of decision-making. First, it has to be decided which countries are allowed to host REDD activities - the general consensus is that non-Annex I (mainly developing countries) are eligible. Second, negotiating parties have to determine the scope of the REDD mechanism because the implications are varied depending on the features of each country (see Table 2.3). The country's deforestation rate and existing forest cover have important implications for its ability to benefit from different forest-related mitigation strategies. Quadrants I & II indicate that those countries with high historical deforestation rates would benefit the most from historical reference levels when deforestation is accounted for. On the flip side, quadrants II & IV allow countries to benefit with high forest covers when a REDD mechanism is based on existing or enhanced carbon stocks. Quadrant III is distinct, since the countries making up that group could only benefit significantly if activities that reward the enhancement of carbon stocks are included. It is expected that such geographic differences between countries and within a country could lead to a potential controversy of equitable benefit-sharing schemes.

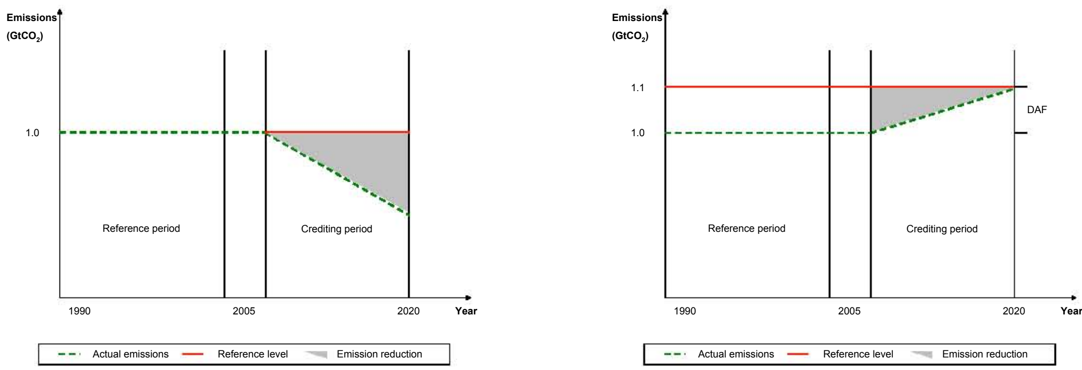
Reference level of REDD

The introduction of a REDD mechanism with a pre-defined rule of conduct for reward raises the issue which reference levels are to be used to measure and quantify success. A REDD scheme, similar to PES, must be based on an accurate and credible BAU assumption in order to evaluate the quantity and quality of emission avoidance and carbon sequestration. Baselines are used to distinguish the impact of LULUCF activities from the BAU scenario, which is by itself subject to natural variability and indirect effects of human activity (IPCC, 2000). The reference level must define a reference period and a scale against which the activities can be evaluated, and in the end rewarded, according to their scope (Parker et al., 2009). The rate of reward then is a reflection of the amount of ER which would have otherwise occurred in the counterfactual case (BAU scenario) over time. The development at different scales within (national, sub-national, jurisdictional and local) or between countries (global and regional) can be challenging and depends considerably on available and applied technology. Greater complexity is added when individual activities are integrated into a higher accounting level during its implementation or at a later stage of development. Specific circumstances have to be analyzed carefully to ensure that marginal costs of action do not end up higher than expected and reduce the overall appeal of the approach.

Reference period The reference period is crucial for the definition of the BAU scenario because it is expected that REDD activities provoke higher forest carbon stocks during a certain time span. The three main approaches used to predict future trends are: historical baseline, historical adjusted baseline, and projected (modeled) baseline. The historical baseline (see Figure 2.5(a)) is a straight forward approach. It takes a geographic area, looks back in time (e.g., 10 years), determines the rate of deforestation that took place and assumes that this rate will remain constant in the future. Any future MRV change below that rate would then qualify for some sort of incentive payment. However, the main challenges of this approach are to determine a specific time period, decide if net or gross rates are applied, decide if forest degradation is included, and identify the required minimum level of data accuracy. The drawback of a historical baseline is that conditions may change over time other than those predicted by the historic trend. This can affect the BAU scenario so that the deforestation and/or degradation rate may be considerably higher or lower. Accordingly, the change of rates would then influence the effectiveness and efficiency of any REDD activity.

Given this uncertainty, it is argued that a historical baseline approach should be adjusted with a so-called Development Adjustment Factor (DAF) (see Figure 2.5(b)) that takes into consideration changing circumstances explicitly or implicitly affecting the BAU scenario. The DAF is used to adjust the deviation from past trends with higher or lower deforestation and/or degradation rates. However, a downward correction of the rates implies a lower return to the ES provider (seller) and would probably face political resistance because the DAF itself may be subject to uncertainty.

In order to increase transparency and reduce uncertainty the projected (modeled) baseline is applied as a third reference option. The approach intends to predict future developments and makes use of a set of available computer-based models (e.g., Busch et al., 2009). Economet-ric models that take into consideration underlying socio-economic, infrastructure, biophysical and/or other factors for projections are the most common (e.g., Muñoz Piña et al., 2003). However, each model is equally as good as its assumptions and input data, and is therefore limited by its design and selected scale (Ogonowski et al., 2009; Parker et al., 2009).



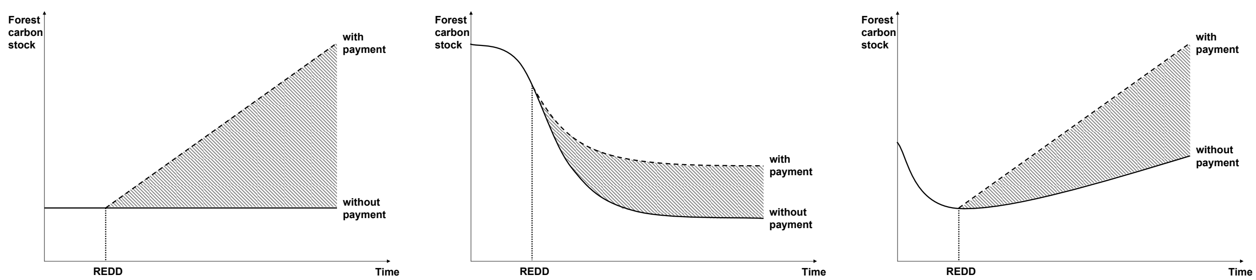
(a) (b)

Figure 2.5.: Historical baselines: (a) Historical simple baseline (b) Historical adjusted baseline
Source: Parker et al. (2009)

In brief, all three approaches have some probability to create so-called "hot air" credits. Hot air refers to the possibility that a REDD mechanism delivers ER benefits that in reality are partially or totally inexistent due to a false baseline assumption and inadequate MRV techniques. In other words, under a REDD regime it is assumed that GHG emissions have been additionally mitigated due to REDD activities, but in reality the development is attributable to activities different from REDD (Ogonowski et al., 2009); for example, deforestation rates decrease due to a serious fall in timber prices and/or demand. In order to highlight the importance of making the "right" baseline assumptions and their implications for effectiveness, three different scenarios are presented in Figure 2.6, where the shaded part in the graphs represents the amount of additionally sequestered and stored carbon. The first scenario is a static baseline (see Figure 2.6(a)) where forest carbon stocks are assumed to remain constant without project intervention. The low carbon stock indicates an open vegetation type, where the carbon stock can be increased through, for example, SFM, IFM or A/R activities. The difference is then attributed to this specific action and the additional amount of sequestered and maintained carbon qualifies for payments. Generally it can be assumed that this scenario is not a typical REDD situation but might be applicable to the "+" notion where SFM and IFM play a role.

The second situation is a deteriorating baseline (see Figure 2.6(b)) likely to be found in many tropical countries where deforestation and forest degradation is an integral part of development, and where the economy and/or a majority of the population depends on revenue streams from the primary sector. Thus, the dynamics of a declining baseline scenario mean that a halt or slow-down in deforestation and degradation qualifies for certified ER. The difficulty is to justify the baseline scenario against which to quantify the carbon benefits. This scenario is actually the main reason for the discussion of REDD as a GCC mitigation strategy.

A third generic baseline scenario (see Figure 2.6(c)) represents countries and/or regions in an advanced stage of development, where economic development is increasingly based on revenues from other sectors. It is assumed that this "progress" goes along with reduced pressure on the natural capital provoking a forest transition process. The consequence is a situation where forest cover is recovering, even without an explicit set of targeted interventions. An example for a *de facto* improving baseline scenario might be the "success story" of Costa Rica. This country is often cited as a pioneer and paragon for the implementation of PES schemes to halt deforestation. However, the magnitude of success regarding the effectiveness and efficiency has been questioned (e.g., Pagiola, 2008; Wünscher et al., 2008; Zbinden and Lee, 2005). The reason is that a historical turnaround of deforestation started in the early 1990s where deforestation decreased significantly before the national PES scheme was implemented from 1996 onwards. Thus, the figure of curbed deforestation actually is considered to be largely exaggerated.



(a) (b) (c)

Figure 2.6.: Baseline scenarios: (a) Static (b) Deteriorating (c) Improving
Source: modified from Wunder (2005)

Scale The REDD mechanism might be applied at a global, regional, national, sub-national, or local scale. Each scale typically has strength and weaknesses. However, local action is required, irrespective of the level, in order to convince landholders to execute a management system which preserves and enhances carbon stocks on discrete parcels of land. Generally, the global scale is the best yardstick to reduce the GHG concentration in the atmosphere due to three main advantages. First, it controls for global net ER originating from deforestation and degradation, thus providing certainty if REDD really makes a difference. Second, global accounting avoids the issue of leakage which is a problem for any lower scale since drivers of deforestation and forest degradation may move to other locations, which is difficult to control. And third, it allows for an equitable distribution of benefits, rewarding countries with historical low deforestation rates as well. Nevertheless, a global baseline requires accuracy in order to consider all the prevailing differences on each scale, which is further subject to cost-effectiveness and probably greater uncertainty of predictions.

Building the baseline at a regional level likely helps to create incentives for bilateral or multilateral REDD activities that complement global efforts or may even replace a global agreement. The advantage of regional schemes is that political consensus is easier to achieve and strengthens bilateral bounds amongst neighbors through coordinated action at the same time. The strength of such an approach is that deforestation drivers are likely to show a regional pattern, and thus collective action tackles the issue more effectively. However, the main challenges identified for a global scale also apply here. Although a number of regional carbon regimes are evolving, as presented in Section 2.1.2 for the North American case, the impact on global GHG concentrations still depends on a broad adoption of regions.

A national scale is probably the approach which most countries can agree to, because a national reference level has the advantage that countries can move forward according to their capacity and retain their feeling of sovereignty. At a national level it is further possible to reduce transaction costs since the state might already have institutions in place which can easily take responsibility in implementation and provide capacity-building for lower government levels. In addition, REDD can be streamlined with other public sector programs that might work complementarily in order to halt forest cover loss and impact on rural development. However, the drawback is that international leakage cannot be controlled and countries may face continuous capacity limits to host REDD.

A sub-national scale can be envisioned in two ways: jurisdiction or eco-region. The jurisdictional approach capitalizes on the existing governance of a relatively small manageable unit, for instance a State. Existing governmental infrastructure and civil society institutions may work effectively and more efficiently together in order to design and implement REDD adequately according to their in-depth knowledge of the circumstances, thus also having positive leverage from a transaction-cost perspective. The advantage of an eco-region perspective is that stratification into harmonized units allows designing and applying appropriate management strategies in order to confront a set of deforestation and degradation drivers that are probably similar across the consolidated region. Thus, the success does not entirely depend on a national or higher scale performance. However, leakage remains a serious concern in both proposals.

A local or project scale is equal to the already existing CDM and VCM project activities. Hence, REDD methodologies could build on the UNFCCC approved methodologies under CDM and employ the existing MRV structures of third party project validation and verification. Consequently, the individual success does not entirely depend on a national or higher scale performance at this level. Nevertheless, on the other end there exist several drawbacks, such as leakage concerns and transaction costs. Despite the concerns related to the project level approach, it is very useful in early stages in order to get things started and gain valuable lessons learned.

The so-called nested approach seems an appropriate interim solution to bridge the scales. The idea is to start on a project level in order to "pre-test" the mechanism and generate knowledge for the various stakeholders involved. Then pilot projects are scaled-up and incorporated into a higher scale, eventually to build up to a national system (Ogonowski et al., 2009). In this approach it is mandatory to develop guiding principles in order to harmonize MRV practices and reconcile accounting levels (New Forests Advisory Inc., 2011). The World Bank's FCPF provides an important contribution in that direction by selecting potential REDD-host countries for developing and financing REDD pilot projects (Ogonowski et al., 2009) such as Mexico. It is expected that selected countries are then in the position to develop the necessary capacity and scale-up their efforts to a national scale.

Leakage REDD, just like other policy instruments such as PES, is susceptible to the effects of leakage (spill-over). That is because although REDD activities might mitigate the GHG emissions at a specific location effectively, they may possibly fail to prevent the same for others (IPCC, 2000; Robertson and Wunder, 2005). The limited coverage of a program might cause a displacement of implicit and explicit drivers responsible for damages to the ES to another geographic area (Asquith et al., 2008; Claassen et al., 2008; Robertson and Wunder, 2005). Thus, leakage directly reduces the effectiveness of ES provision (Engel et al., 2008) and makes it an important issue for REDD in order to mitigate GCC.

Since leakage may occur internally and externally on different scales (local, sub-national, national, regional and international) it is often difficult to perceive. In general, four leakage types can be distinguished (IPCC, 2000): activity displacement, demand displacement, supply displacement and investment crowding. The difficulty is to accurately track these activities at different scales and determine whether the participant could have avoided this leakage (mostly when it is internal) or not (mostly when it is external). In the first instance, the program administrator would have to contemplate penalty measures, while in the second instance, liability would be dealt with on a higher governance level. Therefore, it is important that carbon accounting and MRV practices match with local conditions in order to detect drivers of leakage adequately and subsequently deduct a respective quantity from created removals or sinks of GHG emissions in order to guarantee the effectiveness of the mechanism (IPCC, 2000).

Financing of REDD

The permanence of financial sources is indispensible for assuring that created carbon benefits under REDD remain permanent as well. Thus, the finance mechanism used for the provision of a continuous incentive for REDD is of great concern. When exploring ways to finance REDD, some key design issues are relevant for the creation of sufficient financial sources and funding of countries with different capacities to host REDD (Parker et al., 2009). Five generic approaches are commonly discussed: fund-based, market-based, hybrid, phased and complemented.

The fund-based approach generally refers to the voluntary funding on a national and international scale. Voluntary funds are a common source in international development cooperation between developed and developing countries such as the Official Development Assistance (ODA) (Boucher et al., 2008; Keller, 2008; Parker et al., 2009). Considerable pledges have already been made under the UNFCCC, by Norway for instance, which mainly serve to create the necessary capacity within potential REDD-host countries to MRV related activities. The fund-based scheme is attractive because it provides incentives irrespective of success or failure in REDD activities, which implies that the situation of poor ES providers is not worsened, creating less moral objection than carbon offset markets, and offering more reliable funding (Keller, 2008). However, given the scale required for effectiveness, a single fund may not be sufficient (Keller, 2008; Parker et al., 2009), so the problem is then to attract guaranteed and predictable funding balanced with the intrinsic budgetary limitation. Furthermore, additionality concerns have been raised if ER achieved through voluntary funding does qualify for the fulfillment of compliance targets (Parker et al., 2009).

The second finance path is the "carbon market" where REDD certificates are traded based on supply and demand. The generated carbon credits can be used, for instance, by companies and national governments in order to meet their ER targets in a post-Kyoto Protocol, or in a jurisdictional, national or regional cap-and-trade system (Boucher et al., 2008; Parker et al., 2009). The market-based approach with certificates has the potential to raise a considerable amount of financial resources needed for the large-scale application (Keller, 2008) and is seen as an efficient environmental policy instrument (Bergen et al., 2002). However, others fear that the unlimited entry of REDD credits in a regular carbon market could provoke an access of relatively low-cost REDD credits where other more expensive project types have a competitive disadvantage (Ogonowski et al., 2007) so that several approaches are proposed to confront this concern such as quota, non-fungibility and price ceilings (e.g., Ashton et al., 2008; cited in Keller, 2008). If REDD is really as cost-effective as proclaimed by various authors (e.g., Palmer and Engel, 2009) has to be seen. The initial start-up and maintenance costs for REDD on the ground can be high and such a mechanism is not a one off action.

The third option is a mixed mechanism of financial sources. This hybrid approach suggests mingling features of market-based ER credits along with a fund for preparing countries on REDD-readiness, thus overcoming some of the individual drawbacks (Keller, 2008), and/or addressing market distortions (Ogonowski et al., 2007; Parker et al., 2009). Two variations are commonly reported in the literature: (i) a dual-market approach where ER generated through REDD is connected but not fungible with existing credited ERs, such as under CDM, in order to avoid the risk of flooding with REDD credits a single market and address concerns of permanence (Boucher et al., 2008; Parker et al., 2009; Ogonowski et al., 2007); and (ii) a market-linked approach where emission allowances are auctioned and revenues are used to finance REDD activities (Parker et al., 2009).

The fourth solution is the so-called phased-approach. Its rationality lays in the acknowledgment that each of the three previously mentioned financial focuses has both strengths and weaknesses depending on the phase of implementation (Parker et al., 2009). This approach is able to combine the benefits that each of the aforementioned approaches delivers and is applied on a time line separately for this purpose (Meridian Institute; cited in Parker et al., 2009). The Meridian Institute (cited in Parker et al., 2009) suggests that a country may undergo three main phases: (i) developing a national strategy, building capacity and implementing pilot activities which are financed by voluntary funds; (ii) implementing policies and activities stipulated in the national strategy and scaling up pilot activities which are financed by a market-linked approach; and (iii) implementing standardized MRV activities and paying for ERs delivered on a higher scale (e.g., national) which are financed by a market-based approach.

Finally, the complemented-approach is a slight modification of the previous alternative. This approach recognizes as well the need for different financial schemes depending on the level of progress (Union of Concerned Scientists; cited in Boucher et al., 2008; Parker et al., 2009). While the phased-approach seeks a sequence of steps, the complementary approach emphasizes that different sources can be used in combination, but changes the weight of each source over time (see Figure 2.7). The Union of Concerned Scientists (cited in Boucher et al., 2008; Parker et al., 2009) differentiates therefore three periods: (i) in the short-run the flexibility of voluntary funds can develop faster capacities for implementing REDD; (ii) in the medium-run more funds are needed in order to sustain REDD since leakage risks, non-additionality and MRV errors may limit the demand from a pure market system, and a hybrid approach is most suitable; and (iii) in the long-run, when capacity building has succeeded, a broad experience base is created together with a broad acceptance and adoption, so that a direct market provides the required magnitude and continuity of funding for REDD.

Distribution of REDD benefits

The idea of "conventional" REDD is to provide incentives that directly influence the avoidance of GHG emissions from LUC. Thus, the distribution of created REDD benefits becomes implicit to the selected approach for determining reference levels. Under this perspective, the urgent issues related to the distribution of achieved REDD benefits are the identification of the actual ES provider and proclaim explicitly the type of carbon benefits to be rewarded. It may also be necessary in some circumstances to assign parts of the benefits to others at possibly varying levels due to effectiveness, efficiency and equity considerations (New Forests Advisory Inc., 2011; Parker et al., 2009). It makes sense to introduce a redistribution and/or additional finance mechanism (different from marketed carbon credits) of REDD benefits especially in a situation

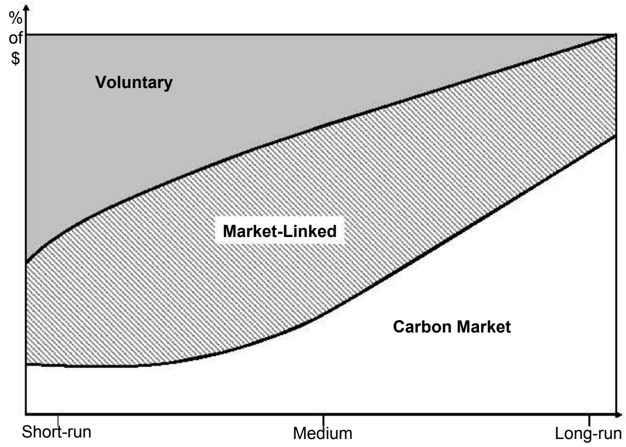


Figure 2.7.: Combined approach of REDD finance
Source: Boucher et al. (2008)

where a higher level baseline is applied against which individual lower level contributions are verified (Parker et al., 2009). Then, the applied benefit-sharing scheme has to elaborate on circumstances where one mechanism is more appropriate than another. Two major examples considered here are jurisdictional and global reference levels.

Jurisdictional accounting assumes that the existing institutional arrangement and relative homogeneity of land cover classes within a jurisdiction (e.g., State) favors a comprehensive REDD approach and represents an important intermediate step for scaling up REDD. The amount of created carbon benefits are then quantified against a jurisdictional baseline. However, policy-makers have to decide if credits are issued to the jurisdiction and/or nested projects (New Forests Advisory Inc., 2011). Consequently three constellations for benefit distribution are possible. In this constellations different issues regarding adequate incentive structures for stakeholders come up that may require the redistribution of benefits or additional financing. First, if credits are only issued to the jurisdiction, the regime has to regulate if the administration is required to redistribute credits to local REDD activities and if incentives are still provided to nested-projects that effectively create ER while the jurisdiction as a whole stays above the baseline (New Forests Advisory Inc., 2011; Parker et al., 2009). Second, if credits are issued to both levels, the accounting has to be reconciled against jurisdictional ER (New Forests Advisory Inc., 2011). And third, if credits are only issued to projects, the administration also has to be compensated for the continuation of activities that support REDD such as MRV activities and policies against leakage within the jurisdiction (New Forests Advisory Inc., 2011; Parker et al., 2009).

The introduction of a global distribution mechanism is highly complex because countries face different national circumstances regarding the subject matter (Keller, 2008). These differences imply that countries having demonstrated good forest stewardship in the past do not benefit from a conventional REDD mechanism (see Figure 2.3). However, High Forestcover Low Deforestation (HFLD) countries could advocate that compensations are appropriate for their past action and renouncement of future development benefits derived from expanding primary sector activities. The rationality of considering HFLD countries and extending the concept of REDD is not only equality but also the concern of addressing international leakage. When REDD proves to be an effective and efficient instrument in a participating non-HFLD country, then deforestation drivers, such as logging companies, might move to a HFLD country which didn't qualify under a conventional REDD mechanism (Parker et al., 2009), thus creating a perverse incentive for and within HFLD countries. An alternative then becomes a global baseline where HFLD countries, generally located below a global baseline with their deforestation rate, benefit most compared to a conventional approach where a forest cover loss rate has to be demonstrated for eligibility. On the other end, countries with high deforestation rates receive considerably less since they are located above the reference level. This creates a distortion effect as well and may provoke a decrease of incentives for countries with high deforestation rates to reduce their emissions (Parker et al., 2009). Given the financial limitations of simple benefit redistribution in such high level accounting, a mechanism of additional financing may be the better solution in order to maintain a high level of incentives for both country-types. The establishment of a "stabilization fund" is frequently mentioned for filling the financial gap (Griscom and Cortez, 2011; Parker et al., 2009). The fund would be integrated into a "stock-flow" approach where ERs (flow) below a baseline are credited to participating non-HFLD countries, while a proportion of issued credits (or other funding such as ODA) is used to endow the stabilization fund where HFLD countries get compensated for maintained or improved carbon pools (stocks) as a function of the proportion of intact forest cover among participating HFLD countries (Cattaneo, 2008; Griscom and Cortez, 2011).

2.3.3. Remarks on REDD

REDD regimes will have to be constructed in a way that real ER is achieved through methods that guarantee effectiveness, efficiency and equality. As seen, the scope is paramount for achieving sufficient ER (effectiveness) where site-specific circumstances favor distinct "REDD removals and sinks" (efficiency) so that perverse incentives have to be addressed (equity). This can be achieved principally through the adoption of an adequate BAU scenario on a reasonable scale which assures that additionality is met with procedures that are in place to define reasonable time spans, identify indicators of change, and elaborate on when and how to review and adapt assumptions. While the specifications regarding scope and reference level are the two blocks that mainly determine the amount of ER created in a REDD regime, the financial sources predetermine the payable amount of compensation and the benefit-sharing scheme allocates this amount among participants. Sufficient funding is often a bottleneck for substantiating an extensive regime which is able to cope with local differences.

Given the complexity of the issue dealt with, three broad challenges will have to be confronted in an initial design and implementation stage - mainly at a national level. First, minimizing perverse incentives by adequately considering that deforestation and forest degradation may be provoked by a multitude of different and interrelated drivers (Ogonowski et al., 2009; Parker et al., 2009) such as the historic absence of internalizing externalities in decision-making, the lack of adequately defining land-use rights, the lack of supervision, the lack of law enforcement, and an excess of subsidies for agriculture and energy production (Karousakis, 2007). Second, the creation of capacity, continuity and enforceability of the REDD mechanism at all levels involved where capacity is of particular importance for monitoring systems, institutional development, technical assistance, training schemes and education programs (Karousakis, 2007; Parker et al., 2009). And third, MRV methodologies have to be put in place guaranteeing transparent, correct and accurate estimations of carbon inventories (Karousakis, 2007; Parker et al., 2009) with a tradeoff between spatial resolution (accuracy) and associated costs that generally increase proportionally to resolution (IPCC, 2000).

2.4. Permanence in a carbon regime

Permanence is a decisive and critical feature of GCC mitigation activities. It guarantees the environmental integrity of any (compliance, pre-compliance or voluntary) GCC regime. In general, it has been argued that changing energy supply, for example, from a coal-powered to a windmill-powered plant means that all potential CO_2 emissions are reduced to zero and effectiveness is achieved in the long-run. However, the existing regimes interpret and apply the permanence condition with a decreasing strictness from compliance to voluntary. In this regard, the particularities and complexity of LULUCF activities are exposed to critical reviews and different treatments. In fact, guaranteeing permanence is, perhaps, the toughest challenge for LULUCF approaches (Aukland and Moura-Costa, 2002) in order to compete equally among other mitigation alternatives termed permanent. The severeness of the permanence concern became obvious under the CDM, where it has led to the widespread failure of adopting A/R activities as offset projects. The problem is that in the first commitment period (2008-2012) CERs from A/R projects were only considered to be "temporal" (Kim et al., 2008; Marshall and Kelly, 2010). The reasoning was that LULUCF activities in particular may not last forever (Aukland and Moura-Costa, 2002; Marshall and Kelly, 2010) and may either release GHGs in the future (Fearnside et al., 2000) or require expenditures to maintain forest-related practices (Kim et al., 2008). It is argued that sequestering carbon or avoiding emissions from the biosphere are different from reducing GHG emissions from fossil fuels (Fearnside et al., 2000) in four ways (Kim et al., 2008; Marland et al., 2001): (i) permanence of created carbon benefits; (ii) saturation of carbon accumulation; (iii) verification of carbon benefits; and (iv) maintenance costs of incentivized practices.

The issue of permanence is a challenge for REDD if it is to perform in a market setting and find acceptance, especially under a compliance scheme. However, the complexity of the problem is not new and has been dealt with in PES literature (e.g., Engel et al., 2008; Pagiola, 2008; Wünscher et al., 2008), which makes it an interesting instrument for synergies to translate the REDD mechanism into on-the-ground action (Ogonowski et al., 2009). As under carbon regimes, PES considers permanence as the ability to achieve long-term ES provisions beyond a certain time frame (Engel et al., 2008). Thus, the "end of contract problem" is critical (Whitby, 2000) and requires reflection about the implications of actions that have delayed negative externalities compared to induced permanent changes in land-use practices. A payment scheme, such as a theoretic PES-REDD, is susceptible to changes in external conditions (Baylis et al., 2008; Wunder and Albán, 2008) such as population pressure, price increases in opportunity costs, and the lack of long-term funding. That means that it is up to the policy-design to respond adequately to these mostly socio-economic changes which have the potential to affect permanence. Institutional design solutions are varied but the treatment of permanence is mainly influenced by three generic choices (Aukland and Moura-Costa, 2002; CAR, 2010; Fearnside et al., 2000; Marshall and Kelly, 2010; Moura-Costa, 2002): (i) time frame and carbon accounting methodology; (ii) forest carbon stock reversals; and (iii) payment structure.

2.4.1. Time frames and accounting

LULUCF activities must result in long-term changes of CO_2 concentrations in the atmosphere in order to contribute effectively to GCC mitigation. It is emphasized that the impact evaluation is of particular interest for understanding the current damages caused by an additional unit of carbon in the atmosphere, as well as the impact of that unit during its stay in the atmosphere (Korhonen et al., 2002; Marshall and Kelly, 2010), considering different time horizons for any specific GCC mitigation activity (Fearnside et al., 2000). The first scientifically substantiated report on the issue is the "IPCC Special Report - Land use, Land-use change, and Forestry" (IPCC, 2000). This report was necessary due to a lack of adequate definitions and accounting rules for making LULUCF activities accountable under the UNFCCC (IPCC, 2000) and applying it effectively for mitigating the human-induced change of the natural rate of exchange of carbon between the atmosphere and the terrestrial biosphere (Aukland and Moura-Costa, 2002; IPCC, 2000; Korhonen et al., 2002). Since then, scientific-findings serve as a basis for the discussion on the best-practice to define what a permanent sequestration or emission avoidance is in terms of time frames and accounting rules for forest carbon stocks.

Time frames

The discussion about permanence in the LULUCF sector reveals that the understanding of "long-term changes" varies substantially. The scientific explanation from the IPCC shows that one ton of CO_2 emitted in the atmosphere requires at least ≈400 years to be completely re-absorbed by the biosphere. This scientific perspective makes it mandatory to think about the credibility of any LULUCF-based mechanism, since it upholds that the avoidance of fossil fuel combustion today by using another regenerative energy source is permanent (Fearnside et al., 2000; Korhonen et al., 2002). Notwithstanding, others argue that this might also be interpreted as non-permanent since "time leakage" is still possible in the future (Fearnside et al., 2000; Herzog et al., 2003; Moura-Costa and Wilson, 2000) and avoided or delayed emissions from the LULUCF sector can be interpreted as equivalent to avoided or delayed emissions from combustion of fossil fuels stored in the ground (Aukland and Moura-Costa, 2002; Fearnside et al., 2000; Moura-Costa and Wilson, 2000). The rationale is that economic considerations indicate that avoided emissions from fossil fuels today will lead to higher emissions in the future. This is because the price path of fossil fuel will be lower in the future as these inexpensive resources still exist. Thus, the basic long-term nature of the problem becomes the requirement of an institutional commitment to pursue a policy indefinitely with an intergenerational commitment (Herzog et al., 2003), or until fossil fuel burning is replaced by either technological alternatives or social changes (Fearnside et al., 2000). Hence, the ability to guarantee permanence of REDD benefits may demonstrate overall environmental effectiveness to bridge a time gap of societal change. This requires the maintenance of a minimum length of time and the impediment of a significant increase in GHG emissions from LUC after a specific incentive scheme is ended. However, there appears to be no unique way to consider time frames in a practical manner for LULUCF activities. The definition of a specific time frame for any accounting scheme has different implications for created REDD benefits (Aukland and Moura-Costa, 2002; Korhonen et al., 2002) so that it becomes more of a policy and less a technical decision in the end (Fearnside, 2002; Moura-Costa and Wilson, 2000). Nonetheless, defining a minimum required time frame is not necessarily the time period an ES seller has to maintain the agreed land use, it is rather a scale to quantify the magnitude of non-compliance, which may result in respective sanctions (Aukland and Moura-Costa, 2002). Since permanence is strongly associated with the duration of the LULUCF activity without reversals, different approaches have been suggested to quantify forest carbon stocks within a predefined period of time. There are four main theoretical time frames for permanence that have been proposed in the literature (Aukland and Moura-Costa, 2002; Marland et al., 2001) in order to define the required length of a LULUCF activity within agreed boundaries: (i) perpetuity; (ii) 100 years; (iii) a minimum (variable) time frame; and (iv) equivalence-based.

Perpetuity At first sight, perpetuity comes closest to the ambition of permanence. If applied, LULUCF activities which sequester carbon and/or avoid emissions have to be maintained forever (IPCC, 2000; Korhonen et al., 2002; Moura-Costa, 2000, 2002) in order to counteract atmospheric impacts from fossil fuel combustion (Aukland and Moura-Costa, 2002). It is implicitly presumed that a reversal any time in the future would completely invalidate created carbon benefits. The advantages of this viewpoint include the simplicity of not requiring sophisticated calculations of temporal values, environmental integrity and equal definition compared to mitigation strategies in other sectors (Aukland and Moura-Costa, 2002). The critics of perpetual time frames point out that it is impossible to guarantee the perpetuity of LULUCF activities (Aukland and Moura-Costa, 2002; Herzog et al., 2003); it creates a conflict with other land uses in the mid- and long-term (Aukland and Moura-Costa, 2002; Moura-Costa, 2000, 2002), there is no need to maintain the land use due to atmospheric decay patterns of CO_2 (Aukland and Moura-Costa, 2002; Marshall and Kelly, 2010), time spans beyond 100 years lead to decisions that are inconsistent with societal behavior (Fearnside, 2002), and fixation of a single land use may provoke interference in sovereignty of host countries (Aukland and Moura-Costa, 2002). Altogether, these objections highlight that such a time frame would rather impede a consideration of LULUCF activities, such as REDD, under a market-based carbon regime.

100 years If a 100 year time frame is applied, then LULUCF activities have to be maintained for that time period. This approach is consistent with the Kyoto Protocol's adoption of the IPCC's GWPs (Article 5.3) and the reference time frame (Decision 2/CP.3, Paragraph 3) for calculating the Absolute Global Warming Potential (AGWP) to measure the radiative forcing effects of different GHGs in CO_2 equivalences (Aukland and Moura-Costa, 2002; Fearnside, 2002; Fearnside et al., 2000; Marland et al., 2001; Moura-Costa, 2000, 2002; Moura-Costa and Wilson, 2000). The perceived advantages of this concept are its compatibility with the GWP calculation, simplicity in fixing a time span, most likely a reasonably long time frame to achieve GCC mitigation, and a finite rather than infinite consideration which jointly reduce concerns of sovereignty, future land-use conflicts and long-term guarantees (Aukland and Moura-Costa, 2002). Furthermore, 100 years correspond roughly to decision makers' explicit contact to the living generation, and a shorter time frame assigns a greater value to undesired effects within that time span (Fearnside, 2002). Despite these arguments in favor there are others which cast doubt on 100 years being considered permanent, and draw attention to the fact that such a policy-decision lacks any fundamental economic or scientific rationale (Aukland and Moura-Costa, 2002; Herzog et al., 2003). In the end, similar arguments as described under perpetuity make this time frame rather unattractive.

Minimum time frame The minimum time frame is indeed a modification of the previous approach. It is equivalent to the introduction of a crediting period (Aukland and Moura-Costa, 2002). If such a concept is adopted, an ES seller has the choice of interrupting the LULUCF activity after that period and claim only the amount of credits relative to the duration of the project (Moura-Costa, 2002). The duration (crediting period) may then also be variable and a function of project-specific operational time horizons (Aukland and Moura-Costa, 2002; Moura-Costa, 2000, 2002) which depend on project specific circumstances and biological cycles (Aukland and Moura-Costa, 2002). Examples of such a treatment represent the crediting periods for LULUCF activities under CDM and VCS but with distinct accounting rules. The positive implication of this approach is that an area has to be actively managed and monitored for only a limited time. This adds some simplicity and overcomes problems of pragmatic application of previous time frames (Aukland and Moura-Costa, 2002). However, an issue similar to the 100 year solution arises. The choice of a time period generally lacks a solid scientifically and economically based foundation, which makes it rather incompatible with the emphasis on long-term storage (Aukland and Moura-Costa, 2002). In addition, there is the difficulty that projects with different lengths would have to be harmonized for correct accounting, causing, ultimately, more confusion. And finally, this approach creates some inherent unfairness given that it reduces incentives for long-term land-use commitment and therefore weakens the obligation to guarantee the permanence of forest carbon stocks (Aukland and Moura-Costa, 2002). Altogether, the problem of temporal storage, as indicated for A/R performance under CDM, makes it rather unfavorable for a conventional market-based approach.

Equivalence-based The equivalence-based approach is envisioned as a circumvention of the permanence problem inherent to LULUCF. In this concept, LULUCF activities have to be maintained until the sequestered carbon or emission avoidance counteracts the effect of an equivalent amount emitted into the atmosphere (Aukland and Moura-Costa, 2002; IPCC, 2000; Moura-Costa, 2000, 2002). This requires an understanding of the diminishing damage that one ton of CO_2 equivalence is likely to cause in the atmosphere, mixed with a policy-decision regarding the applied time frame (Aukland and Moura-Costa, 2002). The advantage of the concept is that it doesn't require LULUCF activities to be run for a pre-determined period of time (Moura-Costa, 2002), thus making it a choice of fairness to recognize that forest carbon credits can be equivalent to avoided emissions (Aukland and Moura-Costa, 2002). Notwithstanding, the critics of this approach complain about the lack of scientific foundation to quantify the environmental value and question environmental integrity (Aukland and Moura-Costa, 2002). A more practical problem, if applied in a market-based accounting scheme, is that the incentives provided to maintain LULUCF activities over time might be too low (Aukland and Moura-Costa, 2002), if not adequately encouraged by a respective payment architecture.

Carbon accounting methodology

Since forest carbon stocks have storage and time components with related non-permanence issues, it is of interest to understand the behavior of emitted GHG in the atmosphere and more specifically the time lag of reabsorption into the biosphere. The impact of GHG emissions on global warming has been described in general terms by the AGWP. The AGWP indicates the potential as "instantaneous radiative forcing of one ton of CO_2-e multiplied by the number of tons present in each year, summed over the years in the time horizon" (Aukland and Moura-Costa, 2002; Fearnside et al., 2000; Korhonen et al., 2002; Moura-Costa and Wilson, 2000). This insight has been further used to calculate an approximation of the decay function through the so-called (revised) Bern Model (Fearnside et al., 2000; Marland et al., 2001; Moura-Costa and Wilson, 2000). According to this model, the response of the atmosphere to an impulse emission of CO_2 has a probable non-linear decay pattern of atmospheric CO_2, where the residence time of approximately 20 percent exceeds 500 years.

This information is fundamental in order to determine the amount of created carbon benefits from different LULUCF activities (Fearnside et al., 2000; Moura-Costa and Wilson, 2000). It forms the basis for creating detailed and pragmatic carbon accounting rules (Korhonen et al., 2002) allowing parties to develop LULUCF activities such as REDD. Accounting methodologies must clarify how to measure the magnitude of any counteracting activity to the radiative forcing effect of carbon emissions (Aukland and Moura-Costa, 2002; Moura-Costa, 2000). Furthermore, the accounting system needs to provide appropriate incentives for these activities and allow for flexible land-use management practices (Aukland and Moura-Costa, 2002), while preserving the integrity of the carbon regime's objectives (Marland et al., 2001).

Estimating changes in forest carbon stocks in a way that accurately addresses permanence while minimizing the liability for any loss is a difficult task. Although finding a common accounting rule for expressing the climate benefit of different GCC mitigation activities is desirable (Fearnside et al., 2000), to do so is difficult, given the troublesomeness of comparing project activities among sectors. Several accounting approaches have been proposed (e.g., IPCC, 2000; Fearnside et al., 2000; Moura-Costa, 2000). In order to provide an overview of the main methodological options, four are presented in the subsequent section: (i) stock-change method; (ii) long-term average; (iii) ton-year accounting; and (iv) linear accounting.

Stock-change method The stock-change method has been adopted by the compliance market under CDM. Here A/R project activities obtain "long-term CER" (lCER) or "temporary CER" (tCER) carbon credits, which must be replaced after expiration so that price discounts usually apply (Olschewski and Benítez, 2005). While lCERs are valid for a fixed crediting period or renewable crediting period, tCERs last just for a commitment period. The method estimates forest carbon stocks as the difference between the baseline and LULUCF activity at a given point in time, usually expressed in tCO_2 per hectare (Aukland and Moura-Costa, 2002). However, this approach reflects just a point in time and does not recognize variability over time. Hence, different results can be obtained depending on species-specific tree growth, forest management practice and selected time of measurement; on the extreme end ES sellers can manipulate inventory results in their favor. The ES seller obtains credits as carbon is fixed or emission is avoided, and credits expire when CO_2 is released back to the atmosphere, irrespective of the period of storage (Aukland and Moura-Costa, 2002). From a climate science perspective this method produces a "zero-sum game" in which ES sellers must return all credits earned if the LULUCF activity is discontinued irrespective of the period of carbon storage or emission avoidance (Aukland and Moura-Costa, 2002; Moura-Costa, 2002). However, an inherent problem of the stock-change method is that it involves frequent exchanges of credits and debts between ES sellers and ES buyers (Moura-Costa, 2002). The consequence experienced in the compliance market (CDM) under the Kyoto Protocol has been that if permanent-coined alternatives exist and no quota is established for different mitigation activities, LULUCF project activities are at a disadvantage to perform in the market and face a low demand.

Long-term average The long-term average estimates the average changes of forest carbon stocks over time in a project area. The carbon value is generally measured and expressed as tCO_2 per hectare. This approach has been adopted by the VCS under the VCM. In this approach, baseline carbon stocks are subtracted from actual carbon sequestration or emission avoidance during the considered time frame and divided by the number of years equal to the time frame selected. The result is the ability to account for dynamics that are particularly likely in A/R projects and allows for comparison of different projects (Moura-Costa, 2000, 2002); thus, overcoming some of the problems previously mentioned in the stock-change method section (Aukland and Moura-Costa, 2002). As in the stock-change approach, a project receives credits as carbon is fixed but only until the long-term average is reached according to the selected time span (Aukland and Moura-Costa, 2002). The selection of the time frame remains subjective (Aukland and Moura-Costa, 2002; Moura-Costa, 2000, 2002) and if the activity is discontinued after the contract ends solutions which guarantee permanence still have to be found.

Ton-year accounting The ton-year accounting method calculates a proportion of the total amount of changes in forest carbon stocks which is considered to have a "permanent" climate effect. Then, the created carbon benefits are issued on a year-to-year basis over the project duration. However, the exact specifications of the accounting method may vary (e.g., Marland et al., 2001; Marshall and Kelly, 2010); the two main variations discussed in the literature are the Moura-Costa Method (Moura-Costa, 2000; Moura-Costa and Wilson, 2000; Moura-Costa, 2002), and the Lashof Method (Fearnside et al., 2000; Fearnside, 2002). In general, the concept acknowledges, "that delaying the release of carbon to the atmosphere deserves some credit regardless of the long-term fate of the carbon" and is greater the longer carbon remains stored in the forest (Fearnside et al., 2000; Marland et al., 2001). The basic idea is to determine an "equivalence factor" that converts the GHG effect of temporarily stored CO_2 to an equivalent amount of (permanent) avoided emissions (Aukland and Moura-Costa, 2002; Fearnside, 2002; Moura-Costa and Wilson, 2000). The factor is based on an "equivalence time" where temporary stored forest carbon prevents the cumulative radiative forcing effect of a certain amount of CO_2 in the atmosphere (Aukland and Moura-Costa, 2002; Fearnside, 2002; Moura-Costa and Wilson, 2000). Thus, ton-year accounting provides credits for temporary carbon sequestration or emission avoidance if a defendable time interval can be defined (Herzog et al., 2003). The main attraction from an ES seller's perspective is the "inexistence" of liability since only credits are issued that are considered "permanent", which makes LULUCF activities also comparable with other sector approaches.

Linear accounting The linear accounting approach is a simplified deviation of the ton-year method but with a distinct implication for liability. The method assumes that a time frame exists which is sufficient for the condition of permanence and assumes that carbon stock maintained over that period may be equally distributed over time (e.g., 1/100 per year for a 100 year time frame). Hence, in the case of a reversal the concept elaborates on the possibility of dividing the period of non-compliance by the required time frame and considers the resulting percentage of the carbon benefits as the portion a party is liable for (Moura-Costa, 2000). The general drawback is the absence of science-backed justification for such an approach (Marshall and Kelly, 2010). This method is not addressing the marginal rate of the damaging potential, which is likely to change over time. Hence, the simplistic approach probably causes questionable results making it an alternative that puts the environmental integrity of a carbon regime at risk.

2.4.2. Carbon stock reversals

Forest carbon stocks can be reversed through natural phenomena or human-induced activities. The possible reversal of carbon benefits represents a key characteristic of the LULUCF sector in contrast to other technological mitigation options (Aukland and Moura-Costa, 2002). They deserve further consideration since they are likely to reduce the environmental effectiveness of, for example, a PES-REDD scheme, however, the discussion around reversals is active and controversial. Besides clarifying the nature of a reversal, its detection requires the PES-REDD scheme to elaborate on who is the responsible party (responsibility), for what amount of reversed ES benefits (liability), and how the responsible party is affected by consequences (sanctions), or other instruments to overcome identified problems (technical solutions).

Avoidable and unavoidable reversals

It is important to determine ex ante which activities allowed in the forest areas are to be included in a PES-REDD scheme, specifically those which have the potential of increasing or decreasing carbon stocks, where the latter is generally referred to as a reversal. An important dimension in order to abstract consequences for the stakeholders involved is the nature of the reversal's cause, since it affects the equity and attractiveness of the instrument. It has been proposed that unavoidable and avoidable causes of forest carbon stock loss should be distinguished. Unavoidable reversals are generally referred to as an event where the ES seller virtually has no chance to prevent forest loss (deforestation and degradation). Thus, the main feature of the driver causing the loss is unintentional from an ES seller's perspective (e.g., CAR, 2010, 2011a,b). However, the exact definition of an unavoidable event is still debated since it very much depends on the context and its various dimensions. It is generally accepted that superior forces (*force majeure*) such as natural disasters (e.g., natural forest fires and hurricanes) belong to that category. A somehow more challenging question is whether forest carbon loss caused by a third party not directly linked to the ES seller is also an unavoidable reversal. The main hurdle here is to verify that there really has been no inter-linkage, especially in countries with weak governance. Accordingly, an avoidable reversal is the opposite in this dialectic interpretation. It refers to an event where the ES seller is in the position to prevent forest carbon loss. Thus, the main feature of the driver causing the loss is intentional from an ES seller's perspective (e.g., CAR, 2010, 2011a,b). However, what is an avoidable reversal similarly depends on the context which could vary. A generally accepted case is an ES sellers' induced LUC through harvesting without reforestation.

Responsibility

The responsibility for any reversal needs some clarification ex ante (Aukland and Moura-Costa, 2002), since created carbon benefits provoke a "permanent" liability if marketed as an offset (Korhonen et al., 2002; Marland et al., 2001). It has to be decided how time frames shorter than those foreseen and ending project cycles are treated (Korhonen et al., 2002). Several options exist to make a participant accountable for any reversal that occurs before a tCO_2-e is deemed permanent (CAR, 2010; Kim et al., 2008; Marland et al., 2001) and it may seem appropriate to guarantee the permanence of forest carbon stocks through shared responsibilities as discussed below.

ES seller In general, the responsibility for any reversal seems to be naturally attributable to the ES seller, since s/he creates a marketable service (forest carbon stock) on a discrete land parcel. It is assumed that s/he has effective control over the ES provision, which Wunder (2005) calls "conditionality". However, natural resource management is frequently subject to a collective property regime (e.g., Mexican *ejidos* or agrarian communities) with associated implications for conditional ES provision. Therefore, policy discussion has recently focused on incorporating aspects of the so-called social capital. The idea is to capitalize on pre-existing and/or developed community bounds (Ogonowski et al., 2009), which gained attention mainly in the Theory of Institutions and Game Theory. The hypothesis is that when policy approaches build on ES sellers' social capital, ES buyers can be confident that the agreed REDD activity is maintained permanently or at least for the duration of a committed period, so that intentional reversals are avoided and become even more cost-effective. Since the burden of an infinite liability to guarantee permanence must seem extremely unattractive to any individual or collective ES seller, it is appropriate to shorten that period or split the burden among other participants.

ES buyer On the other end, the ES buyer could be made responsible for any reversal. The ES buyer is normally referred to a group that has paid for and used the carbon credits in a particular carbon regime. The PES literature refers to such a scheme as user-financed, where buyers are often coming from the private sector. Here reversals would have to be replaced by the buyer, as is the case under CDM for carbon credits from A/R activities. Although this might be convenient for ES sellers, it has several drawbacks in a market approach in terms of attractiveness for buyers. Such a regulation would significantly diminish the value of credits originating from REDD activities. Increased transaction costs for the need of re-assigning corresponding contracts with every sale is of great concern here (CAR, 2010). Moreover, the administrative challenges of tracking the performance of different activities discourage the demand for REDD offsets. Hence, ES buyers would have a strong incentive to negotiate lower prices compared to credits from other sectors not subject to permanence issues.

Administration An alternative is to assign the responsibility for some reversals to the PES-REDD administration, especially in a government-financed set-up. But since the administrator is not necessarily the government, it is possible that other institutional designs involve the private sector, civil society (NGOs) and Intergovernmental Organizations (IGOs). The alternative is of particular interest when jurisdictional (or higher) accounting schemes are applied, thus recognizing that the success of REDD does not only depend on individual land-use practices of ES sellers but also depends on related sector policies which may represent the root-cause of LUC.

Third party The three preceding parties typically involved in a PES approach can be complemented with a third party solution that is also frequently found in other markets. A third party can be an insurer or holder of some sort of a performance bond. The liability for forest carbon stocks can be directed to a third party completely, partially or in different phases over the commitment period. Such an approach generally makes project development (ES seller's perspective) and credit purchases (ES buyer's perspective) more attractive and overcome problems of liability. Nevertheless, the third party would also have to work through the typical problems of insurance concepts such as asymmetric information.

Aggregation A modification of accountability, most likely attributable to ES sellers, is collective responsibility. Although this idea seems to be comparable to common property regimes, it differs as the intention is to aggregate individuals or groups that are too small to cost-effectively participate in a PES-REDD scheme. In a collective approach, individuals pool their exhibited risk of a reversal. An aggregator is needed who has the ability to group individuals, communicate between supply and demand side, and channel and distribute benefits accordingly. Aggregations can be different in nature and comprise, for example, jurisdictions and ethnic groups. However, if the time frame is very long for contracts and/or permanence considerations, it is rather difficult to estimate risk and magnitude of reversals in the mid- and long-run (CAR, 2010, 2011b). Furthermore, the estimation of risks for and insurance against avoidable reversals is a challenge. In the later case, collective responsibility for permanence may not be the correct instrument since non-compliance by a single group member results in sanctions to all members (Pagiola, 2008). The problem is that collective insurance against individual moral hazard is rather unlikely to find acceptance among ES sellers in an aggregation.

Liability

When defining responsibilities, an important aspect is to allocate the liability for the amount of reversed carbon benefits. Liability refers to the assigned obligation of maintaining created and rewarded carbon benefits for an agreed time span. Therefore, the PES-REDD scheme has to elaborate on the proportion of assigned liability in circumstances where the rewarded forest carbon stock gets lost earlier than contractually accorded or deemed permanent. Independent from allotting the responsibility for balancing the loss of unavoidable or avoidable reversals, as discussed in preceding paragraphs, there are three approaches for quantifying the amount a party is liable for: full, proportional or no liability.

Full Full liability for reversals means that if distributed carbon benefits (normally as carbon is fixed) are reversed, these benefits must be returned, replaced or compensated with the same total amount of initial carbon (Aukland and Moura-Costa, 2002; Moura-Costa, 2000, 2002). This method is related to the perpetuity time frame where permanence has to be guaranteed for an infinite amount of time (Aukland and Moura-Costa, 2002). This approach does not consider the temporal value of carbon sequestration or emission avoidance (Moura-Costa, 2000, 2002). It is rather simple since it is easy to verify that issued carbon credits get replaced, and thus conservatively guarantees also the environmental integrity of the carbon regime (Aukland and

Moura-Costa, 2002). However, this perspective considerably reduces the incentive to engage and/or maintain (particularly in the early phase) LULUCF activities (Aukland and Moura-Costa, 2002). Full liability is probably the least desired solution from the perspective of the responsible party. It might convert into a real "regret formulation" and cause adverse selection.

Proportional Proportional liability for reversals is debited from an amount of carbon benefits proportional to the difference between the minimum required time frame and actual duration of the LULUCF activity (Moura-Costa, 2000, 2002). This method is applicable if minimum finite durations are defined, but generally does not apply to infinite time frames (Aukland and Moura-Costa, 2002). The attractiveness of this approach lays in the fair recognition that temporary climate benefits should not result in full liability and consecutive sanctions (Aukland and Moura-Costa, 2002). However on the downside, there is some general concern about the environmental integrity of proportional liability since the climate-effects are difficult to prove with available carbon accounting methodologies and limited global involvement in GCC mitigation activities.

None No liability is an extreme option with mixed implications. On the one hand, this gives the participants some freedom in terms of right of recourse in case of a contract breach, but on the other hand, it questions the environmental integrity of the whole carbon regime (Moura-Costa, 2000). No liability in the case of unavoidable reversals could produce greater acceptance when a contract clause is included where participants have the chance to maintain all or partial benefits if they agree to restore the ecosystem (e.g., reforestation) likely to provide the ES. However, in the case of REDD benefits this probably causes some additional inconsistencies with the intended permanence of remunerated forest carbon stocks and challenges the correct carbon accounting.

Sanctions

In carbon regimes, it is common practice that compensations are withheld until compliance has been demonstrated with corresponding MRV activities. The MRV requirement forms the basis for remuneration of compliance but also justifies sanctions if any contract breach in the form of non-compliance (reversal) is detected. Assigning full or partial liability for issued carbon credits implies the establishment of a sanction catalog including the return, replacement or compensation of lost forest carbon stocks. Under several circumstances, it may also appear appropriate to complement the punitive measures with levels of escalation that affect program participation, and which may range between a simple warning to permanent exclusion (Wunder and Albán, 2008). Furthermore, the distinction between unavoidable and avoidable reversals implicitly requires different sets of consequences for forest carbon stock loss. Hence, the principal options for compensating any type of reversal typically include:

(i) reconciliation according to the magnitude of non-compliance through the retirement of an equivalent quantity of carbon credits (e.g., buffer pool); (ii) replacement of lost forest carbon through specific performance (e.g., replanting); (iii) application of a monetary penalty; (iv) exclusion of participants from future payments; and (iv) repayment of already disbursed payments by participants.

Technical solutions

In the case of non-liability, sanctions might not be necessary and may even become obsolete for ton-year accounting. Yet, where full or partial liability is assigned, several risk reducing strategies for permanence exist to complement carbon accounting rules, reduce regret formulations of sanctions, and increase the long-term attraction of a PES-REDD scheme. These measures may include internal and external approaches with mixed implications for the parties involved (Aukland and Moura-Costa, 2002; IPCC, 2000). None of these is an end in itself and their success and applicability depend on site-specific circumstances such as available resources, capacity, type of reversal, responsible party and liability. Some of the reported approaches include temporary crediting (e.g., Olschewski and Benítez, 2005), rental contracts (e.g., Aukland and Moura-Costa, 2002; Marland et al., 2001; Moura-Costa, 2000, 2002), insurance (e.g., MCII, 2012), buffer pool (e.g., Ogonowski et al., 2009), trusts (e.g., CAR, 2010; Neitzel, 2007), jurisdictional accounting (e.g., New Forests Advisory Inc., 2011) and long-term MRV (e.g., CAR, 2011a).

The VCM and PCM seem to especially count on self-insurance reserves like buffer pools in order to address permanence issues. This represents an internal approach of collective liability where premature loss of forest carbon stocks, mostly unavoidable in nature, occurring during the crediting period is replaced by the buffer (CAR, 2010, 2011b; Ogonowski et al., 2009). Buffer pools retain a certain percentage of generated and issued carbon credits, for example, according to the individual project risk of carbon reversal. Thus, risk-adjusted buffer pools spread the risk across a portfolio of LULUCF activities, which typically involves some sort of "risk assessment" at each verification event (e.g., CAR, 2011a). The percentage of risk may vary between two assessments and LULUCF activities with exceptional high risk deemed as non-eligible for crediting. The drawback of this approach is that after the contracted period, no further incentive exists to continue with the REDD activity. Options to overcome or partially solve this problem include seeking permission to enroll again and/or access to obtaining carbon credits kept in the buffer pool afterwards.

2.4.3. Payment structure

The continued ES provision over a certain period of time is a matter of permanence, and the approaches mentioned in the preceding section represent valid attempts to confront this. But as most research and intuition suggest, it is very important to complement these mechanisms with sustained payments over time in order to guarantee a long-term interest of ES sellers to maintain ES provision (e.g., Wunder et al., 2008). In this regard, policy discussion on carbon accounting often gets mixed-up with arrangements for commercialization of and payments for forest carbon credits (Aukland and Moura-Costa, 2002; Moura-Costa, 2002). Although interrelated, their implications are different and should be treated independently (Fearnside, 2002). While accounting methods quantify the amount of created carbon benefits for a time period (Aukland and Moura-Costa, 2002), financial transactions can occur at any point in time before or after the lifetime of a LULUCF activity (Aukland and Moura-Costa, 2002; Kim et al., 2008; Moura-Costa, 2002). However, the exact payment structure needs to be designed carefully in order to support the program's ability of guaranteeing the permanence of forest carbon stocks. In this context the combination of five components is of particular concern: (i) payment types; (ii) payment unit; (iii) payment level; (iv) differentiated payments; and (v) payment schedule.

Payment type

The nature of the payment represents an important variable when designing a PES-REDD scheme. Although, the type of compensation in PES is commonly cash (Engel et al., 2008), circumstances exist where in-kind payments (Asquith et al., 2008) such as material, training and technical assistance (Wunder et al., 2008) are attractive for the ES seller as well. In-kind payments are particularly interesting where limited capacities for savings, investment and entrepreneurship exist at a local level (Asquith et al., 2008; Robertson and Wunder, 2005), although ethical concerns are stronger when, for example, infrastructure development is discontinued due to non-compliance (Bennett, 2008; Ogonowski et al., 2009). Psychological research supports the perspective that low-value in-kind payment can be more effective than low-value cash payments in stimulating effort, since recipients are more likely to view in-kind transfers as compatible with reciprocal exchange and traditional local systems of "social markets" (Heyman and Ariely, 2004; cited in Asquith et al., 2008). But the attractiveness of in-kind benefits is not limited to rural conditions; as observed on the international level of REDD negotiations. For example, the so-called REDD-readiness process mainly provides incentives in the form of financial assistance and technological transfer in order to build national capacity and capability. Ultimately, the magnitude of any type of payment will be measured and put into the context of transferred money.

Payable units

A second feature characterizing payment is the nature of the traded ES itself. Carbon as such is probably the most homogenous among the four ESs discussed in Section 2.2 and mainly independent of the geographic area where it is created. This makes it relatively easy to introduce into a market scheme. But still, PES designers have to decide on the unit for remuneration as different approaches exist (Ogonowski et al., 2009). The distinct options of selecting a tradable unit for REDD payments have implications on effectiveness, efficiency, equality and political viability. A common alternative is to establish a price per tCO_2-e, which corresponds to the practice under CDM[4]. However, several circumstances may exist at lower levels which question this approach. For example, if the scale for REDD activities is national, it may be advisable to incorporate national circumstances and priorities into an internal PES-REDD scheme and modify unit and magnitude of payments accordingly. Mega-diverse countries, such as Mexico, may encounter a situation where the application of a price based on tCO_2-e implies that landholders within eco-regions of higher carbon content per area unit (carbon density) have a comparative advantage. Approaches that argue in favor of simplifying the scheme and introducing a forest type (e.g., pine versus broadleaf forest) perspective where payments are based on a hectare associated with a certain potential of GHG removal or emission avoidance do not change that. Both make sense from an effectiveness and efficiency perspective but might cause equality concerns and hamper political support. Marginalized and poor groups may be the ones that have smaller landholdings and own forest areas which carry less carbon stocks. Hence, equity considerations may call for adequate redistribution mechanisms and/or adaptation of the paid unit. Suggested modifications include payment based on a proportion of minimum monthly household income and fixed amounts per provider (Ogonowski et al., 2009). Again, these approaches may question the overall effectiveness and efficiency of the carbon regime.

Payment level

The intrinsic value of a created forest carbon unit through REDD activities is difficult to determine. The problem is that the value of the ES may be evaluated from different perspectives including biology, finance, ethics and philosophy. The focus of this thesis considers mainly concepts that relate to the theory of economic value, which in turn uses the cost of producing a good or service as a measure to denominate a value. The production value can deviate from the market value if the "product" is traded on a defined market where buyers and sellers interact with their supply and demand plans. These plans are coordinated by a market price and ideally lead to market equilibrium. Pricing can be explained by the mutual dependencies of the three market characteristics: structure, behavior and results (Bergen et al., 2002). In the end, a PES-REDD scheme follows such a market approach where supply and demand judge the value of the ES traded and form a price for it. The unit on which the price is based is, therefore, a crucial ingredient for achieving effectiveness and efficiency in a PES-REDD (Ogonowski

[4]Under the UNFCCC, the GWP and GHG inventories are reported in tCO_2-e.

et al., 2009), and is a delicate topic from an equity perspective. The pricing strategy has to elaborate on how to connect and structure paid amounts with verified forest carbon benefits from REDD in a transparent manner. Pricing can be calculated in different ways, thus, it is not always easy to draw a clear line between the alternatives. Below will be discussed market, opportunity cost and auction oriented approaches to determine price levels.

Market-oriented It is assumed that financial markets are able to establish the relative value of carbon credits efficiently (Marland et al., 2001) and represent an adequate instrument to leverage financial resources necessary to finance REDD on a global scale (Keller, 2008; Ogonowski et al., 2009; Parker et al., 2009). Yet, a liberalized market structure and the market participants' behavior may also create a market result which is less desirable from a REDD perspective. The buyer's WTP may be determined, in part, by rules established by the market's governing entity to ensure that impermanence risks are properly remedied, and if credits exhibit different degrees of adherence to the rules, these carbon credits may need to be discounted (Kim et al., 2008). The example of temporary crediting under CDM demonstrated that there are factors which represent real obstacles for forest carbon credits to perform in a carbon market. This is because the decision on a long-lived investment requires an estimate of the likely price path of the credit and compare the rate of return on that investment with other ways to invest the money (Herzog et al., 2003; Kim et al., 2008). So, the ES buyer's WTP is mainly subject to an assumed carbon price path for forest carbon credits and may take different forms mainly depending on presumptions such as the invention of backstop technology.

Opportunity cost-oriented Pivotal for the CDM market outcome (low demand and prices for forest carbon credits) is the market structure which emphasizes ES buyers' opportunity costs and undervalues the positive externalities created by improved and maintained forest carbon stocks. However, it is argued that if any carbon regime is to accept that forest carbon stocks should play an active role in an ETS, the focus of the pricing strategy needs to shift towards an opportunity cost perspective of the ES seller, which reflects the minimum participation constraint of the same. Respectively, the payment levels may significantly differ between REDD activities that seek to maintain or retire a current land-use practice, or intend to induce a different land-use practice (Wunder and Albán, 2008; Wunder et al., 2008). Thus, the offered payment level, when assuming rational agents (ES seller/providers) in terms of neo-classical theory, has to fulfill certain characteristics so that an ES seller is WTA. The payable amount has to exceed, or at least match, the sellers' opportunity costs (Claassen et al., 2008; Engel et al., 2008; Wünscher et al., 2008; Wunder and Albán, 2008; Wunder et al., 2008), thus, implicitly basing payment on ES provision costs (Wunder et al., 2008). An option to reduce the payment level is to incorporate the benefits that are associated with eligible activities under PES if they can be monitored at reasonable costs (Ogonowski et al., 2009). Then, the direct benefits are subtracted from the payable amount of the incentivized land use (if available) and should not exceed the ES value to the buyer (see Figure 2.8). Allowing participants to realize certain activities within the project boundaries provides additional monetary incentives to guarantee permanence, and alleviates suspiciousness and fear of masked expropriation (Ogonowski et al., 2009).

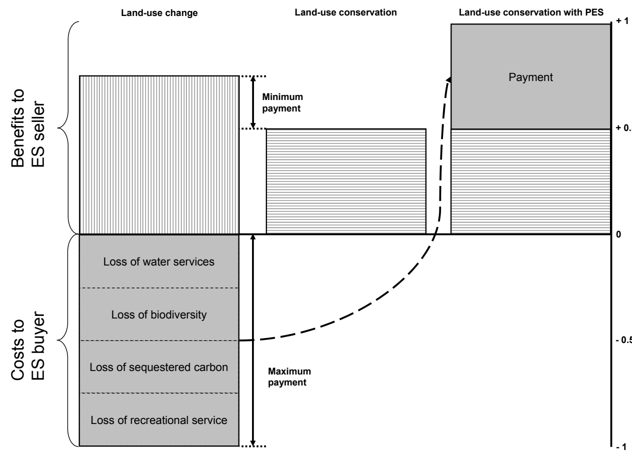


Figure 2.8.: Payment setting for a PES
Source: modified from Pagiola and Platais (2007; cited in Engel et al., 2008)

Auction-oriented The auction-oriented approach is also a market-based approach but uses a different mechanism to establish a price. Notwithstanding, the precondition for this method is a market structure that accepts forest carbon stocks as a bridge-technology (Herzog et al., 2003), considers it as a "perfect" prospect in terms of permanence (Kim et al., 2008), or introduces a quota for their purchase. Auctions have the potential of overcoming some of the asymmetric information problems frequently encountered in markets and help to specifically address adverse selection (Bolton and Dewatripont, 2005). Most promising in a PES setting is the use of procurement auctions as a revelation mechanism for opportunity costs of ES sellers (Ferraro, 2008). These auctions serve to offer contracts which help procure goods and services that do not have a well-established market (Claassen et al., 2008; Ferraro, 2008). Thus, auctions represent an effective way of increasing the programs' efficiency and retrieving information about ES sellers' WTA payment levels (Baylis et al., 2008; Claassen et al., 2008; Engel and Palmer, 2008; Ferraro, 2008; Muñoz Piña et al., 2008). This mechanism has the ability to reduce the incentive for ES sellers to inflate contract prices by applying bidding rules and market competition (Ferraro, 2008). Among problems which might hamper the application of auctions are the difficulty for ES sellers to understand the process (Muñoz Piña et al., 2008) and the strategic behavior of seller groups after the first round (Ferraro, 2008). The relative complexity of this approach demands great caution in its application.

Payment differentiation

The time span necessary to maintain payments (Wunder et al., 2008) and the availability of funds may represent a challenge (Ogonowski et al., 2009), especially where demand for program enrollment is high and administrations need to decide on the efficient allocation of scarce funds (Pagiola, 2008). Efficient fund allocation on the ground is frequently hampered because agents (ES sellers/providers) are not always acting rationally and amounts are often negotiated under political considerations rather than full economic assumptions. As a result, it is found that PES programs tend to use a flat and undifferentiated payment structure with fixed and low amounts per hectare (Engel et al., 2008), especially when government-financed (Pagiola, 2008; Wunder et al., 2008). This practice may be advantageous for the PES administration in terms of transaction costs (Wunder et al., 2008) and equitable concerns (Muñoz Piña et al., 2008; Wunder et al., 2008) in a strong politically charged arena, but runs the risk to be wasted where spatial circumstances are not homogenous and paid amounts do not counteract the BAU scenario (Pagiola, 2008) so that programs underperform and create social inefficiencies. The problem of undifferentiated payment schemes may occur on several occasions where (Engel et al., 2008; Engel and Palmer, 2008; Pagiola, 2008): (i) payments are insufficient to induce adoption of socially-desirable land uses because landowners have higher opportunity costs; (ii) landowners receive payments with low or even negative opportunity costs so that forests would have been conserved anyway; (iii) landowners receive payments with equal opportunity costs so that the incentive to enforce PES rules is low; (iv) payments induce the adoption of socially-desirable land uses but at a cost higher than the ES value; and (v) payments influence opportunity costs and increase them over time in the same location or elsewhere. The problem here to adequately detect these inefficiencies is related to the central issue of determining the correct value of the ES based on considered attributes. This requires customizing payment modes in a way that meets local requirements in a flexible manner while minimizing transaction costs for buyers and intermediaries (Asquith et al., 2008; Wunder and Albán, 2008). Therefore, policy makers must decide whether payments are static, flexible or a mix of both, and whether they are differentiated by location and/or adapted over time.

Targeting of locations may help to avoid the perception of introducing an arbitrary instrument and increase political acceptance. This is primarily concerned with the ability to achieve effectiveness, efficiency and likewise accommodate equity concerns. PES targeting of localities implies the inclusion of attributes in order to determine the spatial importance of locations and/or ES seller types. Once this is decided, the PES administrator has two options to operationalize a grading list for selection (Claassen et al., 2008; Ogonowski et al., 2009; Wünscher et al., 2008): first, to rank potential participants and select those that score highest, or second, to differentiate payable amounts based on single attributes or a mixture.

Furthermore, payments may be handled in a static or flexible manner over time. It is worth noting that a static approach implies some severe drawbacks when opportunity costs change over time. Opportunity costs might increase making LUC (moral hazard) more attractive, or they may decrease so that the PES-REDD scheme could run the risk of losing its efficiency. An updating (flexible) mechanism would overcome this issue, but it is possible that the magnitude and frequency of fluctuations may make it impossible for a PES scheme to catch up with these trends in real-time. One solution would be to update the payment level periodically (a mix of static and flexible) using timely limited contracts of, for example, a five-year duration (Muñoz Piña et al., 2008; Pagiola, 2008). This would provide the opportunity to adapt, while at the same time maintaining transaction costs relatively low.

Payment schedule

The type, amount and disbursement of payments over time affect the propensity of ES seller's conditionality. The frequency of payments plays an especially important role in developing countries where landholders are often the rural poor, which implies that they have a hard time accessing regular flows of income and are led by a strong incentive to make short-term decisions such as land-use conversion with low capital investment in order to generate income. In this context, different disbursement schedules have a distinct impact on the likelihood of behavioral change and ability to achieve permanence with (at least) timely limited conditionality (Engel et al., 2008; Pagiola, 2008). The main alternatives for payment schedules in terms of frequency and magnitude are found on a time axis which ranges from ex ante to ex post payments.

Futures contracts Upfront payments carried out with contract celebrations are equal to call or put options. Options to buy or sell are types of derivatives that can be traded by specialized environmental brokers enabling ES sellers to sell credits before they are actually generated (Fearnside, 2002; Moura-Costa, 2002). Examples are LULUCF activities that have been developed in partnership with stakeholders interested in the rights of carbon that will be generated during the project lifetime, effectively assuming the position of "equity investors" (Moura-Costa, 2002). The advantage of such practices is especially acknowledged in project activities such as A/R where initial investment costs and delayed revenue streams from sales can become a severe obstacle for ES sellers to take the risk (Bennett, 2008; Pagiola, 2008; Wunder and Albán, 2008). ES buyers are only able to use credits for compliance after they are fixed and contractual arrangements for allocation of liability are in place (Fearnside, 2002; Moura-Costa, 2002). High upfront rates take advantage of the ES seller's relatively short financial decision horizon where the subjective discount rate is likely to value present benefits comparatively higher than financial interest rates suggest.

Front-loaded The advocates of front-loaded payment schedules follow a similar logic as in the preceding approach. The argument is that in order to induce new land uses, front-loaded payments are needed since higher initial investment costs occur (Wunder et al., 2008), and high interest among potential ES sellers can be expected because of equally short financial decision horizons and subjective discount rates. It is likely that the payment mode is better able to cover financial risks at the development stage of the project activity. The continuous yet decreasing flow of benefits in the onset helps to bridge the financial gap until alternative income activities such as timber sales start to operate. But again, permanence is not "guaranteed" with continued direct payments over the whole contract duration.

Annuities The permanence of forest carbon stock implies its maintenance beyond saturation of additional carbon accumulation. In this context, annuities represent a probable preferred modality of steady financial stimulus and are most attractive in a setting where subscribers are labelled poor. Annuities are characterized by a forecasted total value that is distributed equally over the crediting period so that annual amounts are paid. Hence, the ES seller has a predictable access to a predefined amount. A modification is a multiple-year interval of disbursements, such as five years, in order to keep transaction costs manageable. Then, a carbon project only qualifies for carbon credit issuance after carbon stocks have been quantified and verified. Thus, this approach provides two main characteristics: predictable revenue streams over time, and payments only upon performance evaluation.

Tail-loaded In a tail-loaded payment mode payable amounts increase towards the end of a contract period. This implicitly means that ES sellers have a high interest in complying with the total contracted period. It also means that ES buyers are only interested in acquiring credits for which carbon has already been fixed and pay upon "delivery" (Moura-Costa, 2002), or later in order to increase the probability of contract fulfillment. In this case, the contractual arrangement establishes the obligation to store a certain amount of carbon for an agreed time frame with the consequence that the bulk payment at the end is reduced accordingly if a reversal occurs. However, a liability could still exist for the rest of the carbon after the project ends, even the total amount has already been paid (Moura-Costa, 2002) so that a policy-decision has to determine the magnitude of this liability. Tail-loaded payments make sense in a setting where the potential ES seller has no significant income pressure, i.e., the ES seller has a solid financial basis to sustain a livelihood and the outlook to obtain a high incentive payment at the end of the crediting period provides a high incentive to comply.

Ex post This payment schedule is in several ways similar to tail-loaded payments. The payment ex post at the end of the contract period is certainly the most desirable payment schedule from a permanence perspective. It is a way to improve conditionality effectively by adapting the payment to a contract time frame. Payments are withheld and disbursed upon contingent conditions of the land enrolled to a later point in time where the last carbon credit is also deemed permanent (Wunder and Albán, 2008). However, this presents a problem of the time dimension in combination with the need to cover (at least) start-up and maintenance costs, in which case, this option is probably applied only in the case of an exception.

3. Description of the context of the area of study

This research focuses on the context of Mexico. Mexico forms a part of the North American region, sharing its northern border with the United States of America, and its southern border with Belize and Guatemala. Its total national territory covers 196 million hectares (land cover: 194 million hectares), which ranks it at number 14 worldwide (CIA, 2012), about 5.5 times the size of Germany. According to the 2010 Census (INEGI, 2010), Mexico hosts a population of 112 million inhabitants, placing it 11^{th} in world ranking. Despite continuous population growth, the average rate has been decreasing since 1970, reaching 1.4 percent for the period between 2000 and 2010. This decrease implies a change in the distribution of the age structure, with the median age being 19 years in 1990, compared to 26 years in 2010. Illiteracy is on the decline, registered at 6.9 percent in 2010, remaining the highest in the age groups over 60 years, and is more pronounced among women 30 years or older. Indigenous languages are spoken by a minority of 6.7 million people (5.96 %).

The United States of Mexico (Mexico's official name) is a Federal Republic made up of 31 States and one Federal District. The Federal District, also known as Mexico City, is the capital of the country and is the focus area of this study. Mexico declared its independence from the Spanish Crown on September 16^{th}, 1810, but it was not until September 27^{th}, 1821 that the Mexican War of Independence ended. The executive branch of the country is led by a President elected by popular vote, who is both the chief of state and head of the government, with the power to appoint the cabinet. Legislation is carried out by a National Congress consisting of a Senate and a Chamber of Deputies. The members of the Supreme Court of Justice are appointed by the President, requiring approval of the Senate. Both President and the National Congress are elected for six-year term.

Mexico has a free market economy. It is an upper-middle income country with a GDP of about USD 1 trillion in 2010, which makes it the second largest economy in Latin America (WB, 2012). That same year, Mexico reported a GDP growth of 5.5 percent and an inflation of 4.0 percent (WB, 2012). The economy is increasingly dominated by the private sector, where recent administrations have expanded competition continuously (CIA, 2012). Since the signing of the North American Free Trade Agreement (NAFTA) in 1994, Mexico's share of USA and Canadian imports has increased continuously (CIA, 2012). However, the economy has been hit hard by the global economic crisis and the collapse of international trade since 2009 (WB, 2012). Mexico's GDP fell between 6.1 and 6.2 percent in the same year as world demand for exports dropped (CIA, 2012; WB, 2012). The subsequent Mexican recession was mainly the result of its heavy reliance on oil exports and trade with the USA (WB, 2012). But Mexico's economy recovered steadily soon after (CIA, 2012; WB, 2012). The rebound was driven by a general higher external demand (CIA, 2012) and more specifically by the recovery of US industrial production (WB, 2012). A key obstacle for stable economic growth in Mexico is summarized in the Global Competitiveness Report 2009-2010 (Schwab, 2009). This report ranks Mexico's competitiveness at 60 out of 133 countries. It is assigned this position due to the country's lack of respect for property rights; ethics and corruption; a lack of independence of its judges; favoritism in government decisions; governmental inefficiencies; the high burden of government regulations; its high costs to fight terrorism, crime and violence; and lack of reliability of police services.

The national census compiled by Mexico's National Institute of Statistics and Geography (INEGI, 2010, for its Spanish acronym) revealed that among the country's economically active population, the majority (73.4 %) are men, which matches with the observation that only 24.6 percent have a female household head. The economically active population is primarily occupied in the sectors of commerce and service (60.9 %), industry and construction (24.4 %), and agriculture (13.4 %). Most of the population (47.8 %) is living in urban centers of more than 100,000 inhabitants. Poverty and extreme poverty[1] continue to be a major problem for Mexico (WB, 2012). According to the National Council of Evaluation of Social Development Policy (CONEVAL, for its Spanish acronym) the number of Mexicans living in poverty increased by 3.2 million between 2008 and 2010 during the recession with around 46.2 percent of Mexico's total population (52 million people) living in poverty, mainly in urban areas (CONEVAL, 2011). Meanwhile, extreme poverty declined slightly in relative terms from 10.6 to 10.4 percent, but remained steady in absolute terms at 11.7 million people between 2008 and 2010.

Following this brief overview of the Mexican context, this chapter continues with an indepth analysis of four specific aspects related to: (i) the Mexican forest sector with drivers of deforestation and degradation; (ii) the study area itself, (iii) the Mexican PES program; and (iv) the Mexican Vision of REDD+. The case of the Federal District of Mexico, known as Mexico City, is introduced here with a description of the conditions related to natural resources, drivers of their depletion, and policies and institutions guaranteeing their conservation.

3.1. The Mexican forest sector

The Mexican forest sector has long been neglected since agricultural production and industrialization became a priority for the government. However, nearly 72 percent (142 million ha) of Mexico's national territory qualifies for forest growth (Ríos and García-Peña, 2001; cited in Ibargüen, 2003). The importance of the goods and services which Mexico's ecosystem forest provides is manifold, and relates to environmental, social and economical categories (CONABIO, 2006; Flores-Velázquez, 2005). Mexico is considered to be a mega-diverse country, hosting approximately 10 percent of the world's biodiversity, which ranks it fourth worldwide (CONABIO,

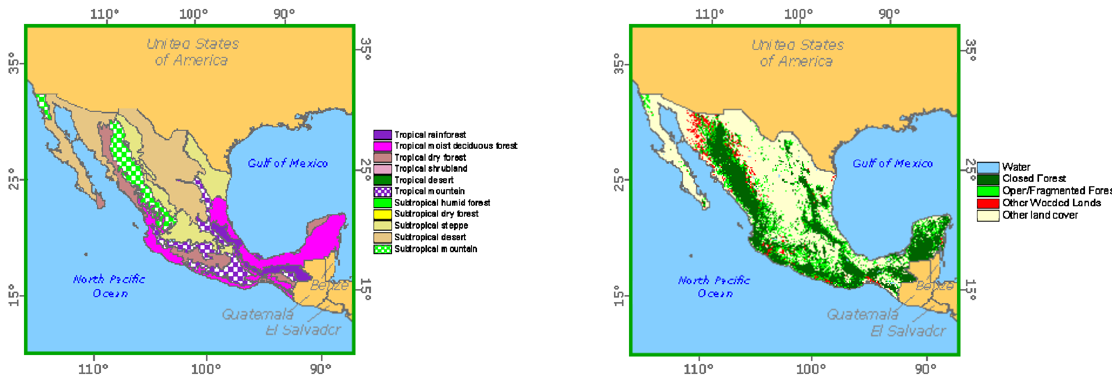
[1] Less than MXN 978 (USD 76) a month in urban areas and less than MXN 684 (USD 53) in rural areas.

2006; Flores-Velázquez, 2005). Forests offer multiple functions, such as carbon sink, regulation of micro-climates, soil erosion prevention and watershed protection (CONABIO, 2006; Millennium Ecosystem Assessment, 2005). Water is of particular importance for Mexico since its secure supply is a critical issue for cities and rural areas alike (Flores-Velázquez, 2005; Muñoz Piña et al., 2008). Approximately seven million indigenous people live in rural areas which are main centers of biodiversity and water conservation (CONAFOR, 2010b), and approximately 12 million people occupy and depend directly on forestry sector activities (Alatorre Frenk, 2000). The natural resource base, managed mainly by agrarian communities and *ejidos*, is of great historical and cultural importance given the social particularity of Mexico's rural areas. An estimated 70 to 80 percent of Mexico's forests are governed by these common property regimes with a total of nearly 8,000 communities and 500 communal enterprises (Bray and Merino-Pérez, 2002, 2004). These social groups obtain a varied set of services and goods from the forests assuring a sustainable livelihood. It is not only this group that reaps an income from forest areas. Some of the timber and NTFP have a domestic and international market (Flores-Velázquez, 2005). Until 2007, the rural population involved in some agricultural or forest activity reached about 24.2 million people, which represents about 23.5 percent of the country's population (Secretaría de la Reforma Agraria, 2007; cited in CONAFOR, 2010b). Thus, forests provide direct and indirect use values for the people who have access to this resource.

3.1.1. Forest cover trends

Mexico's huge extension of territority coupled with its varied topography and maritime exposure (the Pacific Ocean, the Gulf of Mexico and the Caribbean Sea) have produced ecological zones that vary from tropical to desert (see Figure 3.1(a)). Furthermore, the different degrees of human-induced modifications have provoked multiple subcategories under the three general forest cover formations encountered in the country (see Figure 3.1(b)).

The global Forest Resources Assessment (FRA) 2005 compiled by the FAO (2005b) found that forests and other wooded land cover a considerable proportion of the total land area and that by the end of 2005 around 43 percent of the Mexican territory fell into this category (see Appendix A). The data also reveals that forest cover has declined from 85.7 to 84.1 million hectares between 2000 and 2005 representing a loss of 313.6 thousand hectares per year. Most affected was the primary forest and only partially resulted in an increase of modified natural forest, which implies a significant immediate loss of primary forest. One reason is that the main source for industrial timber has been natural forests and little effort has been made in the past to establish large scale commercial forest plantations (FAO, 2010). The plantation forestry sector in Mexico is still in a fledgling stage, despite the fact that the national forestry inventory reports that around eight million hectare are suitable for plantation forestry (FAO, 2010).



(a) (b)

Figure 3.1.: Land cover: (a) Ecological zones (b) Forest cover
Source: FAO (2000a,b)

Although the government initiated an incentive program for the establishment of new forest plantations in the private sector (PRODEPLAN, for its Spanish acronym) with regulations stipulating that commercial plantations can only be established on previously non-forested land (Boyd, 1998 and SEMARNAP, 1998; cited in FAO, 2010), this development is, so far, not reflected in the statistics of the FAO (2005b). It seems rather confusing why an increase in productive plantations coincides with a decrease in protective plantation.

The panorama changes somewhat when comparing the FAO data with forest area statistics recently published by the National Commission for Forestry (CONAFOR, 2010b, for its Spanish acronym) (see Appendix A). It becomes apparent that both do not necessarily match, eventhough they cover only slightly different time periods. The data from CONAFOR demonstrate that in 2007 the area of the forest ecosystem (only temperate and tropical forests) in Mexico has been around 65 million hectares. Compared to approximately 69 million hectares in 1993, that means a loss of about four million hectares over 14 years or roughly 279 thousand hectares per year between 1993 and 2007. However, as reported by the FRA 2005, deforestation rates have decreased. The data from CONAFOR are further disaggregated into primary and secondary forests with the respective area changes between 2002 and 2007. An alarming figure from a REDD perspective reflects the loss rate of primary forests at around 220 thousand hectares (almost 44,000 ha/a), which confirms the trend found by the FRA 2005.

Undoubtedly, Mexico is loosing its natural forest resource base at an elevated rate, but the lack of concrete figures for past deforestation makes it difficult to accurately assess the severeness of the problem comparing officially reported data to FAO (total wooded cover was 84 million ha for 2005) and official data from CONAFOR (total wooded cover was 139 million ha for 2007). In addition, the limited database of the accurate state of forest carbon stocks[2]

[2]For example, no growing stock statistics have been provided by the FRA 2005 (FAO, 2005d).

becomes an obstacle in creating an adequate baseline scenario, which would allow the adoption of a REDD mechanism. Consequently, deforestation rates published for Mexico fluctuate considerably (Flores-Velázquez, 2005). The severity of the challenge is visualized in Figure 3.2, which demonstrates that there is still a lack of adequate technology and methodology to guarantee a certain standard and comparability over time.

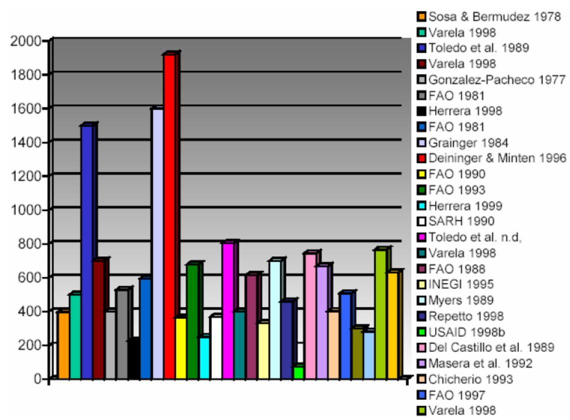


Figure 3.2.: Estimates of Mexico's deforestation rates (in 1,000 ha)
Source: Trejo (2010)

3.1.2. Trends in deforestation and degradation

In general, deforestation in developing countries is considered to be a problem of market failure. Because property rights are often not well-defined or enforced, the private cost of deforestation is effectively zero and people have no incentive to make efficient land-use decisions (Cropper and Griffiths, 1994). Ongoing and increasing population pressure are considered to be the most important underlying cause, and high figures in rural population density contribute to that tendency the most (Cropper and Griffiths, 1994). Although there is a minor controversy that population growth contributes significantly to environmental degradation, it is hypothesized that its effects can be balanced by economic growth and modern technology resulting in reduced land requirements (Angelsen and Kaimowitz, 2001; Cropper and Griffiths, 1994). The arguments are strong considering that a country with higher income is probably deforesting less rapidly because accelerated industrialization implies that labor is increasingly hired in non-agricultural sector, associated income growth allows people to switch to energy sources other than fuelwood, and modern agricultural techniques reduce the demand for agricultural land (Angelsen and Kaimowitz, 2001; Cropper and Griffiths, 1994). Hence, the hypothesis is that as income increases per capita people depend more and more on a different set of "capitals" for a sustainable livelihood, which reduces the pressure on the natural resource.

Nevertheless, the figures impose the question why a "trillion dollar GDP upper middle income" country like Mexico is still showing considerable land-use conversion. Although the loss rates are decreasing in absolute terms, it is questionable if the economic development of the country actually induces forest recovery effectively as generally suggested by forest-transition theory (Klooster, 2003). At first glance, it is surprising that the lack of water provision and deforestation are considered to be national security issues by the Mexican government (CIA, 2012), but current trends in forest cover loss have effectively resulted in soil fertility loss and erosion, an increase in poverty and migration, sedimentation of water streams, loss of ESs, and flooding and water shortages (Chapela, 2010; Magaña, 2010). Furthermore, the Mexican LULUCF sector represents the fourth source of anthropogenic GHG emissions with approximately 10 percent in 2006, where the change of forested areas to agriculture and pasture land, together with associated degradation processes, played a significant role between 1990 and 2006, although at a decreasing rate (SEMARNAT-INE, 2009). This decrease is related to lower rates of LUC in the categories forest to pasture land and degradation of intact forest to degraded forest (SEMARNAT-INE, 2009). But as demonstrated earlier, the loss rates between 2002 and 2007 are still alarming and it is still not confirmed that effective forest recovery is taking place.

Part of the problem of classifying the stages of Mexico's forest transition process is due to the difficulty of adequately identifying the drivers of deforestation and degradation on a national scale. They are generally interrelated with social structures, impoverishment and political economy (Korhonen et al., 2002). Hence, the panorama of cause and effect relationships of drivers which lead to deforestation and forest degradation and countermeasures in Mexico is not simple (see Figure 3.3).

Therefore, it is key to understand deforestation and forest degradation drivers in Mexico in order to formulate a successful GCC mitigation policy within the framework of REDD. It is mandatory that the factors which explain drivers of both processes at selected sites be identified. Regional differences must be addressed, for example, in local contract design, in order to curb deforestation and degradation effectively. The Mexican context is ladened with examples demonstrating that there is no single driver and that several forces act across the country at different scales. The direct drivers presented in Table 3.1 are rather self-explanatory. However, identifying the importance of these drivers in a rural setting and addressing them adequately is a major challenge. In a respective REDD mechanism, it is necessary to explain how a potential ES provider could completely reduce or prevent these drivers.

Several studies suggest that the most important vector for large scale LUC has been the conversion of forests to agricultural and grazing land (e.g., Muñoz Piña et al., 2008). Yet, the underlying causes are incoherent and mixed with inappropriate sector policies that have favored legal and illegal LUC in Mexico (CONAFOR, 2010b; Muñoz Piña et al., 2008). "Distribution centers" which in most cases finance illegal logging are an example (CONAFOR, 2010b). Hence,

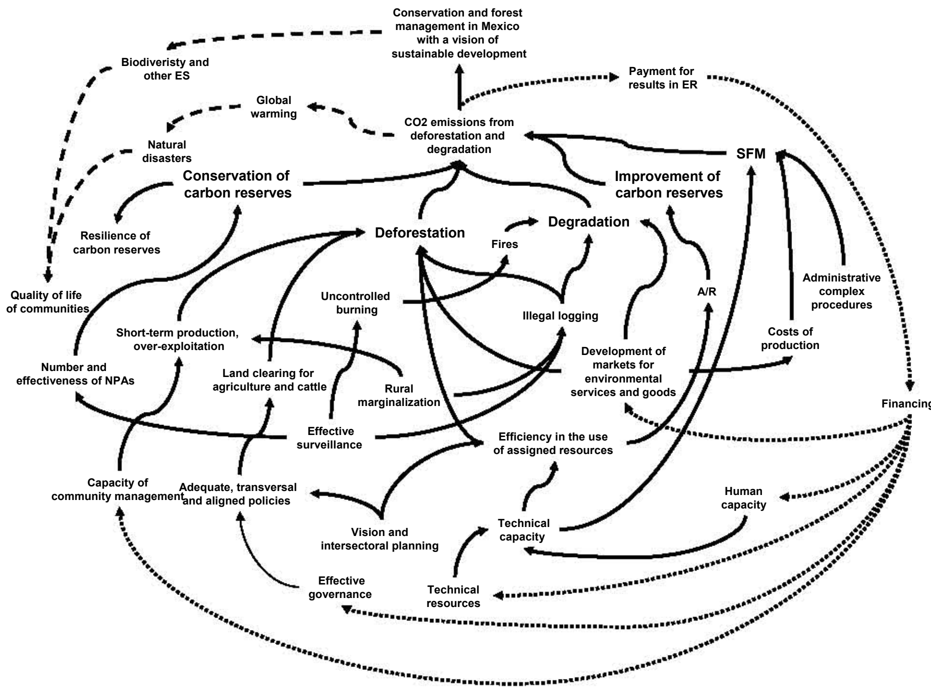


Figure 3.3.: Deforestation and forest degradation drivers in Mexico
Source: modified from CONAFOR (2010a)

Table 3.1.: Explicit vectors of deforestation and drivers of degradation

Deforestation	**Degradation**
Conversion of forests to agricultural land	Degradation of forests through illegal logging
Conversion of forests to pasture land	Degradation of forests through forest fires
Conversion of forests for urban uses	Degradation of forests through fuelwood collection
Conversion of forests for industrial uses	Degradation of forests through NTFP collection
-	Degradation of forests through natural disasters

Source: modified from Chapela (2010); CONAFOR (2010b); FAO (2005a); Magaña (2010)

the main causes of deforestation and forest degradation relate to structural problems which vary on a sub-national level (CONAFOR, 2010b). It is, therefore, insufficient to look only at explicit drivers to explain these trends. The implicit or underlying causes of conversion patterns are often favored by a series of issues, which are more difficult to address explicitly with sector policies such as an incentive mechanism like REDD. The implicit drivers probably relate to the following three broad categories (Chapela, 2010; CONAFOR, 2010b; FIRA, 2007; Flores-Velázquez, 2005; Ibargüen, 2003; Magaña, 2010; Warman, 2001):

- Politics - Mexico has a groundbreaking history of internal colonization policies and land redistribution which began with the Revolution in 1910. Despite the importance of its achievements, this process has been accompanied by ineffective or even an absence of coordination between sectors within the same territory so that a high degree of deficiencies in control measures still exist. Different sectors and governance levels (federal, state and municipal) have designed policy instruments and made decisions based on distinct diagnostics which propose different objectives that are often contradictory, although elaborated for the same geographic region. Hence, regional development projects are carried out in an uncoordinated fashion where incentives and subsidies that actually favor LUC are provided (e.g., *ProCampo*).

- Economics - Difficult economic conditions in rural and semi-rural areas persist. Subsidy programs have created distorted price and cost structures for agricultural producers, and largely neglect the forestry sector. Consequently, NAFTA has hit the primary sector hard. Domestic forest products have a comparative disadvantage in both the domestic and international market since they have to cope with relatively high transaction costs and low productivity. Thus, the opportunities for employment are extremely limited in rural areas and do not provide a dignified standard of living for peasants working their land or future generations of young people. A considerable number of rural inhabitants have to satisfy their basic needs, which causes unsustainable productive activities offering a superior value only in the short-run and fostering illegal activities.
- Social - Governance of a considerable amount of forest resources is subject to common property regimes originating in the Revolution in 1910. However, the particularity of communal organizations in rural areas governing forests has not created "social peace". Conflicts over property rights, such as disputes over neighboring community limits, internal disputes about land distribution and illegal parceling are not unusual features. These conflicts partially have their roots in poverty and demographic change. As a consequence, it is widely observed that rural areas are abandoned and remittances reaching these areas are seldom invested into management activities of the natural resources. Instead, people who stay tend to rent their parcels for extensive cattle grazing.

In summary, the aforementioned points result in a generic causal relationship where governance, organizational and institutional ineffectiveness and inefficiencies at all levels lead to a general unattractiveness of legal natural resource use, inducing marginal agricultural activities, and illegal infrastructure extension, which significantly increases the pressure on land resources in the absence of incentives for sustainable management practices, which ultimately leads to deforestation and forest degradation.

3.1.3. Legal and institutional framework

In the past, the country's development, and especially its rural development, was closely associated with support for the agrarian sector. Thus, the forestry sector was largely ignored and with the introduction of free-trade agreements its poor state of development was revealed

(FIRA, 2007; Flores-Velázquez, 2005; Ibargüen, 2003). The legal framework of natural resource management in Mexico has only relative recently been modified in ways that acknowledge the need to manage not only the agricultural sector, but also look for ways of developing sustainable management approaches for forests (CONABIO, 2006). A description of the legal and institutional framework for natural resource management in Mexico is discussed below providing an overview of the framing conditions, existing legislation and policies, and the institutions which enforce them.

Legislation and policies

In Mexico, a set of legal instruments and public policies have been developed for the country's forest resources. Important federal laws applicable for this sector include the General Law of Ecological Equilibrium and Environmental Protection (LGEEPA, for its Spanish acronym), the General Wildlife Law (LGVS, for its Spanish acronym), The General Law of Sustainable Forest Development (LGDFS, for its Spanish acronym), the General Law for Sustainable Rural Development (LDRS, for its Spanish acronym), and the General Law for Agriculture (LGA, for its Spanish acronym) (CONAFOR, 2010b). Together, these create the legal basis for natural resource management in Mexico and provide the foundation for related programs and activities.

The three principal national forest programs are the Sectorial Program for Environment and Natural Resources 2007-2012 (PSMARN, for its Spanish acronym), the National Forestry Commission's Institutional Program 2007-2012 (PICONAFOR, for its Spanish acronym), and the Strategic Forestry Program 2025 (PEF, for its Spanish acronym) (CONAFOR, 2010b). They are complemented by programs designed for sustainable forest development and at times conflict with programs designed for the agricultural sector (see Table 3.2). Because GCC mitigation and adaptation require activities within several sectors, additional programs have been designed by inter-secretarial commissions to achieve transversality among public policies to confront the problems of GCC and promote sustainable rural development through the National Climate Change Strategy (ENCC, for its Spanish acronym), the Special Program on Climate Change 2009-2012 (PECC, for its Spanish acronym), and the Special Concurrent Program for Sustainable Rural Development (PEC, for its Spanish acronym) (CONAFOR, 2010b).

Recent developments and the debate related to the mitigation of and adaptation to GCC in particular have strengthened the efforts in public policy in relation to the forestry sector. This sector bagan receiving significant governmental support as of 1997 through different forestry programs (Ibargüen, 2003). However, the distribution of governmental funds for programs of the primary sector has been disproportionate in the last decade. In 2003, for instance, the total amount assigned to the forestry sector reached MXN 1,500 million (USD 133 million), while the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA,

Table 3.2.: Sector programs for forestry and agriculture

Forestry	**Agriculture**
Programa de Desarrollo Forestal Comunitario (PROCYMAF)	*Programa de Apoyos Directos al Campo* (PROCAMPO)
ProÁrbol: *Programa para el Desarrollo de Plantaciones Forestales* (PRODEPLAN); *Programa de Conservación y Restauración de Ecosistemas Forestales* (PROCOREF) with the integrated *Programa Nacional de Reforestación* (PRONARE); *Programa para el Desarrollo Forestal* (PRODEFOR); *Programa por Servicios Ambientales* (PSA); *Programa de Prevención y Combate de Incendios Forestales*	*Programa de Uso Sustentable de Recursos Naturales para la Producción Primaria: Conservación y Uso Sustentable de Suelo y Agua* (COUSSA); Biogenetic resources and biodiversity; Productive reconversion; Aquaculture and fisheries; *Programa Ganadero* (PROGAN)
Programa Nacional Hídrico	*Programa para la Adquisición de Activos Productivos*: Agriculture; Livestock; Rural development; Aquaculture and fisheries
Programa Nacional de Áreas Naturales Protegidas	
Programa "Hacia la igualdad de género y la sustentabilidad ambiental" 2007-2012	
Programa de los Pueblos Indígenas y Medio Ambiente 2007-2012	*Programa de Soporte*: Sanitary and safety; *Sistema Nacional de Información para el Desarrollo Rural Sustentable* (SNIDRUS); Technical assistance and capacity-building; Innovation and technology transfer; Inspection and vigilance; Aquaculture and fisheries
Programa de Conservación para el Desarrollo Sostenible (PROCODES)	
Sistema de Unidades de Manejo para la Conservación de la Vida Silvestre (SUMA)	
Programa de Fomento a la Organización Social, Planeación y Desarrollo Regional Forestal	*Programa de Atención a Contingencias Climatológicas* (PACC)
Estrategia de Cambio Climático para Áreas Protegidas	*Proyecto Estratégico de Seguridad Alimentaria* (PESA)
Programa Especial para la Restauración de las Cuencas de los Lagos de Pátzcuaro y Zirahuén en Michoacán	Automation of irrigation
Programa Especial para la Restauración de las Microcuencas en Zonas Prioritarias del Sistema Cutzamala y de la Marquesa	*Sistema Nacional de Recursos Fitogénicos*
Programa Integral de Conservación de los Recursos Naturales del Sur-Poniente del Distrito Federal	Creation and conservation of germplasm banks
Programa de Mecanismos Locales de Pago por Servicios Ambientales a través de Fondos Concurrentes	Development of arid zones
Proyecto de Desarrollo Sustentable para las Comunidades Rurales e Indígenas del Noroeste Semiárido (PRODESNOS)	*Programa Especial Concurrente para el Trópico Húmedo*
Programa de Conservación Comunitaria de la Biodiversidad (COINBIO)	

Source: modified from CONAFOR (2010b)

for its Spanish acronym) manages two agricultural development programs (*Alianza para el Campo* and *PROCAMPO*) which alone receive MXN 20,441 million (USD 1,815 million), which is about 13 times the funding dedicated to the entire forestry sector (Ibargüen, 2003). In comparison, in 2012 the budget assigned to the foresty sector reached MXN 6.8 billion (USD 549 million) and MXN 68.8 billion (USD 5,563 million) for agriculture[3]; ten years later the agricultural sector continues to receive funding 10 fold that of the forestry sector (SHCP, 2012). The most emblematic programs frequently cited in order to illustrate the evident antagonism between the institutions that support both sectors, are ProÁrbol run by the CONAFOR with a budget of MXN 6.5 billion (USD 521 million) and PROCAMPO[4] administrated by SAGARPA with a budget of MXN 18.3 billion (USD 1.5 billion) (SHCP, 2011, 2012). This obvious unbalanced distribution of funds is an example of how governmental action has affected LUC patterns as well.

Institutions of forest governance

The ownership of forests and other wooded land is roughly divided into public and other ownership. Looking at forest categories for the year 2000 (85.7 million ha), as reported to the FAO, some 44.2 million hectares (51.6 %) was publicly owned and 41.5 million hectares (48.4 %) fell under other ownership (FAO, 2005e). Hence, the government is one institution governing

[3]The budget for aquaculture, fishing and hunting is excluded here.
[4]Including expenses for aquaculture, fishing and hunting.

the forest resources of Mexico. The category of other ownership is varied but the most prevalant form is common property, or so-called agrarian nucleus. Since the Mexican Revolution of 1910, this particular form of land tenure has evolved in two forms of common property: *ejidos* and agrarian communities. These common property regimes of 29,011 regularized agrarian nuclei (27,214 *ejidos* and 1,797 agrarian communities) represent 99 percent of all communities of this sort, covering a total land area of 92 million hectares equivalent to 47 percent of national territory (RAN, 2011). Both types of forest governance are explained in greater detail below.

Governmental institutions Mexico created a number of governmental institutions to regulate and manage the environmental sector at the federal level. There are six institutions which are crucial for governing the primary sector in general, and which contribute to the construction of a REDD strategy in particular; although there are others which also hold a stake in this sector. The governmental institutions considered here are the SEMARNAT, the CONAFOR, the Attorney General for Environmental Protection (PROFEPA, for its Spanish acronym), the SAGARPA, the Inter-secretarial Climate Change Commission (CICC, for its Spanish acronym), and the Inter-secretarial Commission for Sustainable Rural Development (CIDRS, for its Spanish acronym).

SEMARNAT is responsible for the formulation and implementation of national policies concerned with the sustainable development of natural resources. This institution safeguards the congruence of national environmental policies with rural development. The mandate for that task is found in the LGDFS (Article 16, Fractions I, III and IV) (CONAFOR, 2010b). CONAFOR is subordinate to this Secretariat. It was founded in 2001 as stipulated in the Official Gazette of the Federation (DOF for its Spanish acronym) on April 4^{th} (DOF, 2001a) to participate, for example, in the formulation and application of national policies related to sustainable forest development, as well as organize and oversee the application of forest policy instruments. The mandate for these tasks is found in the LGDFS (Article 22) (CONAFOR, 2010b). Due to its mission and expertise, CONAFOR is the focal point for REDD+ programs and activities in Mexico.

PROFEPA was created in order to address and control growing environmental degradation in Mexico, not only in cities but also in its forests, jungles, coasts and deserts. On June 4^{th}, 1992, the DOF (1992) stipulated the internal regulation of the Secretariat of Social Development (SEDESOL, for its Spanish acronym) which legally created PROFEPA as a decentralized administrative body with the technical and operational autonomy to regulate hazardous industrial activities, pollution of soil and atmosphere, and oversee natural resources (PROFEPA, 2011). One of its main tasks is to increase enforcement of environmental regulations in order to contribute to the sustainable development of the country. Its responsibilities include monitoring compliance with stipulated laws, safeguarding the interests of the public on environmental issues, ensuring compliance with environmental laws, and punishing individuals who violate these moral and legal rules.

SAGARPA is responsible for the formulation and implementation of national policies concerned with the agricultural sector. Thus, it plays an important role in rural areas, often overlaping with forested areas (CONAFOR, 2010b). This institution operates various programs and components that promote rural development. Specific activities directed at sustainability include supporting the conservation and restoration of soil and water resources. Some activities promote the reconvery of areas that were previously used for intensive schemes of production. SAGARPA supports, where appropriate, perennial cropping systems and reforestation.

CICC is an inter-secretarial institution created to coordinate efforts among various sectors in order to confront GCC. It works with representatives of the following Secretariats (DOF, 2005): the Secretariat of Foreign Affairs (SRE, for its Spanish acronym), the SEDESOL, the SEMARNAT, the Secretariat of Energy (SENER, for its Spanish acronym), the Secretariat of Economy (SE, for its Spanish acronym), the SAGARPA and the Secretariat of Communication and Transport (SCT, for its Spanish acronym). The CICC invites in addition the Secretariat of Health (SSA, for its Spanish acronym), the Secretariat of Finance and Public Credit (SHCP, for its Spanish acronym) and the Secretariat of the Interior (SEGOB, for its Spanish acronym).

CIDRS is another inter-secretarial institution created to coordinate different sectors to promote sustainable rural development, while complementing the work of CICC. This institution works with representatives of the following Secretariats (DOF, 2001b): SAGARPA, SEMARNAT, SHCP, SCT, SSA, SEDESOL, the Secretariat of Agrarian Reform (SRA, for its Spanish acronym), the Secretariat of Public Education (SEP, for its Spanish acronym) and SENER.

Common property regimes The history of land tenure and land distribution in Mexico is unlike that of any other country. Mexico's Independence in 1810 was followed by a revolution one hundered years later in 1910. The Mexican Revolution emerged as a movement of the rural population who aimed to abolish the *Hacienda* system of large individual landowners and, thus, redistribute land among the rural population. Between 1917 and 1992[5], the Mexican Government managed to fulfil this promise and, in essence, redistribute land with profound changes in the country's land tenure structure (Warman, 2001). All natural resources, such as land, subsoil and the sea are public jurisdition where the State has the sole faculty to establish social or private property and retains the right of exclusion and disposal (Rosa et al., 2004). Article 27 of the Mexican Constitution defines common property in two important forms of land tenure: the *ejido* and the agrarian community. This article gives legal status to agrarian nuclei with constitutional rights of a legal person, whose beneficiaries have the right of free association, usufruct, lease, use, transfer rights, and carry out any other legal act which is

[5]The Agrarian Reform of 1992 essentially stopped the process of land distribution and the creation of new common property regimes since the Mexican Government recognized that no more land was available to distribute (Warman, 2001).

not against the law (e.g., Civil Law or Agrarian Law). Common property represents nearly 50 percent of all landholdings in Mexico today (RAN, 2011; Rosa et al., 2004), covering an estimated 70 to 80 percent of the country's natural forest cover (Bray and Merino-Pérez, 2002, 2004; CONABIO, 2006; Muñoz Piña et al., 2008; Rosa et al., 2004), including several types of priority areas such as Potential Water Reserves (RPA, for its Spanish acronym), Priority Hydrological Regions (RHP, for its Spanish acronym) and Priority Terrestrial Regions (RTP, for its Spanish acronym). According to RAN (2011), the size of the agrarian nuclei varies between less than 50 hectares (1 %) to more than 40,000 hectares (1 %) with about 49 percent falling into three categories: 201-500 hectares (18 %), 501-1,000 hectares (20 %) and 1,001-1,500 hectares (11 %).

This territory represents a common pool resource where agrarian nuclei have collective access, extraction, and management rights (Flores-Velázquez, 2005; Rosa et al., 2004). Land resource of common property regimes are termed private *ejidal* property for *ejidos* and private common property for agrarian communities (Spanish: *comunidad agraria*). *Ejidal* property was created when interest groups, often former *Hacienda* workers, requested permission form the Mexican President for cultivating a certain piece of land between 1917 and 1992. This was the outcome of the Mexican Revolution which was included in the Constitution of 1917 by President Venustiano Carranza. Agrarian communities were founded in a similar fashion with the difference that these interest groups, principally indigenous communities, had documentation and testimonies tracing that they have inhabited and managed their landholdings since colonial times. While this is the case for "agrarian communities of right" another exception exists where land can be requested when existing traditions correspond to the characteristics of an agrarian community called "communities of fact". In both common property regimes, the communal land is granted with an Agrarian Certificate (Spanish: *Certificado Agrario*) where the property is recognized and inscribed in the National Agrarian Registry (RAN, for its Spanish acronym). In general, both regimes distinguish internally the community land, dividing it into different categories based on land use and implications for access rights. While an *ejido* usually has three types of use (residential, communal and parceled land), an agrarian community distinguishes between two types (residential and communal land) (Agrarian Superintendence; Spanish: *Procuraduría Agraria*, personal communication 2011). Members of both regimes have the right to settle within the assigned residential areas and claim a percentage of communal land. The right to access communal land is individually granted with a Common Use Certificate (Spanish: *Certificado de Uso Común*) which recognizes each member, assigning a percentage of the area that does not correspond to a specific size or location within the territory. In general, a specific area is assigned for use, development and usufruct internally and respected by the community. In contrast, the individual parcel granted by an *ejido* is clearly identifiable with limits and size, and recognized with a Parcel Certificate (Spanish: *Certificado de Parcela*). In this case, the corresponding "owner" has the right to use, develop and enjoy the benefits of the parcel. Typically, both the Common Use Certificate and the Parcel Certificate are inscribed in the RAN.

Both property regimes have adopted the same basic organizational structure for representation internally and externally. In the General Assembly, the main internal decision-making organ meets ones a month, and community members elect a Presidential Council for a three-year term. The Presidential Council consists of a President, Secretary and Treasurer. As the community's external liason, the presidential council manages all issues related to the community. The community and the General Assembly respectively consist of community members who are formally registered in RAN and are assigned an individual registration number. This number is normally inherited directly from a parent or another family member, although family ties are not explicitly required. There is anecdotal evidence that community members may be in a situation where they are willing to sell their registration to another member of the community. In general, the number of registries is fixed and can only be passed on to one person. However, the General Assembly has the power to increase or reduce the number of members if adequate reasons exist and approval from RAN is obtained.

All registered community members have a voice and vote in the General Assembly of the community. In these meetings, members exchange information and make decisions related to the community. In theory, all registered members have an inherent land-use right. The right of access to common land is granted, but active use of the community's natural capital and resource extraction requires permission from the General Assembly and/or Presidential Council. It is not uncommon that in addition to registered community members, others - often relatives - also have access to the community's natural capital. Most families are often confronted with the problem that they are officially only allowed to pass on their heritage (the registration number and associated land-use right) to a single person. In a context where land represents the sole source of income or is oftne a back up for the well-being of a household, it is often the case that the registered family member is not the only one using the natural capital but that relatives also have access to the resource for cultivation, construction and other purposes (Warman, 2001).

In theory, the Agrarian Reform of 1992 states that an agrarian community has the same rights as an *ejido*. Thus, an *ejido* could become an agrarian community, and *vice versa*. However, two particularities between *ejidos* and agrarian communities exist. First, while an *ejido* is able to transfer usufruct of the land for up to 30 years to a third party on a contractual basis as stipulated by Article 45, an agrarian community is allowed to transfer the same rights to a third party without any time restrictions. Second, with the Agrarian Reform, *ejidos* - in contrast to agrarian communities - have obtained authorization to adopt Full Ownership (Spanish: *Dominio Pleno*) for land which has been parceled and granted a Parcel Certificate. Approval by the General Assembly[6] makes it possible for this land to be sold by the respective

[6]If the General Assembly is attended by at least 75 percent of its registered members in its first consultation,

ejido member to a third party. This process has been accompanied and supported by the Program for Certification of Ejido Rights and Titling of Urban Patios (PROCEDE, for its Spanish acronym) between 1992 and 2006, and afterwards, by the Supporting Fund for Non-Regularized Agrarian Nuclei (FANAR, for its Spanish acronym), who had the task of measuring the exact extension of the *ejidal* polygon and registered parcels. Agrarian communities were exempt from this process since it attempts to protect the identity of the common property which was founded on the basis of a "traditional" cosmovision called *tierra madre*.

3.2. Area of study: Federal District of Mexico

The world's population is urbanizing - moving from rural areas to urban centers - at an elevated rate. The rapid urbanization in the 20^{th} century has resulted in an impressive increase from 13 percent (220 million) in 1900 to 49 percent (3.2 billion) in 2005, a figure which is projected to reach 60 percent (4.9 billion) by 2030 (United Nations, 2006). This trend reveals that the well-being of a great part of the world population increasingly depends on the ability to secure an adequate level of, amongst others, ES provision in urban centers. There is a general perception that ESs are only provided by predominantly pristine ecosystems such as tropical forests. But not all ESs consumed by society are supplied solely by rural areas. In fact, ES provision from the immediate surroundings of urban centers have gained importance (Bolund and Hunhammar, 1999). What can be called the "peri-urban ecosystem" is characterized by slightly different features compared to the "rural ecosystem". These differences have to do with a more active landscape management. The peri-urban ecosystem provides a range of direct ESs that have a specific relevance for urban areas such as air filtration, micro-climate regulation, noise reduction, rainwater drainage, sewage treatment, recreation, cultural values, and other direct use values such as food production and erosion control (Bolund and Hunhammar, 1999). Thus, there is the potential that "natural" urban and peri-urban ecosystems contribute to increased quality-of-life of the population. However, features like rapid urban growth, inefficient resource use and limited recognition of the environmental value in peri-urban contexts cause problems on a local scale to maintain the ES provision. Public policy, so far, has paid less attention, especially in developing countries, on designing adequate policies that protect the natural capital in and around urban areas, and often sacrifices it for urban expansion one way or another. Nevertheless, the growing importance of a rural-urban interface has become more and more evident (Gutman, 2007). It is likely that the implementation of PES schemes in large cities may contribute positively to the provision of ESs (Wunder et al., 2008) which may have relevance not only in the local arena, but also in the global context.

and two thirds of the attendees are in favor, the process can be approved. If in the first consultation less than 75 percent attend, a second consultation is required. At the second consultation, 50 percent plus one of its registered members are required and approval is obtained when two thirds of the attendees are in favor.

Mexico is reflecting this global trend, moving from a rural country to one in which most of the population lives in urban centers (> 2,500 inhabitants). Migration from rural to urban zones, and more recently, the intense movement of people between cities are two forces that define the pattern of current population distribution in this country. The Metropolitan Area of Mexico Valley (MAoMV) is the largest urban settlement of Mexico with approximately 19.2 million residents (18.6 % of the total population). It includes the Federal District of Mexico, also known as Mexico City, with a population of 8.7 million inhabitants (almost 8 % of the total population) (see Table 3.3). The mega city is the country's political capital which is subdivided into 16 administrative units called Delegations (see Figure 3.4). The total area of Mexico City is 148,549 hectares (latitude 19°36'-19°02'N; longitude 98°56'-99°22'O), which is about 0.07 percent of the country's total land surface (INEGI, 2012). The territory is roughly divided into two land cover categories: urban and ecological. Most of the vegetation cover exists in the southern periphery of the Federal District, where the two communities selected for this study are located - in the delegations of Magdalena Contreras and Tlalpan. In the past, the population continuously increased in both of these delegations (see Table 3.3). This population growth is followed by peri-urban settlement growth and appears to correlate with urban marginalization of the city's surroundings as indicated by the National Population Council (CONAPO, 2005b, for its Spanish acronym) (see Appendix B). Consequently, the percentage of vegetated area has decreased at an elevated rate in both the Federal District as well as in the greater MAoMV (Ávila Akerberg, 2004; CORENA, 2011; Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005). This makes Mexico City a particularly interesting case to analyze given the option of guaranteeing the permanence of ES provision, and forest carbon stocks in particular, through a PES approach.

3.2.1. Vulnerability context in the periphery of Mexico City

The vulnerability context of the area of study is quite complex and difficult to grasp in all its details. The concept of vulnerability generally refers to trends, shocks and seasonality at different scales (local to global) which affect "exogenously", for example, the economic and physical well-being of people and makes their future somewhat uncertain depending on the local and "in-house" conditions (see Section 4.2.1). Both previously mentioned and interrelated indicators, level of marginalization and rate of natural area loss, reflect important (socio-economic and environmental) dimensions of the degree of vulnerability to which households and communities are exposed to in the periphery of Mexico City. In order to deepen the understanding for the contextual challenges of vulnerability in the area of study and its relevance for a successful environmental policy application (e.g., addressing water scarcity and/or GCC), this section exemplarily picks urban marginalization and forest cover loss as a central theme.

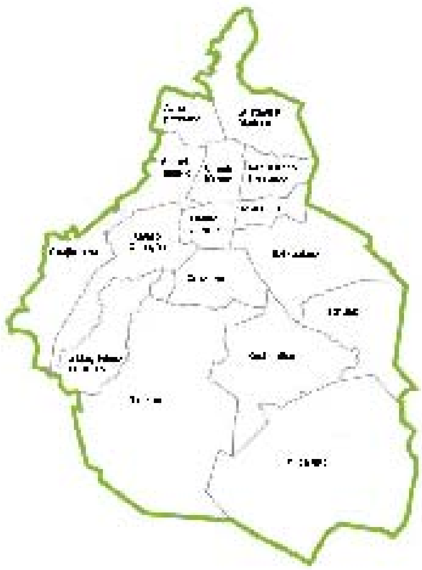


Figure 3.4.: Mexico City
Source: ZONU (2012)

Division	**Population** (in 1,000)			
	1990	1995	2000	2005
MAoMV	**15,564**	**17,298**	**18,397**	**19,240**
Mexico City	**8,236**	**8,489**	**8,605**	**8,721**
Magdalena C.	195	212	222	229
Tlalpan	485	553	582	608
	Annual pop. growth (in %)			**Total**
	1990-1995	1995-2000	2000-2005	1990-2005
MAoMV	**2.2**	**1.3**	**0.9**	**23.6**
Mexico City	**0.6**	**0.3**	**0.3**	**5.9**
Magdalena C.	1.7	1.0	0.6	17.4
Tlalpan	2.8	1.1	0.9	25.3

Table 3.3.: MAoMV - growth rate from 1990 to 2005
Source: CONAPO (2007)

Marginalization

The Urban Marginalization Index developed by CONAPO (2005b) suggests that Mexico City's surroundings are subject to higher levels of marginalization than the rest of the Federal District (see Appendix B). Urban marginalization is thereby characterized as an obstacle to sustainable human development where the overall impact of the hardships faced by the people is a result of lack of access to education and health, residence in inadequate housing and lack of basic necessities (CONAPO, 2005b). Therefore, high levels of marginalization in the periphery of Mexico City indicate a wide disparity in the participation of development processes and the enjoyment of its benefits. The level of social deprivation limits the opportunities for economic development and quality of life. The presumably low-income population inhabiting the identified areas lacks access to affordable and adequate land, housing and basic services so that the urbanization takes place in an unsystematic and unsustainable manner.

The marginalization in the context of study appears to be a phenomenon of trends in population growth and migration of the "poor" respectively (CONAPO, 2005b). As a consequence, illegal settlements exist and grow, especially in the periphery of Mexico City (GDF, 2012; Schteingart and Salazar, 2005). However, these areas are not always suitable for construction due to risks of flooding and landslides (GDF, 2012; Schteingart and Salazar, 2005). In addition, this development causes conflicts over the land resource. Although, land is mainly owned by common property regimes and construction of housing is subject to an approval process of the

Table 3.4.: Land-use change in the Soil Conservation Area of Mexico City

Land class	2003		2007		2003-2007		Vegetation loss	
	ha	%	ha	%	ha	%	%	%/a
Urbanized*	8,288.7	9.4	13,587.4	15.4	5,298.7	6.0		
Vegetation	80,153.3	90.6	74,854.6	84.6	-5,298.7	-6.0	6.61	1.65
Total**	88,442.0	100.0	88,442.0	100.0				

Source: modified from *Guillermo Aguilar and Santos (2011) and **Sheinbaum Pardo (2011)

government, illegal urbanization is frequent (Ávila Akerberg, 2004; Pérez Campuzano et al., 2011; PMRM, 2008; PMRE, 2008; Schteingart and Salazar, 2005). This situation indicates that law enforcement of a "zero urban expansion" policy (this will be further elaborated on below) is week and holds probably true for other types of infringement as well, adding to the vulnerability of groups interested in protecting their natural capital.

Deforestation and degradation

The ecological zone of the Federal District is referred to as the Soil Conservation Area (SC, for its Spanish acronym), and is granted an official protection status where LUC, especially urban expansion, is not permitted. Past development point to the fact that this natural area faces considerable pressure of being absorbed by urban development, which also pushes forward the agricultural frontier. It is estimated that the Federal District loses approximately 240 hectares of vegetation cover every year (CORENA, 2003; cited in Ávila Akerberg, 2004), a figure which may very well be higher (see Table 3.4). Consequences are negative externalities, such as air, soil and water pollution leading to a general deterioration of the mountainous ecosystem (PMRM, 2008; PMRE, 2008). Immediately affected are households nearby which face increased risks of flooding and landslides favored by high seasonal precipitations in the zone (GDF, 2012).

The major force causing this vegetation cover loss in the MAoMV, as mentioned earlier, is population growth which increases the demand for settlements. The associated driving factors are real estate interests, legal urbanization and illegal settlements (Ávila Akerberg, 2004; Pérez Campuzano et al., 2011; PMRM, 2008; PMRE, 2008; Schteingart and Salazar, 2005). The consequence of this is shrinkage of agriculturally productive areas, conflicts in land tenure and greater marginalization of the population (Ávila Akerberg, 2004; Pérez Campuzano et al., 2011; PMRM, 2008; PMRE, 2008; Schteingart and Salazar, 2005). Furthermore, the remaining vegetation and biodiversity of the zone has been affected by illegal deforestation and degradation, forest fires, lack of technical management, agriculture, livestock farming and gastronomic activities (Ávila Akerberg, 2004; CORENA, 2011; PMRM, 2008; PMRE, 2008). It is assumed that the natural forest itself produces no commercial income, at least legal, from timber sales for communities in the MAoMV. This assumption is justified because logging and timber sales from natural forests are prohibited by law (Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005). In general, illegal logging and timber transport are risky, although violations do seem to occur in the study area (PMRM, 2008; PMRE, 2008; Schteingart and Salazar, 2005). Therefore, timber extraction may be characterized as small-scale, unplanned and illegal activity in the study context. Nonetheless, there are commercial benefits aside from timber commercialization. Though prohibited, gradual LUC through the elimination of forest undergrowth and smaller trees towards pasture with scattered shading trees is somewhat more frequent (Schteingart and Salazar, 2005). Thus, the opportunity cost of maintaining forests is equal to the foregone optional net income from pasture or subsistence agriculture or urbanization.

3.2.2. Environmental policies

The legal and institutional framework at the national level (see Section 3.1.3) also applies in principal to the Federal District of Mexico. However, the framework is complemented by two urban-environmental regulations approved for the Federal District (Schteingart and Salazar, 2005): The Law of Urban Development of the Federal District (LDUDF, for its Spanish acronym) and The Law of Environment of the Federal District (LADF, for its Spanish acronym). Both are of relevance for the studied area and also affect the environmental policy instruments SC, Protected Natural Areas (ANP, for its Spanish acronym), and Program for Environmental Services (PSA, for its Spanish acronym) which are applied in the context of both common property regimes studied.

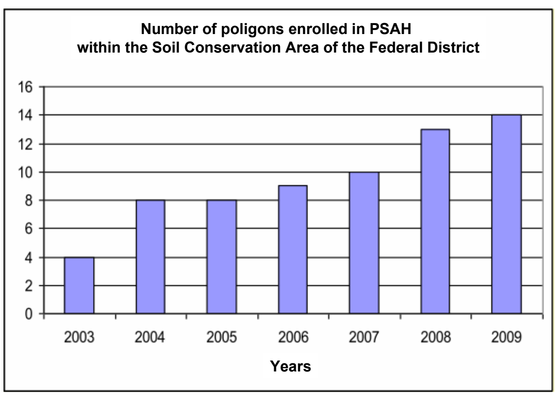
Soil Conservation Area The Federal District has adopted a policy distinguishing the city's territory into two land-use types: urban development and soil conservation (see Appendix C[7]). The so-called SC area corresponds to the ecological part of the city which became constituted by the General Program of Ecological Order of the Federal District (PGOEDF, for its Spanish acronym) in order to conserve the city's natural capital and regulate land use (GODF, 2000). The SC's main objective has been to stop urban expansion and preserve the natural characteristics of the city. Of the city's total surface about 58 percent (88,442 ha) corresponds to the SC (Sheinbaum Pardo, 2011), of which nearly 75 percent (65,403 ha) is property of agrarian communities and *ejidos* (Ávila Akerberg, 2004). The zones incorporated into the SC are mainly mountainous covered with forests, pasture and agriculture (Ávila Akerberg, 2004). The SC is the natural heritage upon which the survival and welfare of future generations of the Federal District depend, since this area provides ESs for the urban population (Ávila Akerberg, 2004; CORENA, 2011): capture and infiltration of aquifer water; regulation of the climate; improv-

[7] Map 1 from Schteingart and Salazar (2005) and Map 2 from GDF (2012)

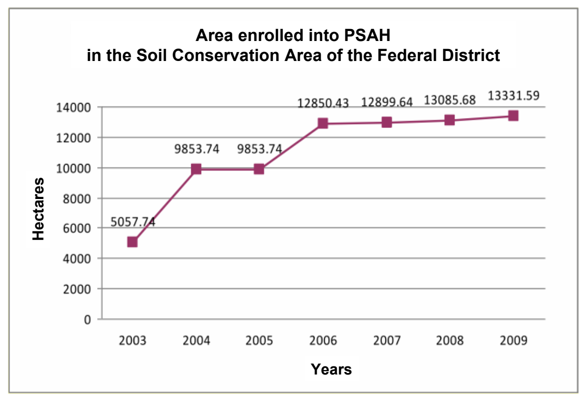
ment of air quality; provision of habitats for biodiversity; opportunities for education, research and recreation; and production of food and raw materials.

Proteced Natural Areas Most ANPs were established in Mexico under national jurisdiction in order to conserve the country's natural heritage. However, various subcategories exist, and others have been introduced at lower administrative levels. Consequently, several ANPs have been established in the Federal District (see Appendix C). Three associated administrative acts are of particular relevance for the studied communities. First, is a Presidential Decree declaring 3,100 hectares as Forest Protection Zone (ZPF, for its Spanish acronym) of Cañada Contreras, which corresponds to the natural limits of a mirco-watershed, called Magdalena River Watershed (MRW) (DOF, 1932). Secondly, a ZPF of the Magdalena River was declared by Presidential Decree in 1947 in order to protect the river and its immediate surrounding, and thus assure the operation of the Industrial Logging Unit the Loreto and Peña Pobre Paper Mill (in Spanish: *Unidad Industrial de Explotación Forestal para la Fábrica de Papel Loreto y Peña Pobre*) (DOF, 1947). The ZPF covers a stretch with a length of 12 kilometers and 500 meters on either side of the river, starting at the river's origin until the urban part of the city (Eguiarte et al., 2002). Neither of the first two administrative acts has been repealed, so that in theory the area continues to fall under its federal protection status. However, there is uncertainty involved in this jurisdiction since the National Commission of Protected Natural Areas (CONANP, for its Spanish acronym) does not consider the ZPF part of federal jurisdiction (Ramos, 2008), eventhough the Federal District in the PGOEDF recognizes the area as ANP consisting of 215 hectares (GODF, 2000). Meanwhile, 1,984.7 hectares of the Ejido San Nicolás belong to a third PA which was expropriated by the government in 2006 so as to maintain the area for ecological conservation (in Spanish: *Reserva Ecológica Comunitaria*) and integrated it into the conservation scheme of ANPs administrated by the Federal District (GDF, 2012; PMRE, 2008). Although these acts exist, they do not limit the studied *ejido* and agrarian community from participating in the national PES program. Yet, it is unclear if the communities received any additional compensation payment for these *de facto* expropriations.

Payments for Environmental Services The public policy instrument PES was introduced in Mexico nationally in 2003 (see Section 3.3). The PES scheme is also applied to parts of the Federal District's SC. Agrarian nuclei were included from the start under the concept of hydrological services called Payment for Hydrological Services (PSAH, for its Spanish acronym). Ever since, the program's scale has been continuously widened (see Figure 3.5) and mainly include areas at the southwestern border of the Federal District (see Figure 3.5(c)) where the two case studies are located. The Index of Marginalization (see Appendix B) and the Index of Deforestation Risk (see Figure 3.5(d)) have been two important indicators, amongst others (see Appendix D), to justify and target the enrollment of these peri-urban areas into the national PES scheme (DOF, 2011). However, the econometric model used for the construction of the Deforestation Risk Index has in particular been subject to criticism (Muñoz Piña et al., 2003, 2008). The application of national averages for agricultural opportunity costs in this model is likely to cause some bias, since local and especially the rural-urban interface has not been specifically considered and have probably higher opportunity costs. This means that the estimate of participation costs is likely inflated and weakens potential flexible payments in order to increase PES program's efficiency. Other limitations of the model are (Muñoz Piña et al., 2003, 2008): the cost of land conversion is not considered; circumstances where forests are found on economically marginal areas with lower potential agricultural productivity are ignored; and family labor is not deducted from opportunity costs assuming that there is no readily available income alternative.



(a)



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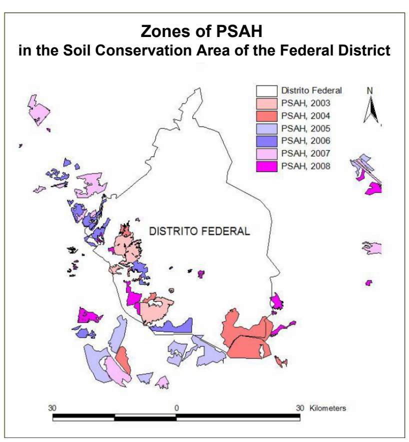

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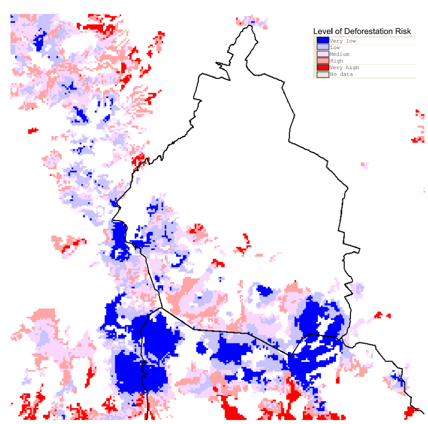


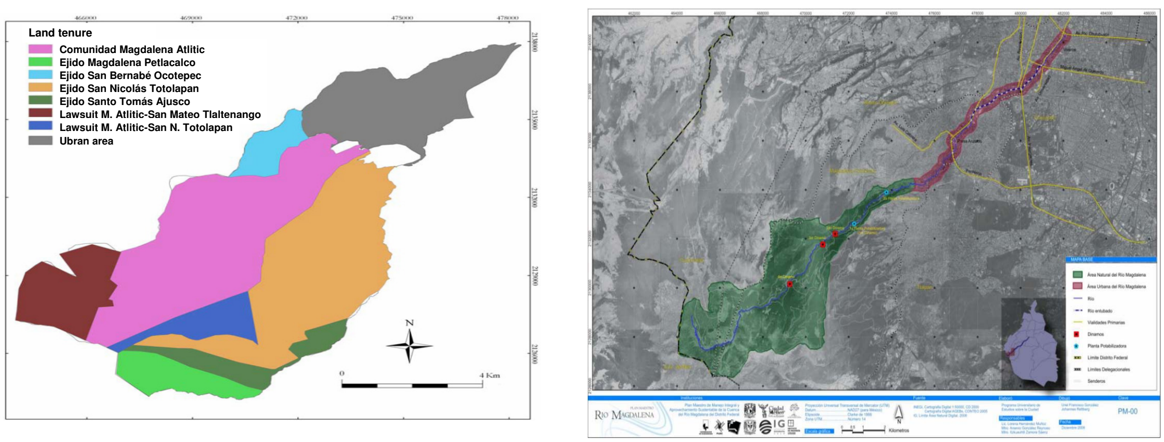
(d)

Figure 3.5.: PES in the MAoMV: (a) Number (b) Area (c) Map (d) Risk
Source: (a)-(c) Perevochtchikova (2010) and (d) INE; unpublished

3.2.3. Case studies: Southwestern Mexico City

The two communities studied are Magdalena Atlitic and San Nicolás Totolapan, located in the MRW (see Figure 3.6(a)). The adjacent communities are both common property regimes. Their communal lands form part of the Federal District's SC, are partially declared as ANP, and are also enrolled in the national PES program. These communities were chosen because they constitute the majority of the MRV which provides several important ESs (positive externalities) to the city and to the global society. The MRW is located on the southwestern periphery of Mexico City (19°13'48"-19°18'00"N and 99°14'24"-19°20'24"W; see Figure 3.6(b)) (Ávila Akerberg, 2002; Nava, 2003; Rzedowski, 1978). The landscape is characterized by an abrupt relief with altitudes ranging between 2,500 and 3,870 meters above sea level (Ávila Akerberg, 2002; Nava, 2003; Rzedowski, 1978). The associated emblematic tree species are oak (*Quercus sp.*) in the lower part, fir (*Abies religiosa*) in the middle part and pine (*Pinus hartwegii*) in the upper part (Ávila Akerberg, 2002; Nava, 2003; Rzedowski, 1978). The climate is sub-humid in the lower part (2,400-2,800 masl) and semi-cold in the upper part (2,800-3,850 masl) (Dobler, 2010). Precipitation ranges from 950 to 1,300 mm and the mean annual temperature falls between 4 and 15 $°C$ (Dobler, 2010). Soils are mainly Andosols (Álvarez, 2000). The MRW covers an area of about 3,000 hectares (Jujnovsky et al., 2010). Fed by numerous springs and tributaries, the Magdalena River is the most important perennial water runoff of the basin (Delegación Magdalena Contreras, D.F., 2012). The MRW is considered to be the last intact watershed within the MAoMV (Ávila Akerberg, 2009). It provides up to two percent of the water consumed in Mexico City, although the quality of the water is decreasing (Jujnovsky et al., 2010). The river flows 14.8 kilometers in this area, which is equivalent to 52.5 percent of its total extension and crosses forested areas of the SC (PMRM, 2008). More than 66 percent of the vegetation cover in this area is well preserved, and it contains 24 percent of the species of plants of the entire basin of Mexico City (Ávila Akerberg et al., 2008; PMRM, 2008). The Magdalena River flows into the urban area of Mexico City and is a landmark of the city.

The colonial period marked an important turning point in the mode of production in the MAoMV and in Mexico as a whole. In the 16^{th} century, concessions were granted to install textile machinery run by water mills on the banks of the Magdalena River where an intact forest cover contributed to a continuous water flow of the river (Acosta, 2001). During the 20^{th} century *Haciendas* started to appear in the periphery, which became major centers of recreation for the residents of Mexico City, while provided them also with a staple source of food (García Cubas, 1993). After Mexico's independence in 1810, people began to construct large factories run by hydropower installations where forests assured the steady water flow necessary for the generation of energy (Ramos, 2008). Local residents were employed in the factories, and agricultural production losts its importance in terms of local income generation and previously cultivated land parcels were slowly abandoned. After the factories stopped operating in the second half of the 20^{th} century, agricultural production was not revived to previous levels since the population was involved in various other economic activities that had developed. By the late 1990's there were considerable less hectares designated to commercial agriculture, and today agricultural activities are only pursued on a small scale mainly for subsistence farming (PMRM, 2008). During the 20^{th} century, a social reform known as the Agrarian Distribution (in Spanish: *Reparto Agrario*) pursued the recognition of community rights and allocated land to common property regimes. Although communities received a considerable amount of land, the vast majority of the community's members worked in the city and did not engage in significant commercial agricultural activities within the MRW (Jujnovsky, 2006; PMRM, 2008).



(a) (b)

Figure 3.6.: Magdalena River Watershed: (a) Communities (b) Watershed
Source: (a) Delegación M-C (modified by Ávila Akerberg, 2009) (b) PMRM (2008)

The MRV has been subject to severe changes in the past and today is under considerable pressure for LUC as is the rest of the periphery of the MAoMV. A study published by Schteingart and Salazar (2005) reveals that the southwestern part of the city has been particularly affected and in the case of San Nicolás Totolapan, its forest resources have decreased at an annual rate of about 1 percent between 1971 and 1997 (see Table 3.5) since urban expansion is continuously pushing the limits of the agricultural frontier. Although timber harvest is prohibited, the vegetation cover of the MRW shows strong signs of degradation (Ávila Akerberg, 2004; PMRM, 2008). The curbed regeneration process is mainly attributed to a lack of communal valorization of natural resource because the law prohibits managing these natural resource actively. Thus, comprehensive and SFM activity is not occuring on a meaningful scale. Forest fires have been frequent in the past and although the communities benefit from PSAH, grazing of cattle (approximately 14 percent of the forested areas is disturbed by induced grazing) is common in the upper part of the watershed, harming regeneration and water quality

Table 3.5.: Land-use change in the ejido San Nicolás Totolapan

Land class	1971		1997		1971-1997		Deforestation	
	ha	%	ha	%	ha	%	%	%/a
Urban	2.8	0.1	448.4	16.2	445.7	16.1		
Rural village	5.6	0.2	0.0	0.0	-5.6	-0.2		
Agriculture	363.5	13.1	469.0	16.9	105.5	3.8		
Scrub/grassland	147.1	5.3	196.7	7.1	49.7	1.8		
Secondary forest	219.2	7.9	134.6	4.9	-84.6	-3.1	38.61	1.48
Primary forest	2,036.9	73.4	1,526.3	55.0	-510.6	-18.4	25.07	0.96
Total	2,775.0	100.0	2,775.0	100.0		Prim/Secon	26.32	1.01

Source: modified from Schteingart and Salazar (2005)

(Ávila Akerberg, 2009; PMRM, 2008). Illegal dwellers in the SC further agrevate the negative processes detected in the watershed and unregulated economic activity such as tourism and restaurants contribute to the risk of soil erosion (PMRM, 2008; Schteingart and Salazar, 2005). Due to several administrative acts restricting natural resource extraction in the MRW, the main uses derived from the forests are related to recreation such as picnics, cycling, running and hiking, as well as spiritual and religious activities. Mushroom and fuelwood collection are activities related mainly to the basic gastronomy in the area and is undertaken in an uncontrolled manner. Although the area is not subject to planned forest management, locals claim that illegal logging takes place, but this has not been confirmed due to a lack of concrete studies on this subject (PMRM, 2008; Ramos, 2008; Schteingart and Salazar, 2005).

Agrarian community Magdalena Atlitic Magdalena Atlitic is a community located exclusively within the boundaries of the MRW and the Delegation Magdalena Contreras. It is an agrarian community according to Article 27 of the Mexican Constitution. The community holds the land title for the majority of the MRW. From 1535 on, land titles were granted to the indigenous community of Atlitic. In the 20^{th} century during the process of land redistribution, the community's land ownership was formally recognized. The first request was submitted in 1945 and finally approved by Presidential Resolution on April 2^{nd} and published in the DOF on April 7^{th}, 1975 (DOF, 1975). The land was granted to 1,779 community members (*comuneros*) and the polygon of common property comprised approximately 2,393 hectares (Community's President, pers. comm., 2010; Ramos, 2008); but there is land which remains in dispute with the neighboring communities San Nicolás Totolapan (693 ha) and San Mateo Tlatenango (357 ha) (Ávila Akerberg, 2004). The criteria applied in the census of the RAN validating the number of community members in Magdalena Atlitic is unclear, since "outsiders" from both the Federal District and other States have been included, while some native people have been excluded, so that two types of community members can be distinguished: legal members and "members *de facto*". The latter group corresponds to those who do not appear in the RAN but are native. Despite their omission during the census, they are acknowledged as part of the community and also comprise the successors of those registered and are normally relatives of the same. However, the omission of some is still causing considerable unrest and conflict in the community (Ramos, 2008). The Magdalena Atlitic community is organized in an autonomous fashion, gathering the first Sunday of each month in order to hold a General Assembly, which is the highest governing authority of the community (Community's President, pers. comm., 2010). The 1,779 community members have the right to participate and vote in decision-making. In reality, the community demonstrates little participation in decision-making and high levels of distrust (Ramos, 2008). Only 250 of the 1,779 registered community members attend regularly meetings and around 800 attend when polls are scheduled (Community's President, pers. comm., 2010). Most likely, the remainder corresponds to those who were counted by the census without being a part of the community, or members who have left the area. This seems to be one of the main obstacles for collective decision-making in the case studied (Ramos, 2008) because the Agrarian Law stipulates that decisions must be validated by 50 percent of the members plus one vote (Procuradurá Agraria, pers. comm., 2010).

Ejido San Nicolás Totolapan The second case studied is an area located within the boundaries of the MRW and the Delegation Magdalena Contreras with a small section in the Delegation Tlalpan. It is an *ejido* according to Article 27 of the Mexican Constitution. The *ejido* San Nicolás is the second largest land possessing community within the MRW. In the 20^{th} century during the process of land redistribution, the community's land ownership was formally recognized by a Presidential Resolution published in the DOF on April 29^{th}, 1924 (DOF, 1924; PMRE, 2008) and slightly changed on November 5^{th}, 1938 (DOF, 1938; PMRE, 2008). In the first resolution, 1,300 hectares of the Hacienda Eslava were recognized and 14 years later an additional 1,475 hectares were added from the Haciendas La Cañada and Eslava (Schteingart and Salazar, 2005). The land was given to 336 community members (*ejidatarios*) who are currently registered in the RAN (Ávila Akerberg, 2004). Although the community's polygon was initially formed with approximately 2,775 hectares (Schteingart and Salazar, 2005), the PMRE (2008) states that the community currently possesses only 354.87 hectares, since 435.43 hectares were expropriated between 1976-1997, and 1,984.7 hectares were integrated into the conservation scheme of ANP in 2006. As stated earlier, it is unclear if the process of land expropriation has been completed since the community continous to participate with a considerably larger land mass in the the national PES program. The community is organized autonomously and its members meet the last Sunday of each month in a General Assembly, which is the highest authority of the community (Community's President, pers. comm., 2011). The 336 community members have the right to participate and vote in decision-making. However, the community demonstrates some internal distrust and appears to be divided into two groups (Community's President, pers. comm., 2011). This feature appear to have caused a problem for the collective decision-making process because the Agrarian Law stipulates that decisions must be validated with 50 percent of the community members plus one vote as well (Procuraduría Agraria, pers. comm., 2010). It is assumed that the *ejido* has a greater ability to organize itself and make decisions, compared to Magdalena Atlitic, due to a considerably smaller number of formal members.

3.3. The Mexican PES program

In the past, the Mexican government principally used non-market based policy instruments to regulate the loss of natural resources. This is including approaches that imposed direct regulations on activities that induce LUC or degrade natural areas, provided subsidies to sustainable forestry activities, and introduced police action to stop timber theft (Muñoz Piña et al., 2008). Some forest-related programs did not have the intended impact on ES provisions, especially hydrological services. A more direct response has been perceived as necessary to confront deforestation and combat water scarcity in the country (Muñoz Piña et al., 2008) given that the National Water Commission (CONAGUA, for its Spanish acronym) has reported that two thirds of the nation's 188 aquifers show signs of overexploitation (DOF, 2003a), and forest cover loss continues (CONABIO, 2006; FAO, 2005b). Therefore, PES is being explored as an alternative policy instrument.

A new perception has been adopted in the political process supporting forest protection as more effective and equitable with PES than with traditional command-and-control approaches (e.g., ANP). The introduction of a PES program in Mexico had been facilitated politically through a series of legislative documents which provide the necessary institutional back-up and rational soundness. Article 4 of the Constitution stipulates that every individual has the right to an environment adequate for development and well-being; the National Plan for Development 2003-2006 (PND, for its Spanish acronym) further emphasizes that the environment is a federal priority, and that development is only sustainable if natural resources are protected (DOF, 2001c, 2003b, 2004). The Constitution and PND have been embodied in two programs that further emphasize a need for improving political instruments to curb the loss of valuable natural resources. The first is the National Program for the Environment and Natural Resources 2001-2006 (PNMARN, for its Spanish acronym) which highlights the importance of national security to stop and reverse ongoing environmental destruction and optimize protection, conservation and the use of natural resources by incorporating society (DOF, 2003b, 2004). And second, the National Forestry Program 2001-2006 (PNF, for its Spanish acronym) recognizes that the ES market has the potential to play an important role (DOF, 2003b, 2004). Legislators acknowledge the existence and importance of ESs derived from the forest ecosystem, and explicitly mention biodiversity, genetic reserves, carbon sequestration, scenic beauty, and

Table 3.6.: Enrollment in PSA (PSAH and PSA-CABSA)

Year	2003	2004	2005	2006	2007	2008	Total
Area contracted (in 1,000 ha)	126.8	184.2	169.1	127.0	545.6	324.1	1,476.8
Number of contracts	272	352	257	241	816	727	2,665
Payment (in million MXN)	192	288	258	204	926	570	2,438

Source: CONAFOR (2009; cited in Perevochtchikova, 2011)

hydrology (DOF, 2003b, 2004). Legislators have recognized that it is important to explore the possibility of finding markets for these ESs and scale-up local initiatives. The PES program should offer forest owners incentives to protect, conserve and sustainably manage their natural forest resource.

In consequence, Mexico has become the second Latin American country, after Costa Rica (Engel et al., 2008; Pagiola, 2008), to introduce a national PES program (Muñoz Piña et al., 2008). This program began in 2003 and was initially set-up to assure water provision. This program was called PSAH (DOF, 2003b), and was substantiated in scope in 2004 with a separate PES program named Program to Develop Environmental Service Markets for Carbon Capture, Derivatives from Biodiversity and Promotion of the Establishment and Improvement of Agroforestry Systems (PSA-CABSA, for its Spanish acronym) (DOF, 2004). Both were administered by the CONAFOR, created in 2001, with the obejective of developing necessary mechanisms to collect and pay for the ESs (DOF, 2003b, 2004). In 2006, both programs were unified under a single PES program called PSA (DOF, 2006), and by 2007 the Rules of Operation were further merged under the program *ProÁrbol* (DOF, 2007) in order to streamline programs, processes and efforts. Within its first six years of operation, the program continuously managed to expand its outreach in terms of enrolled forest area, number of forest owners and allocation of funds (see Table 3.6).

As can be seen, the national PES program in Mexico has continuously evolved since its establishment in 2003. This chapter will limit its focus on the Rules of Operation for 2011 (DOF, 2011), given that these were the rules applicable during the first phase of this research project and established the policy background for Chapter 6. These rules do not explicitly include carbon sequestration, which formed part of the PES program until 2009 (DOF, 2009). The concept of PSA is subordinate to the umbrella program *ProÁrbol* within the category "Conservation and Restoration" and accommodates, in 2011, two project types: hydrological services and biodiversity protection. The objectives of the Rules of Operation for *ProÁrbol*: (i) boost the production and productivity of forest resources, their conservation, protection and restoration, and further increase the level of competitiveness in this sector and contribute to an improved well-being of Mexicans people; (ii) generate economic development and expansion based on sustainable valorization, conservation and exploitation of the forest resources; (iii) contribute to mitigating poverty and marginalization in forest areas by introducing an adequate natural resource use and management; (iv) develop integral activities to boost forest projects that build on and complement existing efforts while buffering risks; and (v) assure compliance with attributes stipulated by the LGDFS, the Institutional Forestry Program 2007-2012 and the PEF 2025.

Based on this list of objectives, it can be derived that the PES program is also placing an emphasis on side-objectives which do not explicitly target the conditionality of ES provisions. Their weight is attributable to the government-financed set-up of the Mexican PES program where the state acts as a monopsonistic buyer who sets the price and defines the criteria of eligibility. From the start, legislation has earmarked a portion of water taxes (together with international donations and grants) to the Mexican Forest Fund in order to sustain direct payments and administrative costs (DOF, 2003b, 2004; Muñoz Piña et al., 2008). The Mexican Forest Fund transfered part of its budget to the CONAFOR earmarking it for distribution among ES sellers and CONAFOR's administrative costs. Legislation stipulates that operation costs should not exceed eight percent of the budget for support of development programs listed in the Expenditure Budget of the Federation for the fiscal year (DOF, 2011). Thus, the program remains subject to budgetary limitations, which causes that the amount of land enrolled tend to vary (Wunder et al., 2008) as it illustrates Table 3.6.

3.3.1. Scope and eligibility

The scale of the Mexican PES program is national but budgetary constraints and implementation reflect characteristics of a program at local scale. In the first three years of operation (2003 to 2005), PSAH reports no clear indicators pointing to water scarcity and natural disaster areas in order to incorporate them into a grading system and guide selection (Muñoz Piña et al., 2008). A continuous effort has been made to improve the allocation of scarce funds in the PES program through a more efficient and focused targeting approach. It has been argued that explicit targeting of ES levels and threats in the selection of ES sellers best address the issue (Muñoz Piña et al., 2008). Hence, the program began introducing a Deforestation Index in 2006 (Muñoz Piña et al., 2003) to tackle previous shortcomings and applied results on a point-based grading system together with project-specific and social eligibility criteria (Muñoz Piña et al., 2008).

In 2011, the Rule of Operation for *ProÁrbol* explicitly stipulated that payments should not duplicate support granted by the Federal Government for the same objective. A modified system of the National Forest Information System (SNIF, for its Spanish acronym) is used to monitor the programs' performance and adequately control the allocation of public funds. The Rules of Operation contain three sets of scoring items (see Appendix D). One set is universal to all categories under *ProÁrbol*, a second set is specific to each category, and a third is applicable for specific project types. It is the task of CONAFOR to determine the areas of eligibility for the different project types.

The four criteria used by CONAFOR to assess any project's feasibility are (i) social criteria, such as the absence of benefits so far from *ProÁrbol* and a high Index of Marginalization; (ii) existence of indigenous centers; (iii) gender, with female applicants; and (iv) demonstration of a certified (or in process) Forest Management Program. The respective scoring system is displayed in the Table entitled "Scoring system for ProÁrbol 2011" in Appendix D.

For the concept of PSA, CONAFOR has elaborated a second scoring system, which is applicable irrespective of the assessed project activity (hydrological services or biodiversity). The scoring system prioritizes the applicant's areas based on eight attributes: (i) location in or around an ANP; (ii) location in a micro watershed where other ES sellers already benefit from PSA; (iii) agrarian nuclei, which have an environmental surveillance committee in place; (iv) participation in a local PES mechanism; (v) forest land arrangements approved by the landowner; (vi) an Index of Deforestation indicating high levels of threat; (vii) high risk of natural disaster based on the National Centre for Prevention of Disasters (CENAPRED, for its Spanish acronym); and (viii) eligible zones which already have voluntarily geo-referenced polygons. The respective scoring system is displayed in the Table entitled "Scoring system for the concept PSA under ProÁrbol 2011" in Appendix D.

The different project activities, eligible under the concept of PSA, have distinct targeting criteria in order to prioritize and select potential ES sellers from a pool of requests. The respective scoring system is displayed in the Table entitled "Scoring system for PSA 2011" in Appendix D. The two project activities involve the following selection criteria:

A. Hydrological services - This project activity is oriented towards the conservation of forest cover in order to assure the recharge of aquifers and wetlands, and avoid soil erosion. The minimum forest cover for eligible land is >50 percent. Further prioritization of areas is guided by official declarations of over-exploited aquifers, average availability of surface water in a watershed, signs of anthropogenic degradation, strategic zones for restoration or attention, and biomass densities based on data from the National Inventory of Forests and Soil (INFyS, for its Spanish acronym).

B. Conservation of biodiversity - This project activity is oriented to promoting the conservation of biodiversity (flora and fauna) in forest ecosystems and agroforestry systems under shade trees. Eligible coffee and cacao producers must be integrated into the national system of Support and Services for Agricultural Marketing (ASERCA, for its Spanish acronym). Producers of *Palma camedor* must show their permission from the SEMARNAT. Areas are prioritized based on official declarations of Area of Importance for Bird Conservation (AICA, for its Spanish acronym), Convention on Wetlands of International Importance (RAMSAR), RHP, RTP, hosts species of the official norm according to NOM-059-Semarnat-2001, and Biological Corridors.

CONAFOR geo-references those areas with the applicant's permission for the evaluation of requests once the first stage of selection has been completed. Depending on the location of the area, CONAFOR determines the eligibility of the project activity and differentiates payment levels in compliance with the established scoring system. Applications obtaining a positive feasibility assessment are then submitted to the National Technical Committee for further consideration. The National Technical Committee allocates funds to applicants in descending order of scores obtained in relation to available funds. If decisions must be made between equal applications, four criteria are applied in descending order of importance: (i) municipalities of special interest as per the SEDESOL; (ii) area size; (iii) applicants are agrarian nuclei; and (iv) certificate of compliance with the Forest Management Program.

3.3.2. Stakeholder architecture

The program design and stakeholder architecture is defined by the government. Based on the differentiation between user- and government-financed programs (Engel et al., 2008; Wunder, 2005), the Mexican PSA falls under the scope of the latter. This is because basic and complicated program design-decisions were made by the government without direct input from real water users, and the "market-link" between the provider and the consumer is created only through an implicit relationship (Muñoz Piña et al., 2008). This indirect program appropriation of ES users is likely to prevent the scheme from obtaining a "buyers' feedback loop" which would explicitly reinforce conditionality, such as withholding payments if, for example, the water service is not provided as agreed upon (Engel et al., 2008; Pagiola, 2008; Wunder and Albán, 2008). Some of the funding is derived from a portion earmarked portion from the federal fiscal revenues coming from water fees.

CONAFOR is responsible for setting-up and overseeing the national PES program. The Rules explicitly state that CONAFOR operate the program, channel payments to ES sellers, and monitor and evaluate the program's performance. Hence, CONAFOR represents both the PES administration and ES buyers. It acts on behalf of the real ES user, i.e. the tax payer, as well as paying ES sellers, mainly *ejidos* and agrarian communities. The administrative task of CONAFOR is further complemented by two committees created to support the operation of the program: the National Technical Committee and the State Technical Committees. Despite this government-financed structure, the federal policy strategy is to gradually increase local government involvement to complement federal funding, and target areas of local interest (Muñoz Piña et al., 2008) resulting in the adoption of Matching Funds (in Spanish: *Fondos Concurrentes*).

The established eligibility and prioritization criteria are used to select potential ES sellers. As per the Rules of Operation, ES sellers (beneficiaries) are natural[8] and/or legal [9] persons

[8]An individual with the capacity to incur obligations and exercise rights.

[9]A group of people coming together for a specific purpose such as a corporation or a civil partnership.

of Mexican nationality who are owners or holders (possessors) of forest land (preferably forest or temporal forest), and whose parcel can be supported by CONAFOR based on the Rules of Operation. Non-eligible entities of the program's support include (i) public federal administrations, federal entities, Federal District and municipalities; (ii) former beneficiaries who have been sanctioned with the cancelation of support up to five years before; and (iii) applicants who wish to enroll land involved in any type of land dispute. Potential ES sellers are required to present the application format with the respective technical details. ES sellers are not allowed to receive support from the Federal Government with a similar concept. Mexican nationality must be proven together with legal ownership and possession of the land subject to enrollment. The legal ownership and possession of the land in the case of *ejidos* and agrarian communities is demonstrated by the "Basic Folder" (in Spanish: *Carpeta Básica*) which contains the Presidential Resolution, records of ownership, demarcation and final plan, or in the case of certified *ejidos* the Act of Demarcation, Destination and Allocation of *Ejido* Land (ADDATE, for its Spanish acronym). Natural and legal persons must present the land title confirming ownership of the land. If the applicant is not the owner of the land, a valid document needs to be presented that certifies legal possession and must be valid for the period subject to the concept of application.

3.3.3. Conditionality and additionality

Obligations of the ES seller are varied in order to guarantee the conditionality of PES payments. When the contract is signed, the ES seller has the obligation to attend a training session implemented by CONAFOR that is held one time and is free of charge. The training informs participants about their rights and obligations to obtain PES payments. In general, the Rules of Operation, terms, conditions and times must be followed. ES sellers are required to accept that the entitled authorities audit, hold site visits for verification and external evaluations in order to verify the correct application of funds and compliance with rules. The owners, possessors or responsible people for the enrolled parcel are required to give permission to access the site in order to verify the correct application of payments. They must facilitate visits and reports to official verifiers. ES sellers are obligated to use provided resources in compliance with the agreed activities, and must return payments if sanctioned with the cancelation of the contract. To obtain the final payment, the ES seller must inform authorities of the termination of the project and realized activities. Project documentation which proves obtained results and correct application of funds must be stored for a minimum of five years. Furthermore, the ES seller has the obligation to formally contract a technical consultant who is listed and approved by CONAFOR. The contracted technical consultant has the obligation and responsibility to elaborate a "Best Practice Management Program" and provide necessary technical assistance to the ES seller in order to carry out the activities stipulated in the program. The objective of the management program is to maintain or improve current conditions of the ecosystem, its function of regulating the hydrological cycle, recharge aquifers and wetlands, avoid soil erosion, carbon storage and biodiversity conservation. The practice program needs to be elaborated through a participatory planning process with the ES seller. Compliance is then dependent on project-specific conditionality criteria:

A. Hydrological services - This project type falls into three area types (I-III). For area types I and II, the ES seller must avoid LUC, conserve forest cover, avoid degradation, avoid overgrazing, in the case of legal persons the technical consultant needs to organize at least two workshops per year to foster the ES seller's capacity-building, carry out activities for surveillance and prevention of forest fire, establish at least one forest fire brigade, and elaborate in a participatory planning process together with a technical consultant a (internal) "Program of Best Management Practices" which is implemented as of the second year. For area type III, the ES seller is not obligated to implement the three last items. Instead, ES sellers must select at least three activities from the list of the (external) "Best Management Practice Guidance of the CONAFOR" and initiate their implementation as of the second year based on a participatory planning process.
B. Conservation of biodiversity - This project type falls in three area types (IV-VI). For all area types, the ES seller is required to avoid LUC, degradation and overgrazing, and has to select activities (at least four for area IV, two for area V and one for area VI) from the list of the (external) "Best Management Practice Guidance of the CONAFOR" and initiate their implementation as of the second year based on a participatory planning process. In addition, for area types IV and V, ES sellers must implement activities of surveillance and activities of forest fire prevention and combat, and in the case of legal persons, the technical consultant must organize at least one workshop per year focusing on capacity-building.

The federal resources assigned to the PES program are subject to MRV activities, including auditing, control, supervision and monitoring through several institutions, among them the CONAFOR and the Internal Control Organ of the same. On-the-ground the managers in the state offices responsible for ES from forests advice staff to implement site-verifications for controlling the compliance of ES sellers' obligations and verifying the effective application of resources. ES sellers who do not facilitate and/or permit the site-visits are subject to an administrative process which can result in the cancelation of payments. The results of site-verifications are filled out in the presence of witnesses with a copy provided to the ES seller responsible for the area controlled. The verifier then submits the respective report to the National Technical Committee for consideration.

However, the application of MRV measures has been criticized on three counts, casting doubt on the effective assurance of conditionality in ES provision. The first criticism has to do with the application of relative low-resolution monitoring with insufficient site-verifications to adequately detect non-compliance (Muñoz Piña et al., 2008). A severe limitation in the Mexican case is that the administrative cost figures are rather artificial since they are predetermined by law as a fixed percentage of the available budget (Wunder et al., 2008). Hence, it is possible that inefficiencies occur when necessary activities are postponed or carried out to a lesser degree than optimal when funding is not sufficient. On the flip side, the PES administration (CONAFOR) has benefited in the past due to continuous budget increases. The second criticism is related to the input-based focus of conditional payments. For example, in the case of hydrological services, as in most Central American countries, a positive relationship between high forest cover and high quantity and quality of water services is perceived (Muñoz Piña et al., 2008; Pagiola, 2008). Yet in reality, water service, as such, is not specifically monitored in order to quantify conditionality because an adequate definition of the relationship between the forests in certain locations and the water service is lacking. The challenge is to determine with certainty the relationship between land use and water supply so as to adequately monitor them (Pagiola, 2008; Wunder et al., 2008). The reliability of water monitoring as a function of forest cover remains vague, although it is accepted that the link between forest cover and water quality is much stronger than between forest cover and quantity or dry season flow in particular (Pagiola, 2008; Wunder et al., 2008). Hence, the PES program is susceptible to actually favoring the wrong land use in some areas by increasing forest cover where water deficits occur (Wunder et al., 2008). Overall, it can be concluded that the PSA follows rather a precautionary principle without addressing conditionality thoroughly in MRV activities. And third, MRV practices do not explicitly consider leakage (Muñoz Piña et al., 2008). Initially, the idea was to control at least internal leakage by requiring ES sellers to enroll the complete territory, but this was condemned as impractical due to the varying sizes affecting the available budget (Muñoz Piña et al., 2008). The unsolved issue is, therefore, if leakage has occurred at different scales.

A review of the deficient application of the conditionality criterion naturally raises the issue of additionality. Engel et al. (2008) and Muñoz Piña et al. (2008) conclude that two general design issues occur under the practiced PES scheme in Mexico: first, zero opportunity costs for forest conservation, and second, higher opportunity costs for forest conservation than the offered amount. In cases where PES programs pay forest owners with effectively zero opportunity costs funds are wasted and do not fulfill the objective of internalizing externalities into economic decisions. Such situations may occur when alternative land uses are less economical than the desired land use or not profitable at all. These cases are typically labeled as "non-additional". The issue is that payments are made without changing any land-use behavior nor creating additional ES provision, and becomes particularly severe where risk-averse behavior is expected, leading to a greater interest on the part of those kinds of landholders to participate (Engel et al., 2008; Ferraro, 2008; Muñoz Piña et al., 2008; Pagiola, 2008). Although not the original intention, some authors argue that it still has the benefit of establishing property rights for landholders over the ES provision in circumstances where land tenure rights are not clear (Muñoz Piña et al., 2008).

3.3.4. Permanence

The Rules of Operation (explicitly DOF (2003b) and DOF (2004)) express the need for a long-term commitment of the landowner or possessor. However, the offered contract period is not effectively long-term, especially from an environmental perspective. Hence, the issue of permanence is not adequately addressed in terms of a time frame, giving the PSA the air of a subsidy program. Landowners enroll their land for a five-year period with the option to extend the contract once expired. Ultimately, the contract renewal decision depends on CONAFOR's prioritization, the landowners' track record of compliance and availability of funds. The program's duration, tentatively five years, and the absence of significant initiatives of local governments adopting the approach (Muñoz Piña et al., 2008) puts the permanence of the conserved ES at risk. Since targeting was also based on deforestation risks (Muñoz Piña et al., 2003, 2008; DOF, 2006, 2009, 2011), it is likely that in the absence of the payments, forest will become deforested. There is the hope that the "time purchase" might have been more effective than originally assumed, since forestry training, community organization efforts and credit provisions for community firms' development continuous, and demonstrate profitability of forestry and forest-related activities induced by the PES program (e.g., Muñoz Piña et al., 2008).

Selected ES providers are subject to site verifications during the valid contract period . If site visits prove that no contract breach has occurred, the National Technical Committee approves further payments to the verified ES seller. In contrast, when non-compliance has been detected, sanctions apply and the process of payment cancelation is initiated (DOF, 2003b, 2009, 2011). The rules implicitly distinguish between avoidable reversals (intentional LUC of enrolled forest) and unavoidable reversals (unintentional LUC or decrease in service provision due to, for example, forest fires or timber theft). While avoidable reversals cause the cancelation of current and future payments until the end of the year (DOF, 2003b, 2009), regardless of the size of the affected area (Muñoz Piña et al., 2008), unavoidable reversals are punished by not paying the area affected, rather than retaining payments for the complete area enrolled (Muñoz Piña et al., 2008). The administrative process of canceling the program may take up to seven month if no arguments are presented to defend the ES provider. Among reasons for payment cancelation are ES sellers' non-compliance with established requirements, non-compliance with obligations, incorrect application of the obtained resources, incorrect provision of information and documentation, and access denied for site verification. Once the National Technical Committee has been notified and confirms the ES seller's non-compliance, the state office manager is responsible for informing the ES seller of this action and what can be done to avoid the cancelation of payments. If no corrective actions are implemented, payments are stopped. If payments are cancelled, the state office manager notifies the ES seller of this decision and request that total payement be returned within 20 workdays. If resources are not returned, the amount is considered to be a debt with the government, and CONAFOR is entitled to take legal measures to obtain the full amount due. In the first three years of operation, the largest share of enrolled forest area was subject to low and very low deforestation risks, possibly explaining why for the same time period almost 100 percent compliance is reported by CONAFOR (Muñoz Piña et al., 2008). A general hypothesis is that low-resolution monitoring rather than testing the real counterfactual case is responsible for such excellent results, thus, questioning the overall effectiveness of the program (Muñoz Piña et al., 2008).

Policy designers were initially faced with the adequate formulation of a payment catalog. Either amounts based on the buyers' (users) value (ES utility) or on the sellers' (providers) costs (opportunity costs). During the design process, it was decided that payments are based on the latter, since no or little information was available on the value of the ESs included (Muñoz Piña et al., 2008). The form of opportunity cost determination has proven to be controversial. An auction format for identifying ES sellers' individual opportunity costs was proposed to maximize the area enrolled for a given budget (Muñoz Piña et al., 2008). It has been argued that this is a favorable method for overcoming problems of asymmetric information where ES sellers are prone to pocket informational rents (Ferraro, 2008). This approach was dismissed by CONAFOR since it was considered too innovative, incurring the risk of high administrative costs, confusing potential ES sellers, and appearing to be an expropriation compared to traditional subsidy programs (Muñoz Piña et al., 2008). In the end, a flat, fixed-price structure was chosen, considering the concerns addressed above in addition to consultations which revealed the perception among forest owners that different prices for the same forest would be unfair (Muñoz Piña et al., 2008). Accordingly, payments are made annually, after verifying that no LUC had occurred, and is renewable for five years if compliance has been verified.

In the first three years of operation, payment levels were influenced by the value of the average opportunity costs for maize cultivation and negotiations between stakeholders (Muñoz Piña et al., 2008). As an outcome, the program adopted payable amounts which were differentiated by two forest types resulting in payable amounts of MXN 400 (USD 36.4) per hectare for "cloud forest" and MXN 300 (USD 27.3) per hectare for "others" (DOF, 2003b; Muñoz Piña et al., 2008). Cloud was rated higher because of the perception that it is more important for the hydrology (Muñoz Piña et al., 2008). However, the political decision to base payments on a simple opportunity cost criterion and a two-dimensional ES value criterion has provoked strong criticism (e.g., Muñoz Piña et al., 2008; Wunder et al., 2008). The arbitrariness of the approach is, for example, reflected by the lack of information confirming that opportunity costs in cloud forests are actually higher than in other forest types. Furthermore, national PES programs face the problem that price levels may vary significantly across the country, as do factors that encourage or discourage PES activities. More specifically, the broad scale application of PES is not capable of enrolling all the high-valued ES areas because they likely have higher opportunity costs which exceed a uniform price structure. Where the PES program effectively offers too little to be considered an economic alternative (e.g., compared to agriculture, cattle farming or real estate) by ES sellers, they do not enroll their land since the return of the desired land use together with PES payments is not high enough. So, if these lands provide greater ES benefits than their alternative land use, social welfare loss occurs. The problem is then that price levels have to be increased in individual cases, which is not the intention of the program since all recipients should receive the same amounts, eventhough "more price differentiation would certainly bring in more environmental benefits" (Muñoz Piña et al., 2008).

In 2011, payments and support were still subject to the financial resources provided by the Federal Government in the Expenditure Budget of the Federation or through transfers and contributions entering the Mexican Forest Fund. Financial resources were awarded through CONAFOR to the beneficiaries of these rules. The Rules of Operation for 2011 maintained the release of PES payments for up to five consecutive years with the provision that the second payment was subject to the elaboration of a "Good Practice Management Program" or the verification of compliance (DOF, 2011). The payments were still subject to the verification of compliance approved by the National Technical Committee. The payable amounts were differentiated by location and size (see Table 3.7). As can be seen, the program adopted a differentiated payment scheme for the two different ESs, as the result of the Scoring System explained earlier. The amounts were a notable reflection of negotiation outcomes and not of pure opportunity cost calculation which would naturally vary significantly across such a huge country.

3.4. The Mexican Vision of REDD+

Mexico has become increasingly concerned about the sustainable management of its diverse natural resource base which is at risk for being depleted. There is a commitment of both policy-makers and land managers to construct strategies which halt and reverse ongoing destruction. Mexico is also aware of the scientific evidence regarding the implication of human-induced GCC on health, development and ecosystems, which is reflected by its active involvement in the UNFCCC. Because of this, Mexico has adopted the aspirational, voluntary and unilateral goal to reduce 50 percent of its GHG emissions by 2050, using 2000 as the basis, and has expressed its intention to complement that goal with 30 percent by 2020, a commitment made at the COP 15 in Copenhagen (Communication made by Mexico to the Secretary of the UNFCCC, 31^{th} of January 2010; cited in CONAFOR, 2010b). However, this goal is conditional upon a

Table 3.7.: Payment levels for PSA in 2011

A. Hydrological services	B. Conservation of biodiversity
Area I: The amount is MXN 1,100 (USD 79.4) per ha/yr. The amounts for technical assistance per year are: MXN 22,000 (USD 1,588.4) for 100 to 500 ha, MXN 41,000 (USD 2,960.2) for 501 to 1,000 ha, and MXN 60,000 (USD 4,332.0) for >1,000 ha. The size limits are (min.) 100 to (max.) 200 ha for natural persons, and (min.) 200 to (max.) 3,000 ha for legal persons and aggregations.	Area IV: The amount is MXN 550 (USD 39.7) per ha/yr. The amounts for technical assistance per year are: MXN 16,500 (USD 1,191.3) for 100 to 500 ha, MXN 33,000 (USD 2,382.6) for 501 to 1,000 ha, and MXN 44,000 (USD 3,176.8) for >1,000 ha. The size limits are (min.) 100 to (max.) 200 ha for natural persons, and (min.) 200 to (max.) 3,000 ha for legal persons and aggregations.
Area II: The amount is MXN 700 (USD 50.5) per ha/yr. The amounts for technical assistance per year are: MXN 22,000 (USD 1,588.4) for 100 to 500 ha, MXN 41,000 (USD 2,960.2) for 501 to 1,000 ha, and MXN 60,000 (USD 4,332.0) for >1,000 ha. The size limits are (min.) 100 to (max.) 200 ha for natural persons, and (min.) 200 to (max.) 3,000 ha for legal persons and aggregations.	Area V: The amount is MXN 382 (USD 27.6) per ha/yr. The amounts for technical assistance per year are: MXN 16,500 (USD 1,191.3) for 100 to 500 ha, MXN 33,000 (USD 2,382.6) for 501 to 1,000 ha, and MXN 44,000 (USD 3,176.8) for >1,000 ha. The size limits are (min.) 100 to (max.) 200 ha for natural persons, and (min.) 200 to (max.) 2,000 ha for legal persons and aggregations.
Area III: The amount is MXN 382 (USD 27.6) per ha/yr. The amounts for technical assistance per year are: MXN 16,500 (USD 1,191.3) for 100 to 500 ha, MXN 33,000 (USD 2,382.6) for 501 to 1,000 ha, and MXN 44,000 (USD 3,176.8) for >1,000 ha. The size limits are (min.) 100 to (max.) 200 ha for natural persons, and (min.) 200 to (max.) 6,000 ha for legal persons and aggregations.	Area VI: The amount is MXN 280 (USD 20.2) per ha/yr. The amounts for technical assistance per year are: MXN 16,500 (USD 1,191.3) for 100 to 500 ha, MXN 33,000 (USD 2,382.6) for 501 to 1,000 ha, and MXN 44,000 (USD 3,176.8) for >1,000 ha. The size limits are (min.) 100 to (max.) 200 ha for natural persons, and (min.) 200 to (max.) 2,000 ha for legal persons and aggregations.

Source: modified from DOF (2011)

new institutional arrangement at an international level where industrialized countries provide financial and technical support as compensation for national efforts. Given this background, Mexico has elaborated the PECC 2009-2012 in order to complement global efforts with local action, and is the result of a collaborative effort between ten Federal Secretariats (SEMARNAT, 2009). The program sets mitigation goals for different sectors between 2009 and 2012 with the goal to mitigate a total of 50.7 million tCO_2-e. The program stipulates that the AFOLU sector will contribute 30 percent to total mitigation, which is equivalent to about 15.3 million tCO_2-e.

The PECC identified several GCC mitigation activities in the LULUCF sector which play a role in achieving established climate goals. Mexico is specifically interested in employing a REDD+ mechanism as an important pillar to achieve the stipulated mitigation goals in the AFOLU sector (CONAFOR, 2010b). Recent studies suggest that REDD+ is a cost-competitive opportunity (see Figure 3.7) with very significant ecological, economic and social co-benefits. It is further assumed that Mexico has an important potential to benefit from such a mechanism of SFM practices in order to stimulate, increase and reinforce the natural regeneration of ecosystems (Klooster, 2003). The Mexican government has demonstrated its political will to construct a national public policy in "real time" that is based and dependent on experiences from the sectors involved and pilot project activities in the field. The REDD+ policy is constructed in parallel and in-line with international negotiations under the UNFCCC (CONAFOR, 2010b). Therefore, its not surprising that in the comparatively early stage of development, critical issues have so far not been addressed. The underlying reasons are twofold: first, globally there are no concrete examples of how to set up and implement a REDD+ regime based on effectiveness, efficiency and equality, and second, the process of identifying a methodology and rules of operation has, up to now, not been expanded to a proactive multi-stakeholder consultation process where REDD+ is constructed on prior, informed and free consent. Mexico, therein, has benefited from being selected by the World Bank to participate in the so-called REDD-readiness process where funds from the FCPF have been made available to create necessary basic conditions for the implementation of a national REDD mechanism (CONAFOR, 2010b; FCPF, 2008). Mexico has initiated pilot projects in several States (e.g., the State of Chiapas and the States located in the Yucatan Peninsula) to test approaches for making REDD operational on the ground.

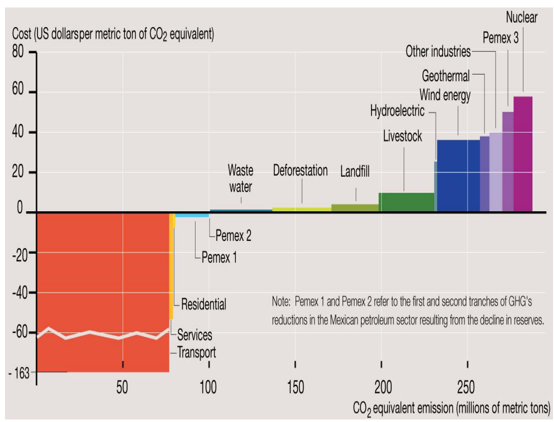


Figure 3.7.: Marginal abatement cost curve for Mexico in 2020
Source: modified from Quadri (2008)

3.4.1. Institutional framework

Given this international and national political background expressed above, Mexico has initiated a process and created a road map including concrete actions in the short- and long-run in order to design and operationalize REDD+. The "REDD line" towards this goal has been implemented and formulated as follows (CONAFOR, 2010b):

- 2006-2012: National Development Plan (PND, for its Spanish acronym)
- 2007: National Strategy for Climate Change (ENCC, for its Spanish acronym)
- 2009-2012: Special Program for Climate Change (PECC, for its Spanish acronym)
- 2010: Mexican Vision of REDD+ 2020 (VREDD+, for its Spanish acronym)
- 2010-2012: Design, establish conditions and construct a base line for REDD+
- 2011-2012: National Strategy for REDD+ (ENAREDD+, for its Spanish acronym)
- 2012-2020: Implementation of the ENAREDD+ with evaluations in 2017 and 2022

The process of designing and operationalizing REDD+ in the Mexican context has been primarily fostered by the decision of the CICC in 2009 to create an institution for promoting and coordinating that process (CONAFOR, 2010b). A Work Group for REDD+ (GTREDD+, for its Spanish acronym) was created under the leadership of CONAFOR in order to facilitate the coordination and communication between affected governmental actors responsible for the development of a REDD+ initiative and the development of ENAREDD+. To assure involvement of civil society in the early stages (NGOs, representatives of landholders, interested individuals, academics and governmental institutions), a Consultative Technical Committee for REDD+ (CTCREDD+, for its Spanish acronym) was also created. CTCREDD+ has the task of complementing the efforts of the GTREDD+ and provide recommendations on this subject matter.

The latest phase of implementing REDD+ in Mexico, and an intermediate result of the coordinated effort between GTREDD+ and CTCREDD+, has been the formulation and publication of a vision paper for 2020 (VREDD+), which was presented at the COP 16 in Cancun, Mexico. This vision centers on the adjustment, strengthening and consolidation of national efforts towards the reduction of deforestation and forest degradation, biodiversity conservation, promotion of sustainable rural development and stabilization of GHG concentrations (CONAFOR, 2010b). The document represents an additional step in designing the ENAREDD+. The document guides the way to harmonizing the prevailing national development plans and associated programs and actions[10] related to REDD+ activities. The remainder of this section refers to VREDD+ explicitly, as it is the latest official document reporting on the progress made in the planning of a national REDD+ mechanism.

3.4.2. Postulates, principles and objectives

The postulates formulated in the Mexican Vision give strong direction for the future development of ENAREDD+. VREDD+ states that the country's progress is founded on effective justice provided by the rule of law, and therefore seeks to strengthen the effective forest governance by respecting property rights, promoting community forest management, protecting ownership, possession and usufruct rights of *ejidos*, agrarian communities and small forest producers, which guarantees their sustainable livelihoods (CONAFOR, 2010b). Reference to the particular role of forest ownership in the VREDD+ text provides three key acknowledgements to be adhered to throughout the process of constructing and implementing the coming ENAREDD+. First, there will be no REDD-induced change in existing land property regimes, as stipulated in the Constitution of the United States of Mexico. Second, it is important that indigenous communities and other rural communities participate in the design and implementation of the strategy. And third, to effectively promote ENAREDD+ and assure free, prior

[10] An extensive review of relevant programs and activities is already included in Section 3.1.3.

and informed consent, information must be evenly provided across the country, consultations must be designed and direct participation schemes must be implemented.

The vision document further elaborates on a set of principles which provide guidelines for action and safeguards under future ENAREDD+. Eight principals reinforce the perception of stakeholders that a REDD mechanism is only viable if it is not translated into an instrument of command-and-control. These principles are (CONAFOR, 2010b): (i) inclusion and equality (territorial, cultural, social and gender); (ii) pluralism and citizen participation; (iii) transparency and legality; (iv) transversality among sectors and governance levels in terms of integral participation, coordination and complementation; (v) equitable benefit-sharing; (vi) certainty and respect of landowner and landholder property rights, and sustainable use of natural resources; (vii) free, prior and informed consent of the communities; and (viii) promotion of competitiveness between rural- and forest-related sectors, including community forest enterprises.

The postulates and principles jointly shape the objectives and scenarios for forest development which VREDD+ adopted from the PECC 2009-2012 and the PEF 2025 (CONAFOR, 2010b). Its goal is to fulfill three main aspirations by the year 2020 as formulated in the vision document. First, achieving zero net emissions from LUC and increment the quality of forest carbon stocks, including the components of conserving biodiversity, safeguarding environmental integrity, and improving forest carbon stocks (conservation, SFM and increase existing carbon pools). Second, reduce the national rate of forest degradation significantly with respect to selected reference levels, including the components of expanding sustainable resource use and natural (or induced) regeneration, discouraging uncontrolled burning, improving prevention practices, combating and controlling drivers of ecosystem disturbance, encouraging sustainable land-use practices, and strengthening law enforcement, education and participation in order to valorize adequately forests and abolish illegal timber and NTFP trade. And finally, to maintain the country's biodiversity, strengthen the social capital of rural communities and promote economic development through sustainable rural development.

3.4.3. Strategic lines

The development of a national strategy requires as a first step the alignment of policies, programs and actions designed and implemented by institutions that are responsible for the management and conservation of forests, mainly SEMARNAT, and the management of agriculture and livestock, mainly SAGARPA. The suitable platform for that work has been provided by the creation of the CICC and the CIDRS, where the definition of institutional instruments and actions is part of the necessary preparatory work. This is required to assure the complementarity between policies, strengthening existing instruments which demonstrate good performance, create incentives for sustainable productive practices, and reduce incentives that artificially increase agricultural and livestock rents. In this regard, VREDD+ has been the first milestone to provide guidelines for the construction of an ENAREDD+ to address the causes of deforestation and forest degradation that are partially related to the conflicting and deficient institutional design in Mexico. This focus draws attention to the need for ENAREDD+ to adopt an integral, environmental perspective which offers co-benefits regarding biodiversity, and improvement of ecosystems and associated services. In order to provide the technical, operational and negotiation support necessary to specify ENAREDD+, CONAFOR (2010b) has identified five strategic lines of action for the future: (i) institutional arrangements and public policies; (ii) reference level and MRV system; (iii) financial schemes; (iv) capacity-building; and (v) communication and participation strategies.

Institutional arrangements and public policies

Institutional arrangements and public policies need to be adjusted or innovated in order to guarantee sustainable rural development and a successful REDD implementation. This can be carried out by analyzing current arrangements and defining measures to eliminate undesired effects of sector programs and increase their positive synergies where possible. Hence, a REDD+ mechanism must allow for coordinating measures, policies and actors of sectors linked to the environment and forestry. The scope of REDD+ needs to continuously expand in this process through the use of financial resources and incentive mechanisms. Under this first strategic line the vision formulates five pillars (CONAFOR, 2010b):

- Improved inter-sectorial coordination - is necessary to address the multiple factors and local differences associated with the causes of deforestation and forest degradation. A diagnostic program is needed ex ante to formulate ENAREDD+ so as to identify the drivers of deforestation and degradation, the role of public policies, barriers of inter-sectoral coordinated action, to implement policies and programs, and activities to avoid contradictory effects. The output of the diagnostic process serves as crucial input for the work of CICC and CIDRS as well.
- Identification and implementation of institutional arrangements - for REDD+ that respond to the variety of deforestation and degradation drivers present in a heterogeneous geographic, socio-economic and environmental context. It permits institutions to address the context-specific necessities, expand their coverage and design flexible policy instruments. Among possible arrangements are the establishment of subnational forest reference levels consistent with national accounting, identification of suitable institutional arrangements for the operationalization of REDD+ on various scales (national and subnational), creation of institutional arrangements to foster and incorporate REDD+ projects and activities under the VCM as pilots, and adoption of successful models of municipal, state and federal collaboration which allow for the development of local initiatives with

different (territorial and time) scales.

- Revision, improvement and up-scaling of existing programs - is an important option in order not to start from scratch. The careful analysis of instruments, programs and policies serves to identify the weaknesses, duplications, barriers and options for improvement and up-scaling.
- Integrity of the legal framework - created in two steps for REDD+: first, revising the legal instruments which are directly or indirectly regulating natural resource management, and second, adjusting or introducing rules that assure congruent legislation and public programs. The intention is to establish a legal framework guaranteeing law enforcement, regulating and supporting investments, and creating incentives that are gender equal. Investments and incentives are provided under diverse economic schemes which are transparent, flexible, complementary and certain, and guarantee the rights of individuals and communities.
- Law enforcement - is crucial and linked to the consolidation and strengthening of institutions related to the environment. Therefore, it is suggested that the PROFEPA become more decentralized and coordinate efforts of the local and state governments. Furthermore, legal processes must be improved and a greater financial endowment granted to employ new technologies for monitoring and surveillance, and support community intervention with effective mechanisms of participation in inspections and control.

Reference level and MRV system

The creation of a reference level and MRV system lays at the heart of a credible and accurate REDD mechanism. Both allow the REDD administration to have a national accounting system that demonstrates progress, directly related to aspects of financing and permanence of impact. A reliable methodology and data platform allow the establishment of a common metric and shared diagnostic of gaps for coordinated action among stakeholders of different sectors and governance levels. The three pillars of that strategic line are (CONAFOR, 2010b):

- Reference levels - for forests providing information on GHG removal and emissions for a given area and period. This reference level is crucial to assess the impact (positive or negative) of the REDD+ mechanism. The construction of that reference level has to balance cost-efficiency and equality. The forest reference level requires a combination of recent historic data on emission levels from LULUCF and an estimate of future emissions and removal in the BAU scenario (without a REDD activity). For that purpose, historic data should be analyzed and driving processes which provok deforestation and degradation need to be identified. Also, remote sensing applications have to be used to calculate carbon densities and emissions. It is indispensable that a national consensus be reached on the definition of forests and different forest categories. These definitions have important implications for the registry and evaluation of achievements. In order to recognize national circumstances, transparent criteria must be put in place. Reference levels on a subnational level need to be consistent and harmonized with the national scale.

- MRV systems - need to be constructed, operated and maintained in order to assess the success of the REDD+ mechanism against the established reference level. MRV systems provide valuable information for related policy design for land use, result-based incentives, and commitments compliance in international forums (e.g., regular reporting). The systems further collect and provide information related to the compliance of safeguards and transparent financing. In order to have a single MRV system in place capable of combining information coming from different sources, REDD+ activities must be measurable in a transparent manner under a consistent umbrella system. Therefore, it is recommendable that a national MRV system be constructed based on international agreements reached under the UNFCCC. The MRV system would then serve as a focal point to implement broader and more coordinated national policies related to formulated mitigation and adaptation goals. It is also necessary to strengthen capacities in terms of infrastructure and human resources in order to monitor annually deforestation, degradation, and other carbon stocks. The desired level of monitoring precision, balanced with associated costs, must also be determined. The INFyS of Mexico provides a robust platform for constructing an effective MRV system with a reasonable margin of error. In order to amplify the inventory effort and incorporate AFOLU, collaboration between SEMARNAT and SAGARPA is crucial. These two governmental agencies need to merge their individual monitoring schemes with INFyS's master data.

- The MRV scale - must be national, both for the system and for protocols. Sufficient flexibility should allow for the consistent and transparent incorporation of subnational and local activities into national reporting. This national scale must explicitly allow for the accounting of most leakage sources. Compatibility and consistency among scales and stakeholders are essential elements for establishing a transparent and reliable system. States, watersheds, municipalities, local communities and their associations and private owners are considered to be relevant subnational scales. Hence, the implementation of REDD+ on a local scale faces several challenges, such as land tenure (common pool resources), leakage, local capacity of implementation, and local appropriation of mechanism. The consolidation of management entities on a subnational level plays an important role in strengthening forest governance and the successful implementation of a MRV system.

Financial schemes

The definition, adjustment and/or creation of financial schemes enable a REDD+ mechanism to strengthen its capacity, obtain information on forest carbon stock levels and provide incentives to maintain and improve the same. Therefore, the ENAREDD+ should coordinate national and international finance sources for REDD+ activities which are already (or will become) available. It is expected that REDD+ financin is best used on a national (or subnational) scale for the construction of adequate institutional arrangements and financial incentive mechanisms to curb driving forces of deforestation and degradation. This implies that adjustments are needed in order to eliminate persistent contradictions and promote synergies in the forest sector. The financial architecture for REDD+ requires the development of criteria for good practice guidance of fund management, including minimizing transaction costs, capacity-building, transparency, and monitoring safeguards. Respectively, institutional arrangements, mechanisms and instruments must be complemented and improved upon so as to support REDD+. It is necessary to promote and strengthen existing administrative arrangements (e.g., inter-municipality agencies, rural development agencies, producer associations, institutional programs, trusts and public funds) capable of capturing national and international funds, and promoting rural low-carbon development. Furthermore, national mechanisms and instruments have to be adapted to international carbon markets. It is likely that in an intermediate phase a sophisticated financial scheme has to be employed in order to cover the temporary gap between necessary investments for REDD+ ex ante and cash-flow from commercialized REDD+ certificates later on. Aspects related to REDD+ financing are twofold: first, sources and forms of collection such as public and private funds, development programs, fiscal instruments (e.g., fossil fuel tax), carbon markets or a combination of these, and second, mechanisms for distributing and redistributing collected funds. VREDD+ considers the following financial sources and instruments as relevant for the Mexican context (CONAFOR, 2010b):

- International agreements - have already been made in order to support national REDD+ initiatives. Mexico is engaged in related finance schemes and technical cooperation to create capacities for the design and implementation of REDD+. For example, Mexico is a participant of the World Bank's FCPF, an observer of the UN-REDD program, and a pilot country of the World Bank's Forest Investment Program (FIP).
- Carbon markets - encourage private participation and Mexico perceives these as an important potential source of financing. Mexico actively supports the creation of internal emission markets, and already has domestic markets for forest-related ESs. Public and private sources are financing activities which target rural and urban development. Mexico recognizes potential institutional experience and the growing contribution of the VCM, both national and international. An international compliance market similar to the existing CDM under the UNFCCC could provide substantial financial resources. However,

any market-based approach would be dependent on conditional and effective results in the reduction of emissions or the increase in carbon sinks.

- Fund mechanisms - for natural resource management already exist in Mexico. These include public and private fund instruments. An analysis of their potential to finance REDD+ activities and their implication for administration is one task for ENAREDD+. Mexico is aware that diverse incentive schemes will be necessary, probably not limited to a single fund, in order to confront the driving forces of deforestation and forest degradation, and guarantee financial stability and sustainability in the long-run. It is likely that national and international funds be used to complement carbon markets.
- Trusts - (national, regional and local) play the role of financial operators with the capacity to administrate and disburse funds available for incentivizing REDD+ activities in an efficient and timely manner. They are also able to track and evaluate the allocation of budgets in a transparent manner based on reliable MRV systems. These trusts can be public, private or mixed. They can be endowed from multilateral funds, carbon markets or other earmarked fiscal resources that receive finance from i.e. governments, enterprises, landowners (*ejidos*, agrarian communities, individuals, enterprises), civil society organizations and/or financial intermediaries.

Capacity-building

The enhancement of capacity-building activities requires a considerable investment of financial and human resources. This is justified since all the other strategic lines depend on the development and strengthening of human and institutional capacities on local, subnational and national levels. Thus, capacity-building is a concern of transversality. Capacity-building is directly related to the effective distribution of information, better communication within feedback loops, and improved coordination between actors and institutions in order to develop ENAREDD+. This effort must assure free, prior and informed consent of relevant stakeholders participating in the process. Particular attention needs to be given to involving rural communities. Active involvement is a central condition for the establishment of an adequate institutional platform in order to design and implement ENAREDD+. Furthermore, it includes the joint construction of mechanisms for the governance of REDD+, such as CTCREDD+, and the establishment of technical and administrative capacities for the implementation of REDD+ activities. Related features include technical training of public officials, and sensitizing various government institutions on federal, state and municipal levels. Among issues to be addressed are (CONAFOR, 2010b):

- The design and implementation - of capacity-building activities which require the evaluation of the status quo regarding capability and capacity of the different stakeholders, definiting and prioritizating necessary capacities, developing curriculum for the different tasks, and creating schemes for closing identified gaps.

- Strategies of horizontal learning - should play a complementary role based on self-managed initiatives of various stakeholders. Exploring alternative forms which fit into the local context, such as community learning, rural training, experience exchange, advisory committees (sector-, theme- and region-specific) are necessary for that purpose. Channels of communication need to be identified to transfer knowledge and lessons learned effectively, while minimizing investment in resources and efforts.
- Officials and institutions - that implement REDD+ on various scales (subnational to local) must create and demonstrate capacities to identify drivers and processes of deforestation and degradation, create markets for sustainable forest products, and evaluate transaction and opportunity costs. The management and monitoring of the forest sector together with the specific demands of REDD+ make it necessary to develop and introduce training programs for key actors in federal and local governments who will probably manage and evaluate REDD+.
- Social and private stakeholders - that participate in the management of the AFOLU sector need to develop capacities in order to support the REDD+ mechanism and carry out related activities on-the-ground. It is necessary to identify capacities that need to be developed.
- Gender equality - has evolved as an important issue in all aspects of civil society, in the public and private sectors. Women have been drivers of change and have demonstrated strong leadership for revitalizing their communities and natural resource management.

Communication and participation strategies

The design and implementation of communication and participation strategies to achieve accountability, social inclusion and transparency is another transversality issue and a central pillar for the future of ENAREDD+. This strategic line guarantees access to, distribution of and exchange of information nationwide. Therefore, it is necessary to identify the distinct stakeholders and their expectations regarding REDD+ and forest resources in general. Such information will provide feedback on the forms of communication and adjustments needed to achieve the desired exchange. Aspects for adequate communication, social participation and transparency strategy are (CONAFOR, 2010b):

- Communication - in a REDD+ environment requires the establishment of new channels of communication that allow and consolidate formal and informal networks between stakeholders transporting goods and people, people representatives and virtual social networks. Virtual platforms provide a relatively new and valuable way of accessing and exchanging information, and promoting collective participation and apprenticeship. Information and communication channels must be adapted to this specific audience, given the different values, interests, languages, organizations, cultures, levels of education, information and access to information. The design of communication channels requires adequate forms and media for communication, to foster a dialog among stakeholders, support participation of stakeholders and disseminate credible public information transparently.

- Social participation - implies the understanding of communication as a dynamic process with permanent feedback. Knowledge must be collected on the interests, concerns and expectations of the distinct stakeholders related to REDD+, forests and their own role in the sustainable management of forest ecosystems and processes of diversification. Regionalization of consultations would enable a more adequate diagnose of specific problems. Forums, networks and advisory councils which provide a balanced sector representation should be part of this social participation process. A participation plan needs to be adapted based on the particularities and socio-economic contexts of the local stakeholders involved, to assure social participation in all phases of public policy formulation and governance, including planning, enforcement, monitoring and evaluation. The gender issue is also of particular concern here, since equality plays an important role in the management of resources, and forest resources in particular.
- Transparency - is a central concern and a key component for a reliable communication strategy. This feature encompasses several issues such as the design and creation of a platform where the public has access to monitoring and information systems related to forest carbon stocks and REDD+ financing. In addition, transparency implies that the development of REDD+ in Mexico take place within an international framework where consensus exists on indicators that allow measurment of and verification of the level of transparency and access to information. This process should encourage transparency in the formulation of objectives for interaction, dialog, information-sharing, capacity-building and participation.

4. Conceptual framework

The conceptual framework for this research is based on Natural Resource Economics. The complexities of related economic problems associated with forest management have troubled economists since the beginning of the nineteenth century (Kant, 2003). Dominant features of forest economics, in general, have followed neo-classical economic thought, characterized by the utility (or profit) maximizing rational (*homo-economicus*) parties (e.g., ES sellers/providers) leading to an efficient general equilibrium. In this framework, people's preferences are static, society is an aggregation of homogeneous rational parties, inputs are provided through market signals, and the institution of the market coordinates demand and supply through prices (e.g., Burkett, 2006; Jehle and Reny, 2000; Mas-Colell et al., 1995). Forest economic models based on this neo-classical framework are subject to serious limitations, which has become obvious over the past decades. The new forest management paradigm requires combined economic models with social perceptions (Kant, 2003), among others. But the gap between theoretical models and reality has its roots in mainstream economics (Holmstrom and Tirole, 1989), and economists have been eager to reduce these gaps ever since they were identified (Kant, 2003). The main challenge has been to get a clear picture of decision-making by *homo-sapiens* versus *homo-economicus* agents where behavioral patterns are supposed to play an important role. Different disciplines have evolved, such as Experimental Economics, Evolutionary Economics and Institutional Economics, but only limited attempts have been made in the field of Natural Resource Economics to incorporate the respective concepts and principles emerging from this new economic thought (e.g., Bateman et al., 2002; Cárdenas and Ramos, 2006; Kant, 2003; Ostrom, 1990).

That said, it is evident that the boundaries of Natural Resource Economics need to be expanded. The development of any future forest management concept, such as REDD, must reflect social, economic, and environmental conditions of the late twentieth and early twenty-first centuries, which are quite distinct from existing conditions in the nineteenth and early twentieth centuries (Kant, 2003). Therefore, this research proposes the use of Contract Theory as main underlying concept in order to analyze the dynamics of a PES-REDD contract where an ES buyer (principal) and an ES seller (agent) enter into a contractual relation. Contract Theory is considered to be an adequate concept for analyzing typical problems in contract design such as asymmetric information among contracting parties leading to problems of adverse selection and moral hazard (e.g., Bolton and Dewatripont, 2005; Ferraro, 2008). The construction of the conceptual framework is guided by the idea that tradeoffs in PES-REDD contracts exist between strict commitments ex ante and flexible arrangements ex post to guarantee the permanence of forest carbon stocks from a policy design perspective (see Chapter 7). Although Contract Theory already provides a powerful approach for addressing the complexities of the problem, incorporating the Sustainable Livelihood Approach (SLA) is likely to further improve the understanding of local conditions and their differences since the combination of the PES instrument and REDD mechanism attempts to align global benefits with local costs in a complex local setting where ES benefits are created and costs for their provision accrued. The SLA permits for a more detailed and adequate picture of the local level where GCC mitigation policies are finally implemented. Despite varied criticism of the SLA (e.g., Grieg-Gran et al., 2005), this concept serves, primarily, as a useful check-list for obtaining a more complete panorama of the research subject - common property regimes. It is assumed that the information gathered will help understand the principal-agent relationship within the current Mexican PES program (see Chapter 6) as well as stated preferences of agents (ES sellers/providers) regarding hypothetical land management scenarios in a choice experiment (see Chapter 8).

The conceptual framework for this research has been developed in order to demonstrate the influence of the GCC context (vulnerability context) on local arrangements (livelihood assets) and political drivers (policies, institutions, organizations and processes) which most likely affect ES buyer (user) and ES seller (provider) decision-making in relation to any PES-REDD scheme. Graphically, this framework is illustrated in Figure 4.1. Through the application of the conceptual framework, different contract designs are analyzed to address research questions specifically related to permanence, to determine the acceptance of such a PES-like scheme and give guidance on course corrections in its development.

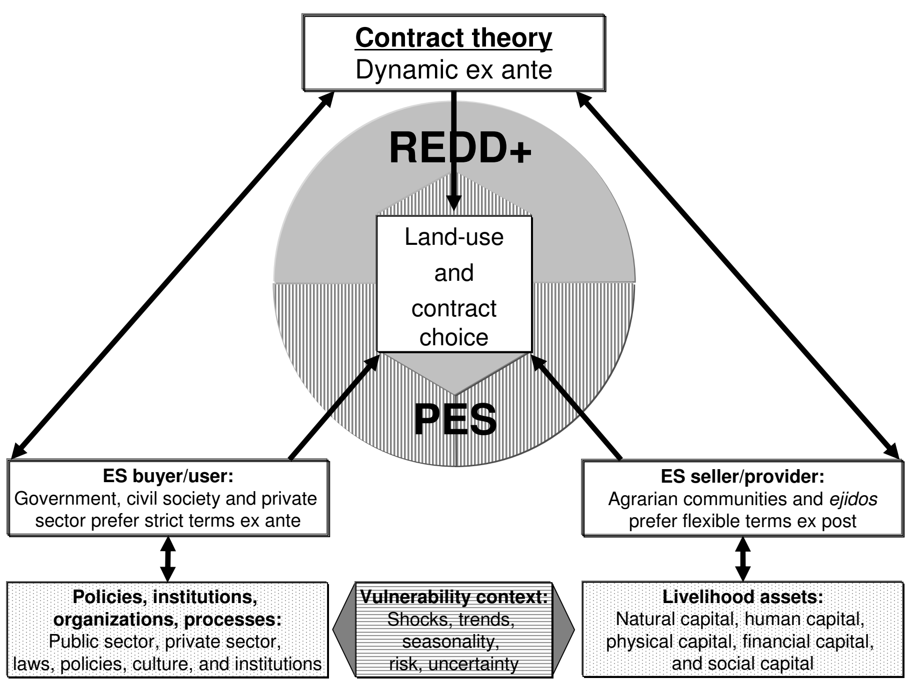


Figure 4.1.: Conceptual framework

The remainder of this chapter is organized as follows: Contract Theory is presented in order to provide a general overview of the fundamentals of the theory and describe generic problems of the principal-agent relationship observed in any contractual arrangement. Where possible, implications for a hypothetical PES-REDD contract are pointed out. Then, two typical problems in contract design are described in greater detail, given that they are the subject of this research - adverse selection and moral hazard. The Contract Theory section is followed by a description of the SLA, a useful tool for obtaining a detailed picture of a household and its surrounding community acting in an environment shaped by external factors, such as the context of vulnerability, and governmental institutions implementing environmental policies. This is included to help explain the outcome in ES sellers' land-use choice and environmental contract adoption.

4.1. Contract Theory

This research has adopted the Contract Theory in particular for its conceptual framework. The superior discipline of Contract Theory is Game Theory, which provides a basic mind set with its concepts and terms. Game Theory received its first impetus by John von Neumann (1903-1957) and Oskar Morgenstern (1902-1977) in the 1940s (Bergen et al., 2002). Its focus tends to be operationalized through experimental methods aimed at further understanding the behavioral underpinnings in valuation of goods and services. It has become one of the main analytical tools for addressing strategic issues in the field of economics and has extended its scope to other fields in the social and political sciences. Given the prevalence of extraction of natural resources and pollution in the environment, Game Theory is seen more and more as a tool for environmental policy-makers; and not only for theorists (Dinar et al., 2008). Thus, it has been adopted to analyze environmental resource problems and their management (Cárdenas and Ramos, 2006; Todd et al., 2009). Resource problems refer to situations characterized by the inefficient use of a resource, while resource management is defined as the design of resource allocation mechanisms which lead to an efficient use of resources.

The attractiveness of game-theoretic thinking has to do with its utility for studying the behavior of decision-makers ("players") whose decisions affect each other. Respective approaches are usually classified into two branches (Jehle and Reny, 2000; Mas-Colell et al., 1995): non-cooperative and cooperative games. Non-cooperative games (or situations) emphasize players' strategies and the consequences of these interaction on "payoffs". The purpose of the non-cooperative approach is to make predictions on the "internal" stable outcome. That is a situation where no player should have an incentive to deviate - the so-called Nash equilibrium. On the other hand, cooperative games emphasize the specifics of the strategies interaction and the possibilities of cooperation among players. It is often assumed that utility is transferable. This approach deals with the question of how the possible collective pay-off of the whole coalition (all the players together) should be divided among all players. Thus, the main issue is finding ways of allocating a certain surplus (or cost) among a group.

Game Theory is a rapidly advancing approach for structuring and understanding complex management problems in the natural resource sector in both developed and developing countries. Although many natural resource problems are complex due to common property or their public good characteristics, researchers have been eager to apply game-theory thinking in order to analyze these circumstances (e.g., Cárdenas and Ramos, 2006) since neo-classical approaches have proven to be deficient (Kant, 2003).

A prominent "kick-off" for a surrounding and still vivid scientific discussion has been the Prisoner's Dilemma (see Figure 4.2[1]) which has been widely used (Bergen et al., 2002), where the main issue is the inability of enforcing cooperation if an incentive scheme, such as PES-REDD, which internalizes positive externalities in the land-use decision of a common property is missing. The absence of such a mechanism leads to what Hardin (1968) has called the "Tragedy of the Commons". Therefore, researchers are interested in analyzing conditions which facilitate cooperation in order to improve the "social" pay-off. The use of Game Theory is generally hindered by a lack of information, paucity of empirical applications and a lack of interest on the part of policy-makers who are looking for quick answers to critical policy issues (Herath, 2006). The majority of policy-makers still rely on more familiar and politically accepted criteria such as efficiency (maximizing output per unit of input), "command-and-control" policies and cost-benefit analysis. It appears that theoretical developments need to catch up with empirical applications to generate information which facilitates the understanding of the decision-making process.

Contract Theory has been one of the offsprings of Game Theory. In the 1970s, with the methodological revolution of Game Theory, more emphasis was placed on strategic interaction among a small number of players in a world where informational problems matter (Bolton and Dewatripont, 2005). From this new perspective, the allocation of resources is no longer ruled by the price system but by contracts between asymmetrically informed parties. This has seriously changed the view of the functioning of organizations and markets, making it increasingly relevant for PES design as well (Wunder, 2008), such as eliciting ES seller's opportunity costs (Engel and Palmer, 2008; Ferraro, 2008). Traditionally, "legal" analysis of contracts took an ex post perspective, i.e., focusing on rights and obligations following an alleged breach, and/or the recovery of losses of the injured party. The innovation of Contract Theory shifts the focus to the ex ante decision, investigating why and under what circumstances parties

[1] This is a modified prisoner's dilemma adapted to a hypothetical scenario of REDD with arbitrary numbers. In this case, two peasants have access to a common pool resource (one hectare of forest). Each can decide independently if they deforest and earn direct benefits or opt to conserve the ES and create indirect benefits (positive externalities). Since this is a non-cooperative game, both will choose independently to deforest and reach the Nash Equilibrium, which is the strict dominant strategy here. Without measures to induce cooperation they will not reach the social optimum (the sum of the highest possible outcome).

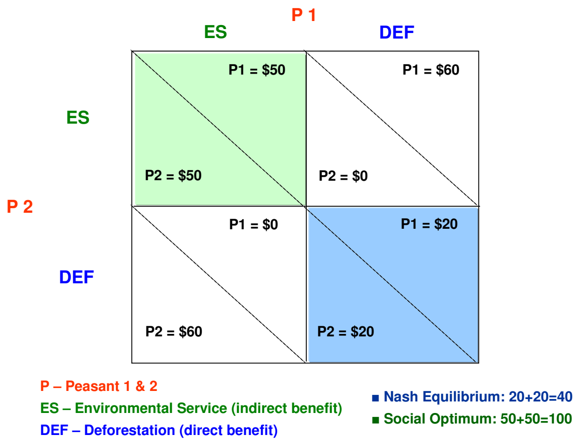


Figure 4.2.: Prisoner's dilemma

(principal and agent) enter into a contract (implicitly assuming consensus among the parties and fulfillment of individual participation constraints), and why contracts are written in a certain way (Van Aaken, 2009). This theory is concerned with foreseeing if contracts are enforceable and what mechanisms are in place for achieving compliance with cooperative goals that are supposed to benefit the collective interest (or joint surplus) of parties whose particular interests may diverge over time, as well as determine how parties best distribute associated risks of non-compliance in a contract (Bolton and Dewatripont, 2005; Van Aaken, 2009).

Hence, Contract Theory deals with the prevalent problem of uncertainty, which has to do with the inability of parties to design contracts which maximize joint beneficial investments ex ante while at the same time responding appropriately to changing conditions ex post (Scott, 2006; Van Aaken, 2009). This is of particular interest in natural resource management since most investments, particularly in forestry, are made from a long-term perspective even though changing conditions are a dominant characteristic of the sector. Those problems become virulent in unforeseen crises where contracts that are too strict and inflexible may impair the joint surplus of the contracting parties (Scott, 2006). Thus, a tradeoff arises in order to uphold the efficiency of the contract. On the one hand, the advantage of writing a contract with "hard" and precise terms ensures credible commitments of both parties, given that they are less open to interpretation. Yet, unless the parties can "fully" and accurately anticipate the conditions that will exist at the time of performance, a contract containing only "hard" terms can turn out to be suboptimal once applied to changed circumstances in the future. This may lead to results that are less desirable than if the parties would have known the uncertainties beforehand (Scott and Stephan, 2006). So, flexibility to adjust whenever future circumstances make the initial agreement unprofitable for either side would be build into the contract (Van Aaken, 2009). On the other hand, too much flexibility can lead to a weakening of the credibility of the parties ex ante (Van Aaken, 2009). Therefore, a balance between the credibility of a commitment ex ante and desired flexibility ex post is necessary and optimal for all contract designs. Mechanisms should be in place to overcome commitment problems between the parties in order to generate mutual benefits (Van Aaken, 2009).

The best contract should yield an optimal outcome. I.e., the first-best "complete contract" can be used as a benchmark. This "pareto-efficient complete contingent contract" is one that parties could write if there were no contracting imperfections, such as bound rationality and unforeseen circumstances, no transaction costs, no enforcement costs, no market imperfections, no unpredicted developments, and no opportunistic behavior (Shavell, 1980; Van Aaken, 2009). Such contracts would assign risks, rights and responsibilities to every possible circumstance implying that parties know all future contingencies (Scott, 2006). In such a contra factual situation, parties would maximize their ex ante commitment as if there were no assurance problems (Van Aaken, 2009). Unfortunately, reality is different making it difficult to design a contract which is "optimal" from both an ex ante and ex post perspective (Burke-White and von Staden, 2007; Scott, 2006; Van Aaken, 2009). These two partially conflicting goals create inherent tension as ex ante each party would like to ensure the commitment of the other, but subsequent events may render inflexible commitments inconsistent with the contractual objective of maximizing joint surplus (Van Aaken, 2009). This problem becomes specifically acute in long-term contracts such as those most likely required for REDD. The reason is partially that it is impossible to draft a complete contract foreseeing every future contingency. Even attempting to do so would imply prohibitive negotiation (i.e. transaction) costs (Van Aaken, 2009). This, in turn, gives rise to the impossibility of foreseeing or appropriately describing the contractual outcome for all circumstances in the future (Scott and Stephan, 2006; Van Aaken, 2009).

A balance must be achieved between commitment and flexibility. Contracts must secure a high level of cooperation ex ante, with a distinction between (desired) flexibility in unforeseen circumstances and cases of purely opportunistic breach of contract ex post, as well as determining adequate compensation for the "victim" (Van Aaken, 2009). In situations where parties do not know whether they will be victim or injurer, contract draft should specify mechanisms of flexibility distinguishing between unintentional contingencies (e.g., *force majeure*) and intentional contingencies (e.g., opportunistic behavior) with differentiated measures based on legitimate regulatory goals (Cooter and Ulen, 2004; cited in Van Aaken, 2009). An "optimal" contract would mandate flexibility in the first case and rigidity in the second, where flexibility would harm the victim and rigidity would be detriment for the injurer so that both errors are likely to reduce the ex ante cooperation of the involved parties (Van Aaken, 2009). Therefore, parties often choose to write "simple or incomplete" contracts. That means that not all contingencies are considered and enforcement is based more on informal mechanisms (e.g., reputation and reciprocity) for adjustment ex post (Scott, 2006).

Incomplete contracts are contracts that do not explicitly deal with all possible contingencies

(Ferraro, 2008). The rationale is that unanticipated contingencies, which would have been known ex ante, would change the initial content of the contract. If unforeseen circumstances (contingencies) are not provided for in the contract, regret occurs if the "complete contingent contract" would have excused performance but the real contract erroneously mandates performance. Regret is, thus, a function of the magnitude of the unexpected contingency or shock ("regret contingency") and the level of ex ante commitments (Shavell, 1980). Regret contingency is different from opportunism in that the former is welfare enhancing (ex post) for both parties, whereas opportunism is welfare decreasing for the victim, so that the former should be permitted in the contract while the latter should not (Van Aaken, 2009). If parties of repeated interaction anticipate unaccounted regret contingencies, they may either choose to express their obligations in more general terms and delegate the interpretation to third parties to account for the necessary ex post flexibility, or have explicit flexibility mechanisms fixed in the contract (Bolton and Dewatripont, 2005; Van Aaken, 2009). The crucial factor is, than, whether appropriate proxies for the contested circumstances can be specified ex ante or whether a disinterested third party (e.g., the court) can be trusted to make such a selection ex post with the benefit of hindsight (Van Aaken, 2009).

Hence, Contract Theory distinguishes between uncertainty on three dimensions: first, uncertainty over the future (unforeseen ability of compliance); second, uncertainty over the actions of other players (asymmetrical information); and finally, uncertainty over the meaning and scope of contractual provisions (e.g., textual ambiguity) (Ferraro, 2008). Information asymmetries between the parties pose the greatest challenge and are of specific concern of Contract Theory (Bolton and Dewatripont, 2005) and this research. Each party has information about itself (private information) that the other has not, giving rise to potential opportunism (Bolton and Dewatripont, 2005; Van Aaken, 2009). Contract Theory specifically analyzes problems of adverse selection (hidden information) and moral hazard (hidden action) along with the difficulty of verifying either (Bolton and Dewatripont, 2005; Ferraro, 2008; Scott and Stephan, 2006; Van Aaken, 2009). The terms belong to Information Economics (Jehle and Reny, 2000) and are extensively investigated in Contract Theory (Bolton and Dewatripont, 2005). Asymmetrical information is a critical issue in most contractual arrangements and a limiting factor for the effective implementation of, for example, PES schemes (Ferraro, 2008). The following two sections further elaborate on the implications of hidden information and hidden action in PES contract design given their importance.

4.1.1. Adverse selection

Hidden information is referred to as adverse selection and occurs in the process of contract negotiation. Adverse selection is a market process where "bad" results occur when a principal and agent have asymmetric information, which leads to an outcome where "bad" prospects (e.g., products or customers) are more likely to be selected (Bolton and Dewatripont, 2005; Jehle and Reny, 2000; Scott and Stephan, 2006; Van Aaken, 2009). There are two main circumstances where adverse selection is likely to occur. One is a contracting situation where the party offering the contract is "uninformed" about the private information the counterpart holds and is called a screening problem (Bolton and Dewatripont, 2005). This name is derived from the solution approach of reducing informational rent by extracting bits of information held by the other party. The other situation is the opposite, where the "informed" party makes the contract offer, so that it becomes a so-called signaling problem (Bolton and Dewatripont, 2005). Under this condition, the party offering the contract is in the position to make tailor-made contract offers fitting a specific agent.

Hence, two ways to model and overcome adverse selection are by screening and signaling contracts (Bolton and Dewatripont, 2005; Ferraro, 2008; Jehle and Reny, 2000). The entry point is to specify the type of problem (screening or signaling) behind the hidden information which has a stake in improving allocation efficiencies (Bolton and Dewatripont, 2005). Types of information relevant for contract design, however, vary naturally by the subject treated. In a hypothetical PES-REDD contract, attributes such as real threat levels of deforestation or high non-forest opportunity costs would be considered. Then ways to identify and overcome this information gap need to be developed. Adverse selection highlights that hidden information becomes a form of "informational monopoly power" resulting in allocation inefficiencies similar to monopolies, so that the main trade-off is between "informational rent extraction and allocation efficiency" (Bolton and Dewatripont, 2005). A guiding principle for improving the efficiency of contracting with hidden information is the "revelation principle". This principle states that in order "to determine optimal contracts under asymmetric information it suffices to consider only one contract for each type of information that the informed party might have, but to make sure that each type has an incentive to select only the contract that is destined to him/her" (Bolton and Dewatripont, 2005). Implicitly, this principle refers to the Game Theory term of "incentive compatibility of the individuals", where each party's ambition is based on individual constraints to select the most appropriate contract.

This phenomenon is also well-known in the realm of Natural Resource Economics and specifically in PES contract design. For example, the dominant forms of price setting in PES programs are bilateral bargaining and posted prices (e.g., Engel and Palmer, 2008; Wunder et al., 2008). Both of these have to cope with inefficiencies due to information asymmetries between ES sellers and ES buyers (Ferraro, 2008). An example of this is a PES program which sets a single low price per hectare of enrolled forest area for all its potential ES sellers. Under this circumstance, the program runs the risk of being adversely selected by those potential ES sellers with low or zero opportunity costs. The implications for additionality, indirect permanence and allocation efficiency can be considerable. This is because it is likely that "low-cost" land users are providing a significantly different level of ES in the absence of a

PES agreement (Ferraro, 2008; Wunder and Wertz-Kanounnikoff, 2009; Zabel and Roe, 2009). Identifying these ES sellers and excluding them from targeting (or paying less) increases the program's "purchasing power" of higher ES levels associated with "higher-cost" landowners (Ferraro, 2008; Wunder and Wertz-Kanounnikoff, 2009; Zabel and Roe, 2009). The ability to capitalize on efficiency gains from increased effort (administrative costs) of classifying ES sellers will directly depend on the degree of information asymmetry and heterogeneity of costs among ES sellers (Ferraro, 2008). The informational asymmetry behind this contractual relationship is that ES buyers generally know less than ES sellers (landowners) about the costs of contractual compliance, and some may use this private information as a source of market power for extracting informational rents from PES (Ferraro, 2008). Detection and reduction of informational rents becomes an important task for ES buyers who wish to maximize services obtained from their limited budgets (Ferraro, 2008). Thus, more theoretical work and experimentation in the laboratory and the field is needed to develop adequate approaches in order to reduce informational rents pocketed by ES sellers (Wunder et al., 2008).

The entry point is the characterization of the agent's "participation constraint". In PES, the constraint is theoretically satisfied if ES sellers are paid at least their opportunity costs (Engel et al., 2008), but "as long as there is substantial heterogeneity in opportunity costs of ES supply, hidden information will be a problem" (Ferraro, 2008). Thus, ES sellers are likely to demonstrate adverse selection, especially when opportunity costs are effectively zero or substantially less than the offered PES payment (Pagiola, 2008; Ferraro, 2008). This private information increases the bargaining power of ES sellers, if ES buyers do not have equal access to maximize ES provision from a given budget (Ferraro, 2008). Ferraro (2008) draws attention to three ways of reducing such informational rents from asymmetric information: (i) costly-to-fake signals; (ii) a self-selection mechanism; and (iii) procurement auctions. The exact application of each approach naturally depends on institutional, informational and technical complexities, and the ability to reduce informational rents without distorting the level of the ES provision.

The first approach, costly-to-fake signals, refers to a process which is initiated in order to obtain information on observable ES seller's attributes that are correlated with compliance costs (opportunity costs). This approach uses the gathered information for identifying adequate contract price levels. Hence, the information serves to establish eligibility criteria in the form of a scoring system for different contract types and price structures. Common attributes that are "costly-to-fake" are soil type, distance to roads, distance to markets and forest types (Ferraro, 2008; Muñoz Piña et al., 2003; Wünscher et al., 2008). Relevant information can be obtained from regional and local intermediaries, modeling approaches, or minimum eligibility criteria (Ferraro, 2008). Using returns from different land use in order to estimate potential payment levels for land-use restrictions may be inaccurate, because they are usually too high if farmers are risk-averse and expect capital gains from the land, or if land-use benefits are uncertain

(Parks, 1995; Ferraro, 2008). However, this approach comes closest to the current practice of the PES program in Mexico.

A second approach is self-selection, which is a revelation mechanism, similar to the third approach, where a menu of screening contracts is offered to landowners and based on the selection their type of ES seller is revealed to the ES buyer and/or PES administrator. The rationale is that the preferred choice reveals which contract satisfies the ES seller's "participation constraint" (payments cover at least all ES seller's costs) and "incentive compatibility constraint" (contract restrictions on payments correspond to the ES seller's type) (Ferraro, 2008). The offer of screening contracts reduces, however does not eliminate informational rents. It is likely that "low-cost" ES sellers need to be over-compensated (above their real opportunity costs) to forgo private information (Ferraro, 2008). Despite their appeal, the design is not straightforward in the field (Bolton and Dewatripont, 2005). The main problem is that mainy contracts have to be designed adequately in order to match "the participation constraint and maximize the conservation agent's objective function, which requires knowledge about the distribution of landowner types and sophisticated calculations by conservation practitioners" (Ferraro, 2008).

Procurement auctions are a third approach to overcome problems of adverse selection. The mechanism for adequate payment level determination has been under discussion for the Mexican PES program (Muñoz Piña et al., 2008). The auction type expected in a PES setting is a "private value auction", where ES sellers (bidders) have "perfect" information about their own opportunity costs (information rent) to accept an auctioned PES contract (with attributes such as time periods, land-use, and payment structure), but generally do not know the competitor's costs (other ES sellers) (Ferraro, 2008). In an auction, potential ES sellers reveal their opportunity cost type through their bid (Latacz-Lohmann and Van der Hamsvoort, 1997), and, as is the case with screening contracts, they reduce informational rents but do not eliminate them completely (Ferraro, 2008). The main advantage of this approach, compared with a "take-it-or-leave-it" offer, is the possibility of periodical repetition so that changes in the opportunity cost structure (e.g., the price changes of agricultural products) can be addressed (Ferraro, 2008). Nevertheless, this advantage is only warranted if no collusion or other strategic behavior in repeated interaction is possible (Ferraro, 2008; Latacz-Lohmann and Van der Hamsvoort, 1997). It is likely that efficiency gains increase specifically with the heterogeneity of the pool of ES sellers.

4.1.2. Moral hazard

Hidden action is referred to as moral hazard and occurs typically after a contract is negotiated between the parties - principal (e.g. ES buyer) and agent (e.g. ES seller). Moral hazard is a market process where information asymmetry is the principal's inability to observe and/or verify the agent's action which is supposed to assure the fulfillment of the agreed terms of contract (Bolton and Dewatripont, 2005; Jehle and Reny, 2000). The problem of verification, thus, distinguishes between the two dimensions of observable and verifiable information. The former can be observed by the two parties, but it may still be that the information is not verifiable. This means that the observing party is unable to establish the fact (contract breach or compliance) sufficiently in order to convince a neutral third party at reasonable costs (Scott and Stephan, 2006; Van Aaken, 2009). The problem dealt with under moral hazard is ex post in nature because it effectively becomes a "problem of assurance" if an agent accepting a contract offered by the principal is showing a behavioral response which does not comply with the terms of the contract. As a problem of this sort might have far reaching effects, the challenge is to adequately control for it within the contract. Moral hazard implies a threat of underperformance, when a contracting party is not delivering a required and/or agreed level of effort to guarantee compliance as formulated in the contract (Bolton and Dewatripont, 2005). This is specifically observed when payments are decoupled from performance of the agent so that full insurance of the agent is effectively provided (Bolton and Dewatripont, 2005). Similar to adverse selection, moral hazard problems are faced with an information asymmetry among the parties. In many circumstances, the principal might not be able to observe and/or verify the effort and/or performance of the agent. Hence, principals offering a contract have to pay attention to the individual rationality and incentive constraint of the contracted agent (Bolton and Dewatripont, 2005).

Performance-based contracts which depend on observable and verifiable output can often be employed in order to provide incentives for the agent to act in the principal's interest (Bolton and Dewatripont, 2005; Jehle and Reny, 2000). But when agents are risk-averse, such contracts are generally only second-best because incentivization precludes full insurance (Scott and Stephan, 2006; Van Aaken, 2009). The general approach for increasing effort and improving performance of the agent is to reward "good performance" and punish "bad performance" (Bolton and Dewatripont, 2005). This implies efficient budget allocation where the principal has to balance the benefits of lower average payments against the costs in lower effort provision of the agent (Bolton and Dewatripont, 2005). Hence, the inherent challenge for the principal is weighing up insurance (increased environmental benefit) and incentives (payments and/or applied MRV) in contractual arrangements with the agent (Ozanne et al., 2001). From an efficiency perspective it would be most desirable to determine observable output ranges which can be linked to the agent's efforts. Thus, low output levels might allow inferring that effort has been equally low with the consequence of "punishment", while high output levels might indicate equally high effort of the agent which qualifies for "reward" (Bolton and Dewatripont, 2005). This would require the ability to observe a certain outcome at a reasonable cost, which can be difficult.

The problem of observability of output and outcome is also encountered in PES (Ferraro, 2008), where the performance of the ES seller to actively guarantee, for example, the permanence of forest carbon stocks is difficult to verify and cannot be provided if no explicit MRV activities are in place to detect and classify reversals in order to assign proportionate liabilities. Monitoring contract compliance can be costly and ES buyers and/or PES administrators might be unwilling to pay for it. The consequence is that ES buyers and/or PES administrators won't be interested in verifying compliance with certainty, and "invite" ES sellers to exploit the monitoring gap (Ferraro, 2008; Ozanne et al., 2001).

The introduction of grouped projects or contracts has some hypothesized power to overcome such a problem of assurance. For example, the grouping of contiguous ES sellers increases not only ES provision but probably also decreases monitoring costs (Ferraro, 2008). Further, it is argued that group contracts can reduce rents from moral hazard through internal group member pressure of informal or formal control building on norms and values fostering reputation and reciprocity (Ferraro, 2008). However, it is also possible that contiguous land units or minimum areas foster the collusion of potential ES sellers (Ferraro, 2008). In a PES context that means that ES providers participate in PES scheme only if the expected costs of constraining (regulatory) sovereignty through PES contracts do not exceed the expected (net) benefits. Then ES providers can react to this tradeoff in various ways, for example in the last resort with contract breach, if they think that the burden has exceeded a certain threshold. Analyzing commitment and flexibility mechanisms in PES-like schemes may therefore help to design better contracts and avoid problems of moral hazard.

4.2. The Sustainable Livelihood Approach

The investigation of PES performance is a challenging task since it involves various dimensions. For example, Pagiola et al. (2004) recommends to consider three major aspects when analyzing a PES scheme: (i) changes in land-use; (ii) the impact of LUC on ESs; and (iii) perception and motivation on participating households. For this research, the third block is of particular concern because it implicitly refers to a composite of factors that explain program acceptance or rejection. Different criteria and indicators are probably responsible for explaining the adoption of SFM practices (Ritchie et al., 2000) and an understanding of these might help explain how the permanence of forest carbon stocks can be guaranteed through adequate PES design. There is a problem related to capturing all the influencing factors on livelihood decision-making (particular in the case of members of common property regimes) such as adverse selection of PES participation. Land-use decisions, in particular, probably depend on highly complex relationships between internal and external factors. In order to analyze these factors, this research selected a concept, encompassing both economic and non-economic aspects, with a "people-centered" framework (see Figure 4.3), called the Sustainable Livelihood Approach (SLA). This concept was originally developed by Chambers and Conway (1991) and was promoted by the UK Department for International Development (DFID, 1999).

It appears to be an appropriate tool for this research since the approach attempts to determine the household within its living reality. It is attractive for assessing the effectiveness of existing and future efforts of sustainable development, and may help minimize problems of adverse selection and moral hazard in contract formulation.

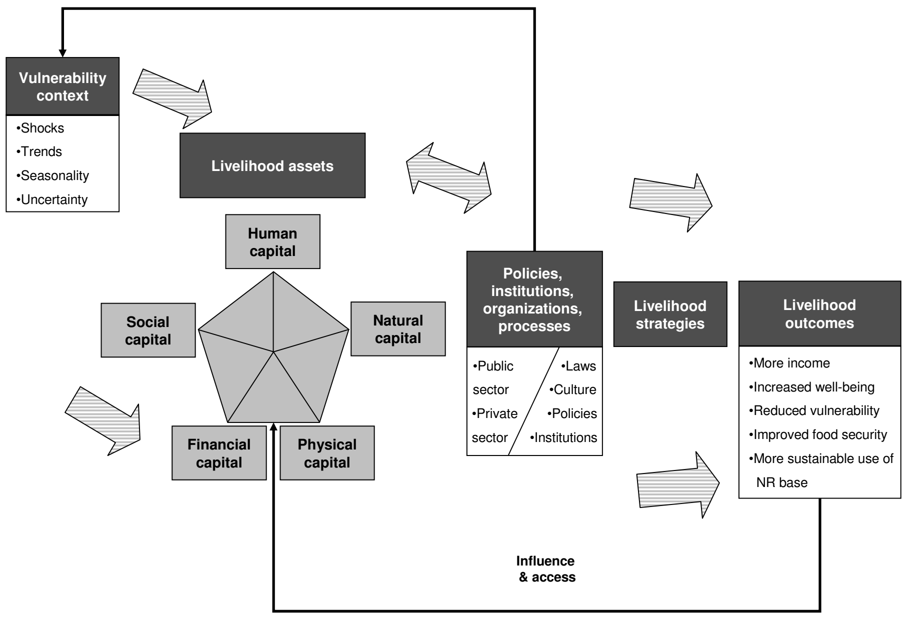


Figure 4.3.: Sustainable livelihood framework
Source: modified from DFID (1999)

In order to make the concept operational, it is necessary to first define what the central observation unit is for the intended study. Although the majority of natural forest resource in Mexico is managed by communities (*ejidos* and agrarian communities), they consist of livelihoods which represent individual decision-making bodies. Hence, it has been found that the working definition which serves the purpose of the research best is from Chambers and Conway (1991): "A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base." Most certainly, as is the case with all definitions and frameworks, this is another simplification of the truth. The full diversity and richness of livelihoods is difficult to compress into a single definition. Accordingly, critics have pointed out, for example, that different assets have overlapping effects, that welfare relates to asset returns rather than to assets themselves, and that the approach cannot rank situations where some assets improve while others deteriorate (e.g., Grieg-Gran et al., 2005). Therefore, this research acknowledges that it is a simplification of the truth and that it does not have the capacity to cover the whole range of reality. Notwithstanding, the SLA provides a useful checklist to survey livelihood conditions that might directly affect the preference and success of any PES scheme. This people-centered approach allows for understanding the livelihood as a decision-making unit through the analysis of people's livelihood strategies built on different assets likely to interact in causal processes that may reduce or increase vulnerability. The main components of the concept (see Figure 4.3) are explained in greater details below.

4.2.1. External livelihood factors

The SLA concept considers the vulnerability context, and the structures and processes to be external factors influencing the decision-making of individual livelihoods. They are representing the outer constraints posed on the decision-making of the household. It is assumed that a general characteristic of these factors is that they cannot be influenced directly by the members of a household, as they represent the exogenous frame for their activity.

Vulnerability context

The vulnerability context describes the external environment to which the household is exposed. Vulnerability is subject to trends as well as shocks, seasonality and uncertainty in general (see Table 4.1). A key characteristic of these dimensions is that households have only a limited control or no control over them. Not all of these dimensions are necessarily negative or cause vulnerability. Notwithstanding, it is important to review these dimensions because they directly affect the household's asset status and options which are open to them in the pursuit of beneficial livelihood outcomes. Therefore, a prior understanding of the nature of local livelihoods is necessary at the start, including what types of livelihood strategies are employed by local households and what factors limit them from achieving their objectives.

Table 4.1.: Examples of uncertainty such as trends, shocks and seasonality

Trends	**Shocks**	**Seasonality**
Population	Human health	Prices
Resource (incl. conflict)	Natural	Production
Inter-/national economic	Economic	Health
Governance (incl. politics)	Conflict	Employment opportunities
Technological	Crop/livestock health	Climate
Climate change	Climate change	-

Source: modified from DFID (1999)

Transforming structures and processes

Institutions, organizations, policies and legislation which shape and/or influence livelihoods transform the structures and processes within the framework of livelihoods. They influence livelihoods in two principal ways. First, they have a direct influence on access (to various types of capital, livelihood strategies and decision-making bodies and other sources of influence), terms of exchange between different types of capital, and returns (economic and others) of any given livelihood strategy. Secondly, they exert influence on whether people are able to achieve a sense of inclusion and well-being. This can also be considered a cultural aspect that accounts for other "unexplained" differences in the "way things are done" in different societies, for instance, within a household power relations and conventions on access to land. By analyzing the overall relationship between transforming structures and processes within communities, a general idea can be determined about roles of organizations, responsibilities (informal or formal), sorts and awareness of rights, relations between different groups, and policies and legislations affecting them.

Structures can be primarily separated into private and public organizations acting at various levels (see Table 4.2). They set and implement policies and legislation, deliver services, and purchase, trade and perform divers types of functions that affect livelihoods, i.e., they make processes work. Information that helps to understand these structures are the legal or constitutional basis, authority and jurisdiction (including degree of decentralization), membership and ownership structures, leadership and management structures, objectives and activities, financial basis (sustainability), and geographic location and extension.

Table 4.2.: Examples of public and private structures

Public sector	**Private sector**
Political (legislative) bodies at various levels from local to national	Civil society/membership organizations (of varying degrees of formality)
Executive agencies (ministries, departments)	Commercial enterprises and corporations
Judicial bodies (courts)	NGOs (international, national, local)
Parastate/quasi-governmental agencies	-
International agreements	-

Source: modified from DFID (1999)

Looking at processes helps to understand how structures operate and interact, and grasp the nature of their relationships. Typical transforming processes (see Table 4.3) are policies that develop new legislation and provide a framework for the actions of public sector agencies and their sub-contractors, and informal practices that determine structural relationships of institutions and make the behavior of organizations somewhat predictable; for example, informal arrangements on land access, institutions of a given society that are embedded in and developed within a cultural system, and pre-existing cultural power relations that determine a particular status of people and pose constraints on their behavior and opportunities. These aspects provide incentives for making particular choices influenced by access granted or denied to assets, by marketing opportunities to transform one type of asset into another, and by the influence of inter-personal relations. These conditions frame livelihoods systematically and restrict them and their opportunities in terms of progress. Thus, in order to understand the impact of existing processes on livelihoods, it is necessary to retrace the effects of given processes on particular groups, including policies and legislation, their effect in theory, and their enforcment in reality.

Table 4.3.: Examples of transforming processes

Policies	**Legislation**	**Institutions**	**Culture**	**Power**
Macro	International relations	Markets	Norms within a society	Age
Sectoral	Domestic agreements	Institutions that regulate access to assets	Beliefs within a society	Gender
Redistributive	-	Rules of the game within structures	Traditions	Caste/Ethnos
Regulatory	-	-	-	Class

Source: modified from DFID (1999)

4.2.2. Internal livelihood factors

The five livelihood capitals (human, natural, physical, financial and social) are considered as internal factors by the SLA. They represent the inner constraints of the household. It is assumed that they depend directly on and can directly be influenced by the household as a decision-making body. Livelihood capitals refer to the asset[2] endowment from and through which a household is put in the position to employ a livelihood strategy that offers the possibility of achieving a positive livelihood outcome. It is assumed that a certain constellation of internal factors enables livelihoods to make decisions on their use, for example the selection of participation in PES with available natural capital, and therefore provokes a particular livelihood outcome. Hence, capitals are seen as input factors and no single capital on its own is sufficient to yield all the many and varied livelihood outcomes that people seek. For example, poor people presumably tend to depend to a greater degree on the combination of capitals because they generally have limited access to it. The capital pentagon (see Figure 4.4) visualizes the interrelationship between various capitals. The idea is that the central point of the pentagon represents zero access to capitals, while the outer perimeter implies maximum access. This concept includes the possibility that a single capital can generate multiple benefits to other capitals or even substitute them. Since each capital is composed from a subset of assets, it is

[2]The terms "capital" and "asset" are not applied in a strict financial sense, but rather more flexible here.

also possible to create a similar "spider web" to show intra-capital variation. In both considerations it would be correct to add a third dimension - "time", because it is logical that access situation change over time. Thus, it is possible to visualize the variation in people's access, the differences between social groups within communities, or disparities among communities.

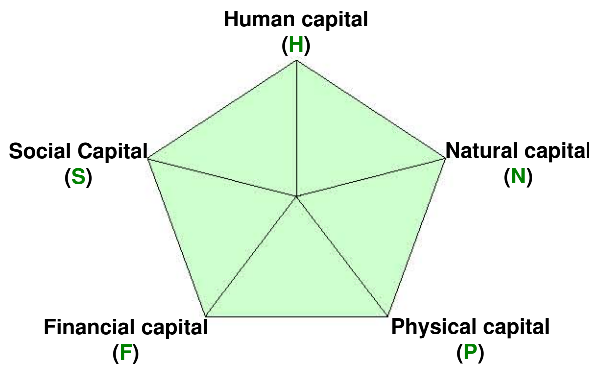


Figure 4.4.: Capital pentagon
Source: DFID (1999)

Two types of relationships are of particular interest within the SLA framework: the interdependence between capitals; and the interdependences between capitals and other framework components. When looking at relationships between capitals, sequencing and substitution of capital endowments are relevant because they provide entry points for the improvement of local conditions. For example, if it is possible to identify a sequence of particular combinations of assets that enable the escape from poverty, this may indicate where external support could be most efficient. Similar consequences accrue when it is possible to identify that one type of capital can be substituted by another or compensated otherwise; then, the focus would be on the "stronger" capital. On the flip side, the relationships between the capital pentagon and other framework components are more complex to understand. However, they are key for sustainable local improvement as well. Capitals are linked to the vulnerability context, transforming structures and processes, livelihood strategies, and livelihood outcomes. Within the vulnerability context, it is of interest how assets are created and destroyed as the result of uncertainty of trends, shocks and seasonality, assuming that assets of the rural poor tend to be particularly vulnerable. The institutions and policies of the transforming structures and processes grant or deny access to assets. They are in the position to determine the character of access, especially in the case of groups dependent on natural capital. Nevertheless, this relation is reciprocal and greater influence is possible as asset endowment improves. Hence, depending on the quality and quantity of the capital endowment, livelihoods with greater assets are usually able to opt between wider ranges of strategies for safeguarding their livelihood.

Therefore, the household will attempt to employ a certain capital combination in order to achieve a livelihood outcome judged to be beneficial for achieving a sense of well-being.

Human capital Human capital generally refers to the availability of skills, knowledge, labor force and good health in a household. The combination of these dimensions enables the household to pursue a certain livelihood strategy and achieve its livelihood objective. Of particular interest and importance are variables such as the size of the household, the skill level, leadership potential and health status. These variables support the household to make use of the four other types of assets. Information is needed particularly on human health indicators (e.g., life expectancy, nourishment, health care availability) and educational indicators (e.g., average number of years spend in school, female enrollment) as provided by national census data and often further processed into several national and international indexes. For example, the educational level reflected by years of schooling indicates knowledge, and this and leadership potential might be correlated. Equally important is existing local knowledge, and how it is shared and improved, as well as what purpose it serves (e.g., agricultural knowledge).

Natural capital Natural capital is understood as a natural resource stock from which a resource flows (e.g., yield) and services are obtained (e.g., nutrient cycle, erosion protection) (DFID, 1999). Intangible public goods are differentiated, such as the atmosphere and biodiversity, from tangible assets used directly for production, such as land and trees (Millennium Ecosystem Assessment, 2005). This capital is of particular importance for livelihoods which depend on resource-based activities. Thus, a close relationship to a vulnerability context is highlighted and of central concern to PES programs. Information must be gathered on the specifications of natural capital. Natural capital might differ by access, quality, quantity and combination and variation over time. From the perspective of an environmental economist, it is of additional interest to determine the overall value of natural capital, often referred to as the total economic value (Constanza et al., 1997). Any valorization of natural capital that is subject, for instance, to a PES-like scheme must investigate the direct use values (e.g., agriculture or forestry), indirect use values (e.g., biodiversity, carbon sequestration, hydrological services), and non-use or existence values (e.g., the amount people would be WTP to see the continued existence of a given resource, regardless of whether they use it or not) (Pagiola, 2003).

Physical capital Physical capital refers to basic infrastructure and goods of production needed to support livelihoods. In general, infrastructure includes affordable transport, secure shelter and buildings, an adequate water supply and sanitation, clean affordable energy and access to information (communication). The goods of production are the tools and equipment that people use in order to improve productivity. An inadequate access to services of physical capital is a core dimension of poverty (e.g., CONAPO, 2005a; DFID, 1999; UN-HABITAT, 2003). Opportunity costs that are associated with poor infrastructure can hamper education, access to health services and generation of income. As a consequence, poor livelihood operates with a comparative disadvantage in respective markets. This might be worsened by the lack of adequate goods of production. It implies that more time and effort are spent on meeting basic needs, producing tradable goods and gaining access to the market. Therefore, it is of interest to reveal the accessibility to infrastructure and/or goods of production and whether an appropriate service provision supports this in the long-run.

Financial capital Financial capital is a resource stock that allows the household to achieve higher and more capital intensive livelihood objectives. It consists of available stocks such as savings held in several forms (e.g., cash, bank deposits, liquid assets such as livestock and jewelry), credit-providing institutions, and the regular inflow of money (excluding earned income) such as pensions and remittances. Aspects making capital important are the possibility to convert it into other types of capital and use it for the direct achievement of livelihood outcomes. Therefore, this capital also tends to be least available to the poor. Gathering information about formal and/or informal types of financial service organizations, form and risk of savings behavior, and type and regularity of remittances helps to understand the financial capital structure present in the area of study. It is assumed that micro-finance approaches (Henry et al., 2003; Zeller et al., 2001) can significantly help to improve this capital. PES schemes may also have a positive impact on financial capital since PES helps to diversify the financial resource base of households by linking it explicitly to natural capital, thus increasing the resource and service flow from it.

Social capital The concept of social capital is a discipline with its own specialized literature (e.g., Ostrom and Ahn, 2003). The term is applied here to mean the social resources upon which the household relies in order to achieve its livelihood objective (DFID, 1999). Social resources are derived from vertical (patron-client or principal-agent) and horizontal (between individuals with shared interests) networks and connectedness, membership to more formalized groups with rules, norms and sanctions, and relationships of trust, reciprocity and exchanges as the basis for informal safety nets (Chambers and Conway, 1991). Social capital is important because it entails lowering costs to work together and to enforce, for example, PES contracts. Hence, it has a direct impact on other types of capitals such as access to natural capital. It can act in several different ways - negative as well as positive. Examples include exclusion, strictly hierarchical structures and obligations.

4.2.3. Livelihood strategies and outcomes

Livelihood strategies serve to fulfill certain livelihood outcomes or goals. Strategies encompass productive activities, income generation and subsistence, investment strategies and reproductive choices. Livelihood strategies typically vary by opportunity and choice. It is a rather dynamic process in which the household combines available capitals in order to meet their various needs at different times. When looking at livelihood strategies, it is likely that they differ by community, household and gender. The following aspects are of predominant interest for an analysis in this regard: livelihood "portfolio" of different social groups (e.g., percentage of income from different sources, amount of time and resources devoted to each activity by different household members), long-term outlook of people, type and reason of changed strategies over time, patterns of strategies that facilitate to escape from poverty, and kind of livelihood objectives and aspirations that are not achievable through traditional livelihood strategies but have become attainable through interventions such as a PES program.

Livelihood outcomes are the result of an available and selected livelihood strategy. The nature of the pursued outcome depends on people's priorities which are the result of and are constrained by internal and external factors. Livelihood outcomes consist of different categories aimed at achieving a standard of living adequate for health and well-being, including food and shelter (see Table 4.4). Since the SLA analyzes people's effort to achieve their own livelihood goals, respective development projects should be measured according to their contribution to the achievement of the livelihood outcomes which people consider important. Given this context, it is advisable to integrate the group of focus into the negotiation of indicators and monitor them later on. For an adequate analysis, it is necessary aside from the aims of particular groups, to include the extent to which these are already achieved. It is also important to monitor people's awareness of their rights and access to means of ensuring these, as well as security of their livelihood assets, quantity and quality of information sources, representation in political processes, and access to core services such as education, sanitation and health.

Table 4.4.: Livelihood outcomes

Category	**Outcome**
Income	More income is intended by pursued activities and relates to the idea of the economic sustainability of livelihoods.
Well-being	Increased well-being reflects that people value non-material goods such as self-esteem, sense of control and inclusion, physical security of household members, health status, access to services, political enfranchisement, and maintenance of their cultural heritage.
Reduced vulnerability	The reduction of vulnerability is a particular concern of poor people that are more unprotected against uncertainties, risks and shocks, than others.
Food security	Improved food security relates to the foregoing aspect of vulnerability, but is of an especially important concern since it is reflected as a core aspect of the Millennium Development Goals (MDGs).
Sustainable management	More sustainable use of the natural resource base is often attributed to the donors' objective within development projects, but becomes increasingly important to those who recognize the long-term benefit of prudent resource use.

Source: modified from DFID (1999)

5. Methodology

The conceptual framework reveals general tradeoffs and problems for guaranteeing ES provision through environmental contracts in a highly vulnerable context where ES buyers and ES sellers interact. The collection of empirical data serves to investigate the causes of landowners land-use decisions and identify decisive factors for achieving the permanence of forest carbon stocks. These insights indicate how strict commitment ex ante and flexibility ex post can be balanced in PES-REDD contract design while specifically addressing adverse selection and moral hazard. The variables determining permanence of forest carbon stocks are only known generically and are exposed to so-called deforestation and degradation drivers. Approaches addressing them are rather difficult to quantify and need to be considered in the respective complex context of the investigated subject: common property regime (*ejidos* and agrarian communities). As such, pure quantitative research methods are rather inappropriate because the relationships between factors influencing decision-making are not only complex, but also the project frame of this research is limited. Therefore, this research has chosen to use a case study approach as its main research methodology, combining it with methods of sound empirical research in order to obtain robust and reliable results that address the proposed research questions. The case study approach usually employs a mix of qualitative and quantitative research methods (Schnell et al., 1993), leading to early, exploratory investigation where variables are still unknown and the phenomenon is not yet well understood (Yin, 1984). It allows for the identification and description of key variables, and there relationship among them to further determine the link between their causes and effects (Yin, 1984). This approach is, therefore, particularly relevant for this investigation so as to identify applicable parameters describing the implications of adverse selection and moral hazard in PES-REDD contract design.

This study is subject to a number of limitations which are inherent to the methods applied on the one hand while being subject to the constraints of the research itself on the other hand. While the first set of restraints is further elaborated on in subsequent sections, the latter will be explained here in more detail. The study's intention of recollecting data from the field (interviews and experiments) is mainly limited by time constrictions, budget constraints and geographic outreach, which supports the case study focus. This approach as such is a qualitative instrument; often with quantitative features. Qualitative research has limited validity, for example, for explaining overall trends in the national territory, or verifying if community members are (or likely to be) actual drivers of LUC or conservation on common property. Nevertheless, case studies provide profound insights from which policy-makers can infer implications for the successful implementation of REDD in Mexico. The research subject is geographically limited and characterized through its land tenure system. This study specifically investigates two common property regimes (*ejidos* and agrarian communities), both with experience in PES, within the Federal District of Mexico City.

In order to achieve the stipulated objective of guaranteeing the permanence of forest carbon stocks through adequate contract design, this research employs three major research methods, envisioned to function as vehicles in order to obtain reliable data for answering the formulated research questions in a specific study context, and ultimately accept or reject the formulated hypotheses. The three methods used are explained in greater detail in the subsequent sections. Their order corresponds to the three objectives, questions and hypothesis formulated in Section 1.3, and their application and results are elaborated on in Chapters 6, 7 and 8.

5.1. Principal Component Analysis

The Principal Component Analysis (PCA) is a multivariate statistical technique. This type of analysis serves to structure and reduce a large set of collected data. The PCA allows representing a large data set through a smaller subset of statistic variables which are a function of linear combinations. Thus, it is possible to use PCA for the construction of a single index and investigate associated relationships. Sample survey techniques are usually employed to obtain the data set for the construction of such an index, which is primarily a quantitative research approach. Quantitative research seeks to place reasonably firm, absolute levels or values on the items it investigates. This section elaborates on the theoretic concepts behind the index and its process of construction. The explanations provided mainly are built on the works of Zeller et al. (2001) and Henry et al. (2003), who describe the basic concept of summarizing meaningful data sets in a way that can be used for the development of an index assessment tool. Following their approach, the intention is to build various indexes for the different components of the SLA (see Section 4.2) and identify implications of adverse selection (see Section 4.1) in current design of PES contracts applied under the Mexican PES program (see Chapter 6). The subsequent explanation refers to the program specifications of the Statistical Package of Social Sciences 16.0 (SPSS), which offers a wide range of options for the statistical analysis and presentation of data collected. The remainder of this section is divided into the two stages of processing data for the construction of indexes: descriptive data analysis and the development of an index.

5.1.1. Descriptive data analysis

Descriptive data analysis is an intermediate step towards the development of an index. Descriptive statistics describe the main features of a quantitative data set collected for that purpose. The analysis aims to summarize the obtained data and make a first attempt in order to learn more about the population that the data represents. The latter part is then further deepened in the second stage with the goal of constructing an index. Therefore, the raw data derived from a sample survey must be organized in such a way to allow for statistical data processing.

Generic steps involve cleaning data from unrealistic values, equalizing and ordering metric units, and where plausible applying averages for missing values, so that a statistical program such as SPSS can be applied. As soon as the data are pre-processed for analysis, they are tested for significant differences between groups. Differences between groups, for example non-participants and participants of PES, can be tested using both the Chi-square test with cross-tabulations and the T-test for comparing differences of the means. The decision of which test to apply depends on the type of data scale used to measure the variable. Significant differences found in the samples can usually be interpreted as representative for the population as a whole.

Cross tabulation and Chi-square test Cross tabulation is applied when one or more variables are measured on a nominal or ordinal scale. Descriptive analysis of the relationships between two variables involves cross-tabulation tables in order to identify patterns of responses that differ by a certain individual status. The Chi-square test is applied in order to accept or reject the null hypothesis that there is no significant difference in responses between sample groups. The Chi-square test determines whether differences in the distribution of responses across categories are significant in a statistical sense. It answers the question of whether the observed differences in responses between categories reflect a sampling error or indicate a relationship. This test thus determines whether the variables are independent of one another or not and identifies a relationship between two variables. A Chi-square value that is significant at ≤ 0.05 suggests that a difference between two groups (e.g., non-particpant or participant in a PES program) exists in terms of a dependent variable (e.g., occupational status). Cross tabulation can be employed at different levels of data and interpreted respectively. Further clarification of the pattern of differences between two groups may be gained by dividing data into smaller categories such as individual survey regions. However, the guiding question for furthering the analysis to ask is: Under what circumstances does this relationship exist? To answer that question, a test of significance at the cluster level for the same data set may uncover differences.

Independent Samples T-test of means The Independent Samples T-test of means is used to determine whether the difference in means between two groups of independent samples for an interval or ratio-scaled variable (dependent variable) is significant. A test variable (dependent variable) is used, for instance literacy status, to understand in which way it relates significantly to an independent dichotomous variable of two groups (e.g. non-participants and participants in a PES program). Determining whether the means are significantly different between the two groups (independent variable) requires studying the T-test in order to accept or reject the null hypothesis, which states that there is no significant difference between the two groups. The Independent Samples T-test is interpreted in two steps. First, a sub-hypothesis is tested with the Levene's Test for Equality of Variances in order to indicate whether the variance between the two groups can be considered equal (null hypothesis). If the level of significance for Levene's Test is $\leq$0.05, the null hypothesis is rejected and equal variance is not assumed. Secondly, the difference of means between the two groups and deviation from the mean within each group is used to derive a "t-value". This value can then be compared with what is called the "critical t-value". If the calculated t is lower than the critical t-value, one can conclude that no difference exists between the two groups regarding the variable in question. But if the actual t-value is higher than the critical t-value and the level of significance is $\leq$0.05, then the null hypothesis can be rejected and the two groups are considered different. The conclusion is that one group (e.g., PES participants) has a significantly greater percentage of individuals associated with a dependent variable (e.g., level of schooling) than the other group (e.g., non-participants in PES).

5.1.2. Development of an index

The construction of an index is a well-known practice for measuring various aspects based on a composite of variables collected for that purpose. The set of quantitative data is screened for interrelations that jointly provide a stronger statement on a selected issue; for instance human capital. Developing an objective measure requires first identifying the strongest individual indicators that distinguish relative levels and then pooling their explanatory power into a single index. After collecting, cleaning and codifying data, the development follows a more or less predefined path of steps that might vary based on the literature consulted or program for analysis used. However, some basic structure is maintained and valid independently. The three steps followed here for the development of an index are: (i) filtering of indicators for the index by calculating the coefficients of linear correlation among variables and selecting variables based on the strongest coefficients; (ii) using PCA for the estimation of the index; and (iii) using relative index rankings (terciles or quintiles) for the interpretation of the index.

5.1.2.1. Statistical procedures for filtering indicators

The combination of indicators that prove the most instrumental in measuring certain aspects in a given survey area will differ, often in ways that are somewhat predictable. Therefore, it is necessary to determine in a pre-stage of index development a benchmark indicator that best represents the research item such as dimensions of poverty. For example, Henry et al. (2003) found that in densely populated countries, ownership of land and dwellings may better signal differences in relative poverty, while cultural differences will play a greater role in rural societies. The statistical procedures for filtering indicators that are associated with a benchmark indicator and compose collectively the index follow a two-stage approach: first, linear correlation coefficients are calculated in order to filter indicators for the index that best appears to capture relative differences among individuals, and second, variables are tested for correlation.

Linear correlation coefficient The linear correlation coefficient procedure is the primary means of filtering indicators for the index in order to determine the variables that best appear to capture relative differences among, for example, households. Testing the level and direction of correlation against a selected benchmark indicator for each index among a wide array of ordinal, interval and ratio-scaled variables is the primary means of determining the strength of the index components' indicators. The linear correlation coefficient is a statistical procedure used to measure the degree to which two variables are associated. The correlation coefficient can determine the level and direction of a relationship between two variables. Linear correlation does not require that the units used in each variable are the same. The values of the correlation coefficient range from -1.00 to +1.00, and their sign and magnitude indicate how the two variables relate to each other. A coefficient value at or near -1.00 indicates that the variables are inversely related. In contrast, a value at or near +1.00 suggests a strong positive relationship between the two variables. Coefficient values at or near 0.00 suggest that no strong relationship exists between variables. Further, the Pearson's Correlation Coefficient allows testing the significance of the observed correlation. Levels of significance are usually set at $\leq$0.05, meaning that a minimum 95 percent confidence interval is used to either accept or reject the hypothesis that the association between two variables is random. If the level of significance is found to be $\leq$0.05, the association between the two variables is considered strong (rejecting the null hypothesis).

Selecting variables to test for correlation The correlation procedure is set up so that the respective index benchmark indicator appears as the first variable listed in the "Bivariate Correlation". Output from the analysis can be summarized in an SPSS table listing all indicators tested and ordered according to the strength of association measured, noting the number of cases found with missing values. Indicators registering the highest levels of significance ($\leq$0.01) top the list, while indicators registering insignificant levels of association (>0.05), are excluded from the list. It is important to note the sign of the correlation coefficient, which indicates whether the relationship was found to be negative or positive. In this step, it is also reasonable to evaluate if these relationships make sense or if variables are better excluded from further processing. The final table with indicators (variables) of significance is used for estimating the index in the following step.

5.1.2.2. PCA to estimate an index

The PCA method is applied in order to determine how information from various indicators can be most effectively combined for measuring a household's relative index status. Accordingly, the end result of PCA is a single index that assigns a specific value, called a score, to each sample unit (e.g., household) representing the sample unit's index status in relation to all other sample units in the sample. The idea is to create an index from the combination of individual indicators that correlate significantly with each other based on shared underlying components. Therefore, one of the reasons why households answer differently to indicator questions is because of their index status. If indicators are related in more than one way, then more than one underlying index can be created and the number of indexes that can be "extracted" increases with the number of indicators included in the analysis. However, only one index measures a specific household's characteristic (e.g., natural capital). For that process several statistical tools are used in the PCA method in order to create an index, which includes the following steps:

1. Select a screened group of variables highly correlated with the benchmark indicator;
2. Run a test model and interpret the results; and
3. Revise the model until the results meet the performance requirements.

Select a screened group of indicators

Before the PCA method is applied to the data, index indicators must go through a series of filters to ensure that the resulting index does not represent a distorted measure of the respective item intended to be measured. A list of all indicators correlated with the respective benchmark indicator for the index is created previously to the PCA process. The reduced list of indicators from, for example, a questionnaire constitutes the first screening of indicators for PCA. These indicator variables are generally in ordinal, interval and ratio scales, which is required for the PCA method. It is suggested to check the list for any variables with a disproportionate number of missing values and use these as sparingly as possible. The index benchmark variable is now added to this list of indicators and treated as any other variable within the PCA method.

Two additional filters are used to further narrow down the selection of variables for the PCA model. First, the number of indicators used in PCA is limited because having fewer variables reduces the complexity of the resulting calculated components. Closely related variables that effectively measure the same phenomenon can be screened, with only the "strongest" (correlated) added to the PCA model. It is recommended that at least 10, but no more than 20, variables are used to create an index. And second, the range of indicators is balanced in order to reflect different dimensions of the observed phenomenon. Several indicators measuring similar aspects of a phenomenon can be included in a PCA model. However, a heavy concentration of similar indicator-types can inappropriately skew the resulting index and over-emphasize one aspect.

Run a test model and interpret the results

In the PCA method, each underlying component that is calculated represents a linear combination of the indicator variables used in the model. If the PCA is run in SPSS, the first component is the combination that accounts for the largest amount of variance in the sample. The second component accounts for the next-largest amount of variance and is uncorrelated with the first. Successive components explain progressively smaller portions of total sample variance. All components are uncorrelated with one another. Because of this trait, only one can be considered for index development in order to measure relative aspects of a certain phenomenon. The first model run serves to verify if the variables expose the hypothesized relations within the index. If relations appear to be unrealistic two possibilities exist, first, the considered component for the creation of the index does not represent the phenomenon in question, or second, the variables with unrealistic signs are poor measures for the phenomenon of interest. Both aspects have to be further tested and the model refined in the subsequent stages. In addition, if the intention is to use the PCA method to develop an index for analyzing the treatment of two groups within a sampling population (e.g., PES participants and non-participants) it is good practice to only use the untreated group (e.g., PES non-participants) for the construction of the first model in order to avoid a bias of the results and include the treated group (e.g., PES participants) when the final index variable is created.

Revising the model until results meet performance requirements

PCA does not provide an easy way to generate a "best-fit" model for an index. The approach requires "trial and error" and continual scrutiny of variables in order to determine the combination yielding the most logical results. The primary strategy is to systematically screen the list of variables that could be used in the model without compromising the explanatory power of the index. The initial output for the PCA model in SPSS includes four tables that help determining how to improve the PCA index model: (i) component matrix; (ii) common variance table; (iii) communalities table; and (iv) Kaiser-Meyer-Olkin (KMO) and Bartlett's test. Each output can be used to interpret results and refine the model, but it is recommended to use them in the displayed order.

Component matrix The most critical output for determining the composition of the index is the component matrix. Results shown in the other tables may indicate that changes are needed, but the results of the component matrix indicate what changes should be made. Determining how well the PCA model works in creating the index involves assessing the coefficients for each component, called "component loadings", which are the determinants of the index. Component-loading coefficients represent the amount of correlation between the component variable and the indicator variable. To check whether the PCA model is correctly specified, two steps are performed:

1. Check the size of the absolute value of the coefficients for each indicator. This indicates the degree of correlation between the component and the indicator. Large absolute values indicate a high level of correlation, while low values indicate a lower level of correlation. To be considered significant at the 0.01 level in a sample size of 300, a factor coefficient should have a minimum value of 0.180 (Burt-Banks, cited in Henry et al., 2003), but are best screened for those $\geq$0.300 (Henry et al., 2003).
2. Check that the sign of each component coefficient is what would be expected for each indicator in the model. Positive coefficients indicate a direct relationship between the indicator and the component. As the values of an indicator increase, so does the value of the component. Negative coefficients indicate an inverse relationship between the indicator and component.

The model's explanatory power is improved by screening out variables that have low component loadings, since these do not improve the explanatory power of the index, and by adding new variables from the "long-list". In general, when weak variables are removed from the model, the coefficients on the remaining variables often increase in magnitude and the number of extracted components declines. In order to improve the model results, numerous combinations of variables have to be run for determining the combination of indicator variables that most appropriately explains the underlying phenomenon. Analysis of results can be repeated with alterations until the resulting model appears to be the most appropriate for the survey data. Ideally, the final version captures several dimensions of the respective phenomenon, with no single group of measures constituting the entire measure.

Common variance table The level of explained common variance is displayed in the SPSS table "Explained Common Variance" and shows the Eigen values calculated for each component. The size of an Eigen value indicates the amount of variance in the PCA explained by each component. The larger the Eigen value, the more that component is "explained" by the included indicators. The SPSS table shows in one column the calculated Eigen values for each component and in another column shows the percentage of total variance explained by each component. The columns under "Factor loadings" show the "sum of squared factor loadings for extraction". If the model has been carefully screened in order to include only indicators of the respective phenomenon, the first component is likely to explain the variance associated with it. As variables are systematically added or deleted, Eigen values and the associated level of variance explained by the component guides the refining process of the model. As variables are deleted, the Eigen value for the index component changes and the percentage of common variance explained by the component. The change in the share of explained variance can signal whether the addition or elimination of a variable improved or reduced the explanatory power of the index. As a rule of thumb, a minimum Eigen value of 1 is needed if the component is to be considered representative of a common underlying dimension (Henry et al., 2003).

Communalities table Another means of testing the appropriateness of the index model is to note the relative size of communalities in the model. Communalities represent the strength of the linear association among variables and components. Statistically, they represent the same measure as R-squared in a regression analysis. The values of communalities range between 0 and 1, with higher numbers indicating that a greater share of common variance is explained by the extracted components. Communalities indicate how well the indicators combine to identify different components. Since the research is interested in only one of several shared components, communalities alone do not indicate the appropriateness of a variable for the index model. Improving the measures for communalities will not improve the index component if the added variables correlate strongly with components other than the selected index component. As a result, variables may have low communality coefficients but still be relevant indicators for building the index. However, it is suggested that communalities close to 0 (<0.1) signal that the variable in question may be a candidate for exclusion in subsequent runs (Henry et al., 2003).

KMO-Bartlett test The KMO test is an index for comparing the magnitudes of observed correlation coefficients with the magnitudes of partial correlation coefficients, thus measuring the sampling adequacy. The smaller the value of the index, the less appropriate the model. In general, scores >0.6 are acceptable, >0.7 are good, >0.8 are commendable, and >0.9 are exceptional (Henry et al., 2003). SPSS generally shows the results of both the KMO test and the Bartlett test of sphericity. The Chi-square test is at this stage generally not used for the methodology because the test will almost always show less than 0.001 significance with sample sizes as large as 500.

5.1.2.3. Relative index rankings for interpretation

The last part of the PCA method is the testing and interpretation of the final index model. For that purpose two last steps are performed: first, index scores are safed as index variables from the final model, and second, relative index rankings are created from index scores.

Saving index scores as an index variable

Once the final model for computing the index is decided based on the performance requirements, the final version of the PCA model is saved as a standardized value of the index as a variable in the respective data file of SPSS. A common property of the index variable is that it is dimensionless. Standardizing a variable strips away the units in which a variable is measured. A standardized variable has a mean of zero and a standard deviation of 1.

However, if the sample size used to calculate the components has been reduced in the beginning in order to analyze, for example, the treatment of different groups within the sampling population (e.g., PES participants versus non-participants), then the untreated group (e.g., PES non-participants) is increased to the full sample with the treated group (e.g., PES participants). It is likely that the measures of good-fit decline slightly, but the model does not have to be re-specified. Then index results will have to be checked mainly in two ways: first, identifying the level of relative component differences between the two groups (e.g., PES participants and non-participants); and second, verifying that the component index differentiates relative phenomena among sample units (e.g., households) consistently across the survey area and against individual indicators. For example, to check for significant differences between relative index component levels of two groups, a T-test of means can be run using the index for the phenomenon as the dependent variable and the status of group membership (e.g., PES participation) as the independent variable. It is checked if the level of significance is $\leq$0.05. If not, then there is no significant difference between the two samples and the index may not be helpful for explaining, for example, participation. However, the analysis may be deepened by testing for significant differences between index score rankings (e.g., $<$ -1.0, between -1.0 and 0.0, between 0.0 and +1.0, and $>$ +1.0), or checking for differences among survey sites at the "cluster level"; for example two communities.

Creating relative index rankings

The creation of the index for the phenomenon of interest assigns a ranking score respectively to each sampling unit (e.g., household). The lower the score, the "poorer" the sampling unit relative to all others with higher scores. For example, the scores of PES participants and non-participants can thus be compared in order to indicate the extent to which PES reaches community members that yield "poor" levels in the different created indexes. First, however, the share of the local population likely to fall into the "poorest" group must be decided. Different categorizations may be used, such as terciles, quartiles or quintiles. The decision of which cut-off values to use depends on the context.

For example, an assessment study may include a random sample of two groups (e.g., PES participants and non-participants). In order to use the index for making comparisons and create relative rankings a three-stage process is applied. First, the untreated sample group (e.g., PES non-participants) is sorted in ascending order according to the index score. Second, once sorted, the group (PES non-participants) is divided into, for example, quintiles based on their score so that each subgroup contains 1/5 of the total households from that group. The cut-off scores for each quintile define the limits of each group. Third, the second group (PES participants) is then categorized into the five groups based on their individual index scores. Any deviation from the equal proportion of quintile grouping signals a difference between the two groups of the sampling population.

5.2. Delphi Method

The future is characterized by little predictability. However, all kinds of institutions, organizations, companies and individuals have to act and pursue their objectives under this uncertainty (Landeta Rodríguez, 1999). They have to make decisions related to future events and continuously changing circumstances. In order to make the future more predictable, they frequently rely on people's knowledge, judgment, experience, intuition and formal (or informal) education (Gordon and Helmer, 1964; Landeta Rodríguez, 1999; Linstone and Turoff, 1975) in the absence of objective information that would generally be preferred. Accordingly, prevision techniques are separated by objective and subjective information inputs, while thelatter is further subdivided into individual and group techniques (Landeta Rodríguez, 1999). Using subjective information for the prevision is based on a filtration process of beliefs, expectations, opinions, experiences, events and accumulated data (Landeta Rodríguez, 1999). Since this type of information is naturally available (and often the only information available), it is important to make use of it in the most effective and efficient manner possible. This means that more explicit, reasoned and systematic techniques need to be developed for processing such information on an individual or group level.

Individual information is usually added by single persons or a group of independent persons through, for example, answering a survey. On the opposite, group information is derived from the interaction of a group that comes up with a single judgment. The core of the latter is the belief that under certain circumstances results from a group dynamic are superior over an independent treatment of the individual group members (Dalkey, 1975; Gordon and Helmer, 1964) with four arguments supporting this assumption (Landeta Rodríguez, 1999): (i) greater number of resources (knowledge, expertise, experience and information); (ii) social motivation of positive performance (social acknowledgement such as power and esteem); (iii) heterogeneous groups provide a balanced level of knowledge (superior knowledge based on quality); and (iv) integration of stakeholders directly involved in the problem. Therefore, *vis-à-vis* group discussions are a technique frequently used to forecast. They create a major feeling of consensus. But their direct interaction is not under all circumstances a first best solution (Landeta Rodríguez, 1999; Turoff, 1975) and has to balance several positive (e.g., creativity, complementarity, more resources) and negative (e.g., inhibition, status incongruence, individualistic or competitive motivations, pressure to achieve consensus, internal coalitions) influences (Landeta Rodríguez, 1999). Hence, there is a need to improve the prevision techniques embedded in a group decision process and overcome the problems related to direct interaction but without completely refraining from its advantages.

The encountered shortcomings of conventional group techniques and the need for improved forecasting techniques when mainly subjective information is available have been the justification for the development and operationalization of the Delphi[1] Method. The Rand Corporation, a North American research center, is seen as the origin of this method which was developed in the late forties (Landeta Rodríguez, 1999; Linstone and Turoff, 1975; Stewart, 1987). The idea was to design a process of prevision that, first, demonstrates the superiority of group over individual previsions (Dalkey, 1975; Landeta Rodríguez, 1999), and second, avoids the problems associated with the negative psychological influences when experts interact directly (Landeta Rodríguez, 1999). However, especially the latter advantage has been questioned (Sackman, 1975; Stewart, 1987).

In general terms, the Delphi Method is an instrument that employs a group dynamic in order to forecast an event. Linstone and Turoff (1975) described Delphi as "a method to structure a process of group communication that is effective when a group of individuals treats a complex problem". It is applying a systematic and iterative process to obtain a group opinion, and if possible, achieve consensus among a group of "experts" (Landeta Rodríguez, 1999; Sackman, 1975). The underlying philosophical perspective of the Delphi Method is the Lockean viewpoint that data are always prior to formal theory (Mitroff and Turoff, 1975). However, it has turned out that this can be inadequate since, also depending on the panel composition, a forecast is related to uncertainty and it is possible that a group consensus can only be reached for subgroups of the panel. Nevertheless, advocates argue that the Delphi process helps to explore a problem more thoroughly from an heuristic perspective (Sackman, 1975) and actually allow to reveal subgroup opinions (Derian and Morize, 1973; cited in Sackman, 1975; Linstone and Turoff, 1975) that might have gotten lost in a normal group discussion. Therefore, the objective of the Delphi Method, as formulated by Landeta Rodríguez (1999), is "to obtain a trustworthy group opinion based on a conjoint of experts", and becomes especially attractive where improved communication among geographically dispersed groups is desired and alternative techniques are not available (Linstone and Turoff, 1975).

5.2.1. Methodology of Delphi

The Delphi Method has been created and derives its appeal from circumstances where important decisions sometimes depend on judgments over the future. These decisions frequently have to be made with or without an adequate scientific foundation (Stewart, 1987). The Delphi Method has the ability to contribute positively to such a decision-making process (Landeta Rodríguez, 1999), especially as an informal and heuristic exercise (Sackman, 1975). But the critics of the method are varied. A peculiarity of the critics is that it predominantly came

[1] Delphi is the English translation of Delfos. Delfos is an antique Greek city located at the foot of Mount Parnassus, known for the oracles that Apollo carried out there through a priestess called Pythia.

initially from the same research institution that originated the method - the Rand Corporation (Sackman, 1975; Stewart, 1987). Specifically, it is criticized that the foundation and process are not scientific enough (Stewart, 1987). Above all, its utility and belonging to quantitative research has been questioned (Sackman, 1975). However, Stewart (1987) points out that judgmental forecasts are unavoidable, although the problem persists to select adequate and context-dependent experts. Thus, the Delphi is a quasi-scientific instrument that is attractive when other scientific "correct" models are not applicable (Landeta Rodríguez, 1999) or it is possible to use them in combination.

The Delphi Method is a relatively flexible and easy to implement opinion polling instrument. The decision-making process is enhanced in two basic ways (Landeta Rodríguez, 1999). First, it improves the quality of the decisions by considering more and better sources of information. And second, it improves the acceptance and effective application of the taken decisions through the adoption of a communication process that broadens participation, facilitates a positive learning experience, generates satisfaction and creates trust. Hence, the Delphi Method intends to obtain from a group communication process an opinion that is more definite, rational and accurate. The application of four main features is key for the intention of the method and is supposed to overcome problems of traditional group techniques (Dalkey, 1975; Landeta Rodríguez, 1999; Linstone and Turoff, 1975; Sackman, 1975):

- Iteractive process - The individual experts are all forced to provide their opinion on each single item "discussed" within the process of opinion polling in successive rounds. It is expected that initially opinions diverge, but at the end of the process opinions stabilize and reveal a consensus or subgroup formation of consensus. The development of a group opinion is stimulated by providing the single expert with the opportunity to reflect and change positions as a consequence of reasoning from the group and complementary information provided by the Delphi administrator.
- Anonymity - The participants are not able to relate particular stated opinions to any participant of the panel, and more rigorous, they should not know the list of participants. Handling the process that way reduces the influence of elements that are affecting the process negatively and inhibiting the participants to freely contribute. To guarantee anonymity the process may rely on different tools that avoid the direct interaction of the expert panel. Commonly these are paper-pencil questionnaires (distributed by mail, fax or email), telephone interviews, *vis-à-vis* interviews and web-based questionnaires. The control of communication is the responsibility of the Delphi administrator.
- Controlled feedback - The basic assumption of Delphi is that a group process with controlled interaction of the experts is superior over individual opinion polling. The controlled interaction refers to the ongoing transmission of the "statistical" position of the group between each round. This group position is further enriched by contributions or

suggestions of the experts, reasoning of outliers or additional information requested by the group from the Delphi administrator or independently provided by her/him. Usually before a next round starts this information is made available by the Delphi administrator to all experts. Within this communication process the control and filter of transmitted information helps to assure the free transmission of information and avoids the noise in communication among experts. The noise refers to irrelevant, redundant and wrong information. In addition, this control helps to use a common and understandable language.

- Statistic group response - After each round, the individual answers are analyzed and summarized by a numerical estimation of central tendency and dispersion. For the central tendency it is usually the median. If taking the median instead of the mean, it is avoided that the extreme values are given excessive weight in the final result and blur the opinion of the majority. However, although it is desired to obtain a group consensus, it is not the ultimate goal. Reporting the intermediate and final results that way has two advantages: first, it assures that individual opinions are not getting lost and form part of the final result, and second, it reduces the pressure towards conformity.

However, the Delphi Method is not free from methodological imperfections as already indicated. For example, the Delphi administration has an unavoidable influence over the selection of information provided to the expert panel so that experts' responses are not strictly independent (Landeta Rodríguez, 1999; Sackman, 1975). In addition, the method is not able to avoid ambiguities in the questionnaires, uncertainty towards the level of panelists' expertise, instability of the panel and the possibility of deliberate or unconscious biases (Gordon and Helmer, 1964; Landeta Rodríguez, 1999; Sackman, 1975). In such a subjective group process, there is always a combination of signals and noise involved that has to be treated adequately. Signals are contributions and transmissions of knowledge, experience and expertise that support the objective of the group process if valid (Landeta Rodríguez, 1999; Stewart, 1987). Noise or errors are contributions that represent irrelevant experience, useless information, bias, wrong belief, and social pressure that do not help or even hamper the process to achieve the study's objective (Landeta Rodríguez, 1999; Stewart, 1987). That said, the Delphi Method is trying to maximize the signals and minimize the noise in order to improve the quality of the result (Landeta Rodríguez, 1999); although it is difficult to prove its superiority over other methods in this regard (Stewart, 1987). However, the Delphi Method is not only subject to inherent imperfections, the process is also susceptible to inadequate application (Landeta Rodríguez, 1999; Linstone and Turoff, 1975; Linstone, 1975; Sackman, 1975). Most of them occur as a consequence of insufficient consideration of preexisting scientific knowledge and recommendations. However, a rigorous application is needed it order to maximize the utility of the instrument, which is explained in the following section.

5.2.1.1. Delphi process

The point of departure is a formulated problem where a Delphi is appropriate to better structure the problem and ultimately produces a forecast for a solution. Typically, a Delphi is coordinated by an administrator that is contacting a group of people considered to have expertise in the field of interest. The group that is finally "recruited" for the process is generally referred to as the panel of experts. The Delphi administration is functioning as a coordinating organ in order to assure the four basic characteristics of the method: interactive, anonymous, controlled feedback and statistical result. Generally, the administration is formed by specialists of the research object, and have a profound knowledge of the applied method (Landeta Rodríguez, 1999). Therefore, the result is a bargained reality between the administration and panel of experts (Scheele, 1975). Although, there is not a strict rule found in the literature for the size of the administration, Landeta Rodríguez (1999) indicates that the number should be at least two and not exceed five. The Delphi administration has to fulfill a number of functions in order to maximize the result of the process. Pashiardis (1993; cited in Landeta Rodríguez, 1999) puts forward six generic tasks that have to be coordinated by the administrator of the process: first, the study and work plan have to be approved, which includes the identification of selection criteria for the experts, schedule of the process, capacities and resources to be used, and design of the final report; second, the review and approval of the list of participating experts; third, the construction of the questionnaire and assurance of effective panel member participation; fourth, the analysis of responses, preparation of successive questionnaires and facilitation of adequate feedback; fifth, the interpretation of the results; and sixth, the supervision of correct application, proposition of corrections and correction if appropriate.

The Delphi process follows a generic sequence of repeated interaction between the administration and the panelists (see Figure 5.1). Various authors (Astigarraga, 2004; Landeta Rodríguez, 1999; Linstone and Turoff, 1975; Stewart, 1987) have reported and confirmed its practicability. In the first stage, the task of the Delphi administration is to translate the research object (the problem) into manageable questions and answer options that allow the individual expert to submit an estimation that can be summarized ex post into a statistic response of the expert panel. The statistical treatment of the obtained inquiry answers is particularly useful when the panel is asked to make quantitative estimations, state probabilities of occurrence or put items into a hierarchical order. An alternative to that initial inquiry can be an open-ended question that wants the panel to enumerate, for instance, items, reasons and statements. Then the administration would have to classify and summarize the varied contributions and use them within the further process. Once the set of questions is finalized and a questionnaire with the answer choices has been constructed, the administrator submits it to the panel in a second phase. The form of submitting the questions to the panel can be varied, but is probably limited to mail, fax, email, web-based, *vis-á-vis* and telephone. Each application has its disadvantages and advantages, and is probably more or less significant depending on the heterogeneity of the expert panel and capacity of the individuals. Depending on the type of expert, it could be helpful to use a mixed approach with the most appropriate tool for each expert. In a third phase, the Delphi administration receives the responses of the expert panel and aggregates individual responses into a single measure that reflects a central tendency - usually the median. Where possible the interquartile range is also calculated as a measure of dispersion. After analyzing and aggregating the individual responses, the measure of central tendency and dispersion is resubmitted to the panel of experts, together with their personal response. The Delphi administration can also choose to add information from the previous round. That information could have been requested by panel members, provided by panel members (e.g., outlier opinion), or added by the administrator when it is perceived helpful for the research. Finally, the expert panel is asked to consider this information and repeat the exercise of answering the questionnaire. Particular attention is then given to the panel members that still stick to an outlier estimate. These experts are usually asked to further elaborate on their opinion and provide justifications, which should be made available to the whole panel. The rounds of inquiry, if possible, continue until a maximum of consensus and/or stability in the answers of the panel is reached. The crucial indication for stability, and thus ending the process, is when the median is not oscillating and the interquartile range is not expanding anymore according to a predefined benchmark. Then the Delphi process is closed when stability is achieved, final statistics are transmitted to the panel and the results are used to prepare the report.

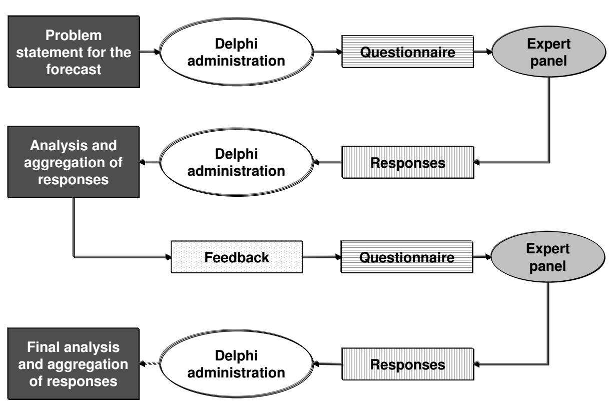


Figure 5.1.: The Delphi process
Source: modified from Soldevilla García and Grande Esteban (1987)

5.2.1.2. Delphi panel of experts

The group of experts constitutes the foundation of the process, since their judgment provides the input for the forecast. Because of the important role the panel plays, it is of great concern to carefully review four basic criteria, suggested by Landeta Rodríguez (1999), when setting up the panel. First, defining who is an expert and which criteria to use for her/his selection; secondly, deciding on the optimal number of experts for the panel; third, identifying the best way of communicating with the panel in order to achieve the highest participation; and fourth, considering the need to evaluate the expert knowledge and weigh it accordingly during the process.

Experts and selection criteria The concept of employing experts was handled initially quite rigidly. But more recently, the term expert is used with more flexibility (Sackman, 1975). The decision of whom to consider as a potential expert is attached to the Delphi administrators' choice. The administrator has to find selection criteria for identifying eligible candidates. The level of knowledge is naturally the most important indicator (Brockhoff, 1975) but does not always mean that it is associated with predictive effectiveness (Landeta Rodríguez, 1999; Sackman, 1975). The latter, of course, is most desired when composing the expert panel. Since the notion of an expert is blurred, this research adopts the description of Landeta Rodríguez (1999), who states that an expert is an individual whose situation and personal resources enables her/him to contribute positively towards the objective of the Delphi Method. A number of selection criteria might help to identify the appropriate expert, using, for example, the level of knowledge, predictive power, level of concernment, facilitation capacity, level of motivation, and other practical considerations such as costs, proximity and organizational concerns (Landeta Rodríguez, 1999). In addition, since the expert is employed as a surrogate for direct knowledge, it is also desirable that individual estimations are honest, accurate, definite, realistic, certain, and free from bias (Dalkey, 1975). However, it is likely that the composition of the expert panel differs according to the nature of the problem. In this sense, Scheele (1975) distinguishes three types of experts: specialists, affected and facilitators. It might be useful to separate the different expert types or mingle them in appropriate proportions. But it is important to keep in mind that the Delphi Method has to deal with high drop-out rates of experts (Sackman, 1975), which emphasizes that special attention has to be attached to the level of motivation in participation.

Optimal number of experts It is impossible to determine ex ante the optimal number of experts in order to maximize the precision of the forecast. It is likely that group performance depends on the size of actively involved participants (Brockhoff, 1975). It is well-known from statistics that an increase in the sample increases overall precision. The Rand Corporation (1970; cited in Landeta Rodríguez, 1999) demonstrated for the Delphi technique that an increase of the expert number has a positive effect on the precision of group estimations when comparing it to the real value. In fact, error tends to decline exponentially when increasing the sample (Landeta Rodríguez, 1999). However, the same research institute recommends that a minimum number of seven experts should be maintained, but not exceed 30. They state that the improvements on precision are marginal and do not compensate for the increased workload and costs. This ideal number of experts, although desirable, will likely suffer under a process of adjustments according to the specific circumstances of implementation. Landeta Rodríguez (1999) points out that the number of experts will probably be a function of and therefore varies according to included areas of knowledge, desired geographical outreach, different groups involved, level of motivation, and other factors related to administration such as organizational capacity, time and budget.

Communication strategy with the experts The Delphi is a two-way communication process where information is transmitted, received, processed, analyzed and returned. That process is repeated several times and the Delphi administration has to decide basically two things to facilitate communication: first, the mode of communication, and second, the kind of information to communicate. Both have a decisive impact on experts' participation. Potential participants will ask themselves what will it cost them and what are the benefits for them to participate (Scheele, 1975). Accordingly, as mentioned earlier, the administrator of the inquiry can employ a set of different communication channels such as mail, fax, email, web-based tools, *vis-à-vis* and telephone. However, the information that can be transmitted that way is normally restricted to the study's objective, the nature of the method applied, the type of participants and criteria applied for their selection, the number of rounds and time necessary to answer each questionnaire, the approximate duration of the whole process, the potential utility of the information, and the benefits obtained through participation (Landeta Rodríguez, 1999). Customization of these factors and adaptation to the research's circumstances is decisive in order to stimulate the desired level of participation and minimize dropout rates.

Evaluation and weighing of the expert judgement A basic issue for Delphi advocates and critics is if experts' responses can and should be treated equal. The underlying concern is that the quality of the contribution may vary and thus a differentiation might improve the final result, and *vice versa*, equal treatment might corrupt the power of the outcome. The problem though is to construct a reliable set of criteria for weighing the experts within the whole process or in varying sections of each round. Factors such as the level of intelligence and gender have proven to be insignificant, and especially latter has proven to be ridiculous (Landeta Rodríguez, 1999; Sackman, 1975). In fact, it is acknowledged that a gender-balanced approach enriches the process and provides a more balanced picture. Ultimately, the predictive individual power is the most appropriate variable (Landeta Rodríguez, 1999), which is indifferent of gender considerations and generally related to the level of knowledge. However, predictive power and level of knowledge does not always match, but is for practical reasons easier to measure and verify. Nonetheless, the difficulty still remains to reveal ex ante the level of experts' knowledge. For that purpose alternatives are proposed such as the revelation of knowledge through a test, the use of a set of implicit indicators (e.g., number and quality of publications, citations, years of experience, level of precision in previous studies), or the evaluation in a subjective manner (e.g., external panel, same panel, administration, self-rating) (Brockhoff, 1975; Landeta Rodríguez, 1999; Linstone and Turoff, 1975). However, Sackman (1975) cites various studies which were unable to find statistical significant differences between "laymen" and "experts". Instead, it seems that in explanatory socio-economic inquiries the level of expertise is independent from evaluative opinions.

5.2.1.3. Obtaining and transmitting information

The central idea of the Delphi Method is to provide a better way of obtaining and transmitting information within a group dynamic. The technique helps to encourage greater involvement and facilitates communication between stakeholders (Ludlow, 1975). Within this process of transmission three aspects are of particular concern (Landeta Rodríguez, 1999): (i) formulation of questions; (ii) integration of individual opinions; and (iii) controlled feedback.

Phrasing questions In the stage of question formulation, the Delphi Method is not different from any other survey technique and has to deal with the same problems. Questions generally reflect cultural circumstances, subjective bias and knowledge of the designer. That has a considerable impact on how experts understand the questions and thus influences the quality, properties and completeness of the responses (Landeta Rodríguez, 1999; Sackman, 1975). Therefore, special attention should be paid in the stage of formulation in order to assure that questions are clear, precise and do not condition the answer. Questions that are too short or too long may have a negative impact on the precision. As a rule of thumb, Landeta Rodríguez (1999) suggests limiting questions to approximately 25 words, although it finally depends on the complexity of the topic and expertise of the panel. Useful approaches for minimizing the stated kinds of flaws include obtaining feedback from other researchers and running pre-tests. Another convenient way for reducing the influence of the Delphi administration is to start the process with open-ended questions that leave it up to the panel to identify items and questions. However, since the Delphi is closer to a quantitative method, a structured questionnaire with closed questions has to be applied to the panel in the end. Spetzler and von Holstein (1975; cited in Landeta Rodríguez, 1999) distinguish two classes of questions applicable for the purpose of a Delphi: (i) hierarchizations, valorizations and comparisons; and (ii) concrete quantitative estimations.

- The first group of questions provides a relation of items which offer the possibility to process them as a function of indicated criteria. A hierarchy is usually established when items are put into an order according to their greater or lesser proximity to the reference criteria. A valuation applies when a scale has been defined (e.g., the Likert scale or yes/no questions), and accordingly it is possible to assign points or weights. Valuation is superior to hierarchizing in two ways: first, it is simpler to answer when the number of items is elevated, and second, more information is added since the difference between each item is not linear because a weight has been assigned to each response. A comparison-type is applied if a set of items is compared parwise, which is attractive for questions with a large list of answer options.
- The second group of questions is most common in the Delphi Method and is further discriminated into point and range estimates. A point estimate represents a unique numerical value that can be absolute or relative in nature. A range estimate is appropriate when concrete values are difficult to state and it is more adequate to express the answer as a confidence interval or confidence triplet.

Integration of individual responses The responses of single experts represent the input for the group estimation that is used for internal feedback and final result. The way of asking the questions has to be simple so that any bias or noise is avoided, or at least minimized. In a first stage it is not unusual that a Delphi starts with open-ended questions where answers are less structured, not quantifiable and ambiguous (Scheele, 1975). It is up to the Delphi administration to interpret, summarize, scrutinize and adapt the responses but without changing the sense or losing real information (Scheele, 1975). As stated previously, two classes of questions are relevant and vary by their form of integration: (i) hierarchizations, valorizations and comparisons; and (ii) concrete quantitative estimations.

- Hierarchization results in the same amount of quantifications as expert opinions exist. For integration a measure of central tendency is applied to each item and finally ordered from the least to the highest central measure. In the case of equal central tendencies, a measure of dispersion can be employed. The valorization calculates the central tendency of the values assigned to each item for each response that are finally put in order. The comparison calculates the number of positive elections for each item or response compared to the rest. The individual score is then used for a classic hierarchization or for a valorization.
- Quantitative point estimates are summarized and represented through a measure of central tendency and dispersion. Range estimates are summarized and represented, for example, as confidence intervals or confidence triplets. Integration follows the principles of point estimates with the exception that here two to three values per response must be combined. In the case of confidence intervals, all individual responses are integrated

in order to identify the lower and upper boundaries. A measure of dispersion can be calculated for each extreme.

Feedback A key attribute of the Delphi Method is feedback during the forecasting process. The purpose of the feedback is to allow the panel of experts to rethink their initial opinion and make changes in subsequent rounds if considered appropriate. This feature allows to unite and enrich the individual perspectives of panel members. The origin of the information used for feedback can be varied but is limited to individual experts, groups of experts and Delphi administration, and is always controlled by the administrator. It is the administrator's task to decide which information is shared and how. The administrator's challenge is to extract and summarize the information that is useful and contributes to the goal of the process. The risk of losing information or misinterpreting it in the filtering process cannot be completely avoided. The utility of feedback can be grouped into three principal areas. First, feedback which improves the quality of group results. It is argued that a group opinion is superior to individual contributions (Dalkey, 1975; Landeta Rodríguez, 1999) as the panel has access to a wider set of information than before the process started when it was limited to individuals or subgroups (Landeta Rodríguez, 1999; Linstone and Turoff, 1975), so that the complemented data can be new or distinct and may provoke the correction of wrong perceptions and opinions (Landeta Rodríguez, 1999). Second, feedback which allows for formulation of a common basis over which individual estimates might achieve major convergence (Landeta Rodríguez, 1999). And third, it helps to anticipate the reaction of the group which will be affected by the study results (Landeta Rodríguez, 1999). The way the feedback is transmitted and presented has probable impact on the final result. That is why special attention has to be paid to what, how and when the feedback is given (Landeta Rodríguez, 1999). Feedback generally contains subjective information originating from the expert panel, which is processed and might be enriched by the Delphi administration. The processed information is usually reported using measures of central tendency and dispersion of responses from the previous round and, optionally, single responses (e.g., outlier) (Landeta Rodríguez, 1999; Linstone and Turoff, 1975; Sackman, 1975). The transmission of the feedback is then reported through the same channel as the submitted questions. It is important to take care of the style and representation of this information, since it has to animate panelist participation (Landeta Rodríguez, 1999). Feedback can be given before or at the same time the "new" questions are submitted to the panel. It might be useful to provide feedback as soon as possible after the round has ended so that the panelists still recall their position.

5.2.1.4. Concluding the Delphi process

Various considerations need to be explored in order to maximize the quality of the results of the Delphi process. Two items stand out in the literature (Landeta Rodríguez, 1999; Linstone and Turoff, 1975): first, the criteria used to determine the end of the process, and second, the analysis of the results.

Criteria used to end the process

Two different approaches are mentioned in the literature for determining the end of the process: theoretic reasoning and pragmatism. The first employs as its study objective the aim of achieving consensus or stability in the responses of the expert panel and, thus, does not predetermine the number of inquiry rounds (Landeta Rodríguez, 1999). The second approach is straight forward. The end of the process is predetermined as a function of the capacity and resources available to the Delphi administration, the deadline of submitting the results and risk of experts' abandonment (Landeta Rodríguez, 1999). Generally, the Delphi administrator will find it sufficient to develop a process of two to three rounds, and, as pointed out by Linstone and Turoff (1975), this is sufficient to attain stability in the responses, where successive rounds do not necessarily improve the outcome (Brockhoff, 1975). Although this procedure is inadequate from a methodological point of view, it is most likely the common course of action.

The remainder of this subsection focuses on the first approach which can be used to evaluate the Delphi outcome when using the latter approach. The theoretical criterion for concluding a Delphi is subdivided into two different groups: consensus and stability. Both are related to statistical reasoning. The consensus is the original criteria used by Delphi (Landeta Rodríguez, 1999) especially a Policy Delphi (Scheibe et al., 1975). The process is completed when a consensus is achieved. A generic definition of consensus is "the level of convergence for individual estimations that is reached when the opinions present an acceptable level of proximity, normally a reduced interquartile range" (Landeta Rodríguez, 1999). Hence, the process is repeated until the desired level of proximity is reached. The risk of this is that subgroup opinions are ignored and experts are forced into convergence (Sackman, 1975), leading to possible information loss or arriving at a fictious consensus.

Consensus Two techniques are frequently reported in the literature to measure the level of consensus (Landeta Rodríguez, 1999): Relative Interquartile Range (RIR) and Coefficient of the Variance. Since the reviewed literature does not indicate superiority of one over the other, this study has selected the first due to its simplicity and easy interpretation. The RIR is calculated based on the difference between the upper quartile (Q_3) and lower quartile (Q_1) divided by its median, which is equal to the middle quartile (Q_2) (see Equation 5.1). Consensus is reached when the RIR is less than an arbitrary predetermined value; usually close to zero.

$$RIR = \frac{Q_3 - Q_1}{Q_2} \tag{5.1}$$

Stability A stability of responses is achieved when no significant variation of expert opinions occurs in successive inquiry rounds, independent of the level of achieved convergence. That means that consensus is featured by stability, but stability does not necessarily mean that consensus is achieved. The two main approaches for this measurement are group and individual stability of answers (Landeta Rodríguez, 1999). Individual stability necessarily implies group stability, whereas group stability does not necessarily imply individual stability. There are several ways to calculate stability as suggested in the literature. Landeta Rodríguez (1999) enumerates seven main approaches: Variation of the RIR, Variation of the Coefficient of Variance, Relative Variation of the Median, Comparison of Variances through Snedecor's F-Distribution, Chi-square test, Proportion of Modified Expert's Opinion, and Index of Predictive Association. Generally, the applicability of each depends on the type of data and study objective. Since this study has selected RIR for calculating consensus, it is appropriate to use the variation as a measure of stability. The Variation of the RIR (RIR-V) is calculated by the variation of the RIR between two rounds (see Equation 5.2). This approach also concludes the process based on a subjective predefined criteria where values around and close to zero indicate stability.

$$RIR - variation = (RIR_n - RIR_{n-1}) \tag{5.2}$$

Analysis of the results

The idea behind the Delphi Method is that by the end of the process all experts have exchanged their opinion on a given topic with the help of controlled interaction administered by the Delphi administration. Between the different rounds of interaction, the Delphi administration begins the analysis of the partial results. Data analysis consists of three generic steps (Landeta Rodríguez, 1999): (i) data collection; (ii) calculation of summary statistics with measures of central tendency and measures of dispersion; and (iii) data interpretation and analysis. Data interpretation is particularly challenging, since it is possible that subgroups exist or bias occurs.

Subgroups It is very likely that the panel may give divergent answers to the posed questions. Thus, it is useful to check for the presence of subgroups with their respective behavior and characteristics. This requires the interpretation of sub-results and their reflection in the final results. Furthermore, it might be helpful to explore the underlying causes of the answer choices, such as differences in geography, professions, culture, economics and politics. Different instruments can be applied in the framework of Delphi in order to detect subgroups. These approaches can be used to compare answers of likely subgroups for a set of questions (Varela, 1989; cited in Landeta Rodríguez, 1999) or to compare the questions applied to different subgroups (Jones, 1975) in order to detect correlations between the answers that the same group provide for different questions. Landeta Rodríguez (1999) proposes approaches such as Variance Analysis, Chi-square Distribution, Snedecor's F-Test, Spearman's Rank Correlation Coefficient, and Spearman's Rank Correlation Coefficient "simple". Since RIR-V falls under the Variance Analysis approach, this study has chosen the use of Equation 5.2 as well, to confirm the existence of subgroups.

Bias A final consideration relates to the identification and correction of structured and known bias. Bias of the Delphi results might occur at different points (Jones, 1975; Stewart, 1987). When stability is achieved in the experts' answers and these exhibit any characteristic bias or a response distribution assimilable to any known distribution, it is appropriate to realize a correction or adjustment of the results (Landeta Rodríguez, 1999). The final result should reflect the position of the experts in relation to the object of study, highlighting the causes or reasons which justify their positions and the shared reality. Therefore, the results obtained need to be analyzed in two ways (Landeta Rodríguez, 1999). First, a global analysis which is accomplished by integrating the qualitative results obtained from the experts, and complementing the results with the researchers' (Delphi administrator) perceptions. And second, a quantitative analysis of the response distribution by calculating the central tendency with the measurement of the median (and/or mean), calculating the dispersion with the measurement of the interquartile range (and/or standard deviation), verifying the existence of subgroups (e.g., RIR-V), and analyzing the form of the distribution.

5.3. Conjoint Analysis

Experimental methods in the laboratory or in the field are attractive tools for economics whose goal is to address intricate incentives and contextual questions which arise in assessing values through direct statements of preferences. By combining empirical observation with theoretical insight, researchers use the experimental mindset for explaining how economic and social contexts matter to valuation (Todd et al., 2009). In Game Theory it is argued that results depend on decisions and estimated probabilities of individual decision-makers ("players") involved so that it is possible to evaluate if a group is optimally managing, for example, natural resources, or if not. It can, thus, reveal individual incentives which provoke non-optimal management. If individual incentives are the driving force, then organizational structure and institutional design need to be tailored to the incentive structure that successfully influences behavior and, consequently leads to an effective environmental policy (Todd et al., 2009). This research investigates through experiments such incentive structures in environmental policies that are designed to protect public and private goods. It employs a stated preference technique for the valuation of different policy designs that influence land-use behavior. The choice modeling techniques, as described by Bateman et al. (2002), are used to fulfill that task. Choice modeling is different from contingent valuation (Bateman et al., 2002) since in the first method the respondent is confronted with different alternatives of election, while in the second approach the respondent is only confronted with two alternatives. Choice modeling or Conjoint Analysis (CA) is a statistical technique (multivariate method) originally developed as a marketing tool for sourcing attributes that make clients opt for a certain product - conjoint refers to CONsidered JOINTly. This method is also referred to as multi-attribute compositional modeling, discrete choice modeling, or stated preference research (Vásquez Lavín et al., 2007), and is part of a broader set of trade-off analysis tools used for systematic analysis of decisions. The objective of CA is to determine which combination of a limited number of attributes (or characteristics) at various attribute levels is most influential on respondents' choices or decision-making (Bateman et al., 2002; Vásquez Lavín et al., 2007). As "products" from a respondents' view point usually have both, i.e., certain advantages and disadvantages, they are forced to weigh the importance of the different properties relative to each other and become conscious about the actual meaning and value of each attribute and attribute level.

5.3.1. CA design

CA is an interesting tool for analyzing preferences in individual and collective land-use behavior and how this might affect the choice of alternative environmental contract designs. CA is capable of analyzing environmental policy design in terms of attributes which significantly influence the values that people place on alternatives (or goods and services affected by the alternative) respectively and the implicit ranking of these attributes (Bateman et al., 2002). An environmental contract, as is the case of a product or service, is described in terms of a number of attributes (Vásquez Lavín et al., 2007). For example, a PES contract under the Rules of Operation from *ProÁrbol* has certain attributes related to, for example, time frames, accounting rules, payment levels and obligations. Each attribute can then be broken down into a number of levels (Bateman et al., 2002; Vásquez Lavín et al., 2007), for instance, levels of payment may be fixed, variable, or mixed. ES sellers are shown a set of contracts created from a combination of levels from all or some of the constituent attributes and asked to either choose from, rank or rate the contracts they are shown (Vásquez Lavín et al., 2007). Each alternative is similar enough that ES sellers see them as close substitutes, but dissimilar enough that they can clearly determine a preference. Thus, alternative contract designs are composed from a unique combination of contract features providing respective utilities to the parties.

5.3.1.1. CA methods and main approaches

In general, the data obtained from CA consist of individually stated preferences regarding presented combinations of alternatives. In choice modeling, there exist several techniques of operationalization. This method can be divided into four main approaches (Bateman et al., 2002): choice experiments, contingent ranking, contingent rating and paired comparisons. However, it is argued that only the first two are actually in line with the Theory of Welfare Economics and able to produce relative (not absolute) estimates on WTP and WTA (Bateman et al., 2002).

Choice experiments The choice experimental approach uses a series of alternative scenarios which are compared to the status quo. The respondent is then asked to choose among them, thus, implicitly revealing her/his preferences regarding several attributes representing the alternatives. Welfare Economics' consistency is achieved through four main characteristics (Bateman et al., 2002): (i) "they force the respondents to trade-off changes in attribute levels against the costs of making these changes"; (ii) "the respondents can opt for the status quo, that is, no increase in environmental quality at no extra cost to them"; (iii) "represent the econometric technique used in a way which is exactly parallel to the theory of rational, probabilistic choice"; and (iv) "derive estimates of compensating and equivalent surplus from the outcome of the technique".

Contingent ranking Contingent ranking is different from choice experiments in that it presents alternatives which the respondent has to rank rather than indicating the most preferred option. The order of ranking reflects the preferences for each alternative. Hence, contingent ranking can treat a greater number of alternatives at the same time, usually three or more, while adding greater complexity to the valuation process for the respondent. Similar to choice experiments, this approach has to involve a status quo option representing the currently available choice set in order to be compatible with Welfare Theory (Bateman et al., 2002). This avoids forcing respondents to select an option that is not desired. Furthermore, this approach requires a transformation of results in order to make individual utility statements comparable among respondants. Modifying the approach to a sequential choice process increases its similarity to choice experiments.

Contingent rating Contingent rating asks respondents to indicate a rate of preference on a predefined scale (e.g., 1 to 10) for alternatives that are individually presented to them. Hence, the research obtains individual rating scores for different environmental goods, services and/or policy designs. The difference between contingent rating and contingent ranking is that no direct comparison of alternatives is requested, which makes it incompatible with Welfare Theory (Bateman et al., 2002). However, it is similar to the contingent ranking exercise since it requests the transformation of results in order to make individual utility statements comparable among respondents.

Paired comparisons The paired comparisons technique is a combination of the choice experiment and contingent rating exercise. Usually the design requests that the respondent makes a choice between two alternatives presented to them and rate the strength of preference on a predefined scale. Since generally no status quo option is provided, this technique appears to be incompatible with Welfare Economics.

5.3.1.2. Standard procedures and common design stages

The number of potential alternatives (e.g., contracts) increases exponentially as the number of combinations of attributes and levels increases. Consequently, different factorial designs are possible to evaluate sets of alternatives and ensure that enough data are available for statistical analysis, resulting in a carefully controlled set of "profiles" for the respondents to consider. The standard procedures of applying CA in the field vary considerably depending on the specific discipline and circumstances in the field. Bateman et al. (2002) suggests five generic design stages of choice modeling approaches: (i) selection of attributes; (ii) assignation of levels; (iii) choice of experimental design; (iv) construction of choice sets; and (v) measurement of preferences.

Selection of attributes

The identification and subsequent selection of relevant attributes for determing the characteristics that a good, service or policy have is the first step. Usually this task is accomplished by literature review, group discussions or interviews. Generally, a mixture is best since each source of information may provide an incomplete picture. However, the number of attributes should be restricted (e.g., four to six) in order to avoid reduction of the statistical power of estimates since the required sample size increases exponentially with the number of considered attributes.

Assignment of levels

Each attribute is determined by levels of specificity and may have different ranges. As for attributes, the number of levels should be limited in order to avoid unreasonably large profile sets. In the design stage, it is important to identify realistic scales that are practical. The same sources might be relevant, as used for the identification of attributes. Especially the monetary tag is susceptible to strategic behavior, which should be minimized in order to avoid bias. Usually extreme values will demonstrate such effects.

Choice of experimental design

The process of constructing a set of scenarios (alternatives or profiles) that combine levels of attributes is based on Statistical Design Theory (Louviere et al., 2000; cited in Bateman et al., 2002). This offers the possibility of employing complete or fractional factorial design sets where the actual choice depends mainly on the number of possible profile sets. A general relation is one where the larger the number of attributes and attribute levels, the greater the number of profiles. That is because the total number of possible profiles is calculated by taking the number of levels to the power of the number of alternatives.

Complete factorial design The earliest forms of CA were known as "full-profile" studies, in which a small set of attributes, typically four to five, were used to create profiles shown to respondents. In a complete factorial design, all the possible combinations are considered. Complete profile sets offer the possibility to estimate the full effect (main effects and interactions) of considered attributes. Main effects are the effects of each individual attribute and interactions are the extent to which behavior is connected with variations in the combination of attributes. However, there are two drawbacks in full-profile designs. First, the number of attributes included is heavily restricted because with large numbers of attributes the consideration task for respondents becomes too complex. And second, the task itself becomes unrealistic and does not link directly to behavioral theory. In real-life situations, the task requires actually chosing between alternatives rather than artificially ranking and rating as is used in some approaches.

Fractional factorial design Fractional profile sets reduce the number of alternatives from all possible combinations. Issues of impracticality of complete factorial design are overcome at the detriment of the ability to detect interactions. Design catalogs are used to define subsets of attributes and levels from the total number of possible alternatives in a statistically efficient manner. In general, the intention is to employ orthogonal main-effect plans for symmetrical or asymmetrical factorial experiments in order to significantly reduce the number of alternatives (Addelman, 1962a,b). Orthogonality means that attribute variables have zero correlation among each other, which implies that only individual (main) effects on the choice can be examined. Factorial designs have four principal drawbacks: first, implausible and unrealistic alternatives can be created, which makes adaptation necessary; second, underlying relations (interactions) remain undetected so that weights of variables can be biased; third, ratios with the cost coefficient are not perfectly possible; and fourth even with fractional factorial designs, the number of profiles for evaluation can increase rapidly. Louviere (1988; cited in Bateman et al., 2002) points out that more than 80 percent of a respondent's behavior can be explained with main effects.

Construction of choice sets

The number of profiles identified in the previous step is then grouped into choice sets that can be used in experiments. Depending on the selected technique, three main modes can be used to present those to the respondent. The first option and most convenient form is to present all alternatives at once for a choice, ranking or rating exercise. However, the number of alternatives with associated attributes and levels might be too complex to handle at once, especially if the topic is unfamiliar or abstract. The second option is to construct smaller subsets of alternatives in an experimental design where the respondent is asked to choose, rank or rate among fewer alternatives than the total at once. However, the problem of dominance effects for single alternatives makes this approach uncommon in practice. The third possibility for choice sets is using the alternatives from the experimental design and defining the differences between alternatives. This reflects either a reference case of interest or the choice alternatives as experienced by respondents. If the research is considering too many attributes and attribute levels respectively, the task for a single respondent may still not be manageable and other solutions have to be sought. One set of alternatives is simply reducing the attributes and levels, or grouping attributes into subsets according to coherent topics, or employing a large set of experimental designs but dividing the total set into equal blocks where only one block is presented to each respondent. The drawback of these solutions is that in the first case, information gets lost and in the last two alternatives the sample size has to be increased accordingly.

Measurement of preferences

The choice sets are then applied according to the survey mode and procedure. Data for CA can be obtained from different sources such as research surveys, a carefully designed configurator or data from an appropriately designed experiment (Vásquez Lavín et al., 2007). Typically, survey techniques employ *vis-à-vis* interviews, telephone interviews and mailings. Rules of thumb or strict sampling rules may apply with regard to statistical sample size and accuracy when designing CA. The length of the research questionnaire likely depends on the number of attributes to be assessed and the method of CA in use.

5.3.1.3. Advantages and disadvantages of CA

The four main approaches presented under CA do not all meet the consistency criteria of economic theory. Actually, only choice experiments are completely consistent with the Theory of Welfare Economics and comparable to other stated preference techniques. The main advantages of choice experiments are the ability to estimate psychological tradeoffs that respondents make when evaluating several attributes together, measuring preferences at the individual level, uncovering real or hidden drivers which may not be apparent to the respondents themselves, modeling realistic choice tasks, valuing the attributes of change which is different to binary discrete choice of contingent valuation, measuring the marginal value of changes in attributes more accurately than in contingent valuation, reducing the extreme multi-collinearity[2] problems in models based on variations in actual (and hypothetic) attribute levels, and overcome the typical response problem in contingent valuation of respondent's "yea-saying" (socially desirable responses or strategic behavior).

The main disadvantages of choice experiments are the possibility of producing too many options, provoking simplification strategies of respondent's responses, making the design of a conjoint study too complex, designing an inaccurate study which may over-value emotional preference variables and undervalue concrete variables, forcing respondents to articulate attitudes toward new categories where they may feel uncomfortable or would otherwise not give much thought, suffering under the "packaging problem" referring to the assumption that obtained estimates on value are equal to the sum of the parts (attributes) considered, employing a study design that is not able to produce estimates on welfare values or utilities, increasing the random error involved through the complexity of the experimental design, and elaborate less than contingent valuation on the values for a sequence of elements.

5.3.2. Forms of data processing and analysis

After collecting the data, but prior to the econometric analysis, they have to be cleaned, codified and organized accordingly. Data include individual socio-economic (case-specific) information and responses to the presented choice set (alternative-specific). A data set can be created in, for example, EXCEL and be further processed in STATA. In the data sheet, each respondent generates n rows, one per choice made, keeping socio-economic information constant. During the transfer of data from the input data sheets into the electronic data sheet, the administration of the study has to apply quality control procedures in order to clean the set by deleting unrealistic and incorrect information. When transferring data, decisions have to be made on codification which allows for adequate analysis. Attributes are generally codified in three ways: giving continuous values, dichotomous (0-1 dummy), or "effects coding" (n-1 dummy variables).

CA departs from the idea that "any good can be described as a bundle of characteristics and the levels they take" (Lancaster, 1966; cited in Bateman et al., 2002). However, the challenge is to identify the correct attribute set that fully describes the good, service or, for example, environmental contracts likely to assure them. Since this is generally not possible, the CA method employs the Random Utility Theory to incorporate this information gap into choice modeling (Luce, 1959 and McFadden, 1973; cited in Bateman et al., 2002).

The basis for the theoretical foundation upholds that respondents (e.g., ES sellers) have

[2] Multicollinearity is a statistical phenomenon in which two or more predictor variables in a multiple regression model are highly correlated. In this situation, the coefficient estimates may change erratically in response to small changes in the model or the data. Multicollinearity does not reduce the predictive power or reliability of the model as a whole, at least within the sample data themselves; it only affects calculations regarding individual predictors.

preferences that are represented by a utility function U (see Equation 5.3); where utility depends on the levels of X marketed and Z non-marketed goods and services.

$$U = U(X_1...X_m; Z_1...Z_n) \tag{5.3}$$

Since some elements (X and Z) of goods and services are unobservable, only observable with an error or simply ignored, it is possible to overcome this problem by breaking down the original utility function $U(\cdot)$. The function from Equation 5.3 can be modified so that one deterministic (observable) part $V(\cdot)$ and one error part $e(\cdot)$ is included (see Equation 5.4).

$$U = U(X_1...X_m; Z_1...Z_n) = V(\mathbf{X}) + e(\mathbf{X},\mathbf{Z}) \tag{5.4}$$

Generally, given n alternatives implies different degrees of utility so that $U_1 >...> U_n$. Decision-making of the respondent, therefore, becomes a function of the utility each alternative provides. The Random Utility Model (RUM) helps to evaluate n alternatives of, for example, environmental policy designs from the perspective of an ES provider in a peri-urban location. A simple example is a respondent i being confronted with the choice between two alternatives a and b that are characterized and discriminable by attributes and levels. It is expected that the respondent chooses the alternative that generates the greatest utility to her/him. Since it is not feasible to construct a complete choice set for consideration, the error component makes predictions uncertain so that the analysis is of probabilistic choice (see Equation 5.5). Hence, alternative a is chosen if the difference in the observable part exceeds the difference in the error component.

$$P[(V_{ia} + e_{ia}) > (V_{ib} + e_{ib})] = P[(V_{ia} - V_{ib}) > (e_{ib} - e_{ia})] \tag{5.5}$$

In order to derive an explicit expression during the data analysis phase for the probability, an assumption must be made about the distribution of the error term e if the real dispersion is unknown. A general assumption is an independent and identical distribution according to Gumbel. Gumbel is similar to a Normal distribution and expressed by Equation 5.6 where e_{ij} denotes a random variable for the error of respondent i and alternative j, and the letter t is a possible value of e_{ij}. Accordingly, the probability that e_{ij} is less than or equal to t equates to the cumulative distribution function $F(t)$ which is the non-exceedance probability for the value t.

$$P(e_{ij} \leq t) = F(t) = exp(-exp(-t)) \tag{5.6}$$

A further analysis of choice modeling data on the basis of RUM is explained in the subsequent sections by elaborating on the differences among the four main approaches: choice experiments, contingent ranking, contingent rating and paired comparison.

5.3.2.1. Choice experiments

The choice experimental approach adopts the assumption that the error component of a probabilistic choice function follows a Gumbel distribution. This distribution implies that the probability of choosing alternative a can be expressed as a logistic distribution (McFadden, 1973; cited in Bateman et al., 2002; Long and Freese, 2006) and formulated as, for example, a conditional Logit model (see Equation 5.7), where the scale parameter μ is inversely proportional to the standard deviation of the error distribution but is implicit in the terms estimated. Although μ is irrelevant for the calculation of relative welfare estimates, it influences total absolute measures of value. That means that two choice experiment models from different data sets cannot easily be compared and the ratio of scale parameters must be used in order to adjust for differences in error variance and make data sets comparable.

$$P(U_{ia} > U_{ib}) = \frac{exp(\mu V_{ia})}{\sum\limits_{j} exp(\mu V_{ij})} \tag{5.7}$$

Furthermore, it is important to note for standard Logit models that the selection from a choice set has to comply with the property of Independence from Irrelevant Alternatives (IIA) (Luce, 1959; cited in Bateman et al., 2002). The IIA "states that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives" and is also a consequence "from the independence of the Gumbel error terms across the different options contained in the choice set". Hence, the greater the degree of utility specification for each alternative, the lesser the probability of IIA violation. Compliance with the IIA property can be tested by comparing if the model estimated on all choices is the same as the estimate for a subset of alternatives. Strategies to overcome or reduce this problem include socio-economic variables which further specify the probability of alternative selection, re-specification of the problem as a nested Logit model, or utilization of a random parameters Logit (Train, 1998; cited in Bateman et al., 2002).

Depending on the number of dependent variables different models can be used. If the dependent variable is dichotomous, a binary Logit model is appropriate. In the case of three or more values, the multi-nominal Logit model is employed. The latter becomes paramount if a Normal distribution is actually applied. Logit and conditional Logit models are used based on conventional maximum likelihood procedures provided by statistical software such as STATA. The procedures use a log-likelihood function (see Equation 5.8), where y_{ij} is an indicator variable which takes 1 if respondent i choses option j and 0 otherwise.

$$logL = \sum_{i=1}^{N}\sum_{j=1}^{J} y_{ij} log \left[\frac{exp(V_{ij})}{\sum_{j=1}^{J} exp(V_{ij})} \right] \tag{5.8}$$

This model is frequently assumed to be "linear-in-parameters". Hence, Equation 5.8 can be modified into Equation 5.9, where X is a vector of independent variables that determine utility, and β is a vector of parameters. The X includes choice set attributes and may further contain socio-economic variables that are constant across choices made by an individual.

$$P(choose\ g) = \frac{exp(\beta' X_{ig})}{\sum_{j} exp(\beta' X_{ij})} \tag{5.9}$$

5.3.2.2. Contingent ranking

The contingent ranking approach is also based on RUM and used for the econometric analysis. The assumption holds that the random error term follows a Gumbel distribution and terms are likewise independently and identically distributed. In addition, the rank-ordered Logit model also has to comply with IIA property. A rank-ordered Logit model is able to analyze data sets with ranked orders (Beggs et al., 1981; cited in Bateman et al., 2002; Long and Freese, 2006). This model uses the repeated application of a probability expression similar to Equation 5.7 (see Equation 5.10), where the probability of individual i selecting any particular ranking of alternatives j can be modeled.

$$P_i(U_{i1} > U_{i2} > ... > U_{ij}) = \prod_{j=1}^{J} \left[\frac{exp(V_{ij})}{\sum_{k=j}^{J} exp(V_{ik})} \right] \tag{5.10}$$

The rank-ordered Logit model also uses the maximum likelihood procedures, similar to Equation 5.8 as used for choice experiments. The parameters of the utility function are estimated by maximizing the log-likelihood function (see Equation 5.11), where y_{ij} is an indicator variable that takes different values depending on the respondent's i choice among a set of options j.

$$logL = \sum_{i=1}^{N}\sum_{j=1}^{J} y_{ij} log\left[\frac{exp(V_{ij})}{\sum\limits_{k=j}^{J} exp(V_{ik})}\right] \tag{5.11}$$

5.3.2.3. Contingent rating

The original approach of contingent rating is not able to provide welfare consistent estimates. That is because usually no "do-nothing" option (status quo) is provided and the underlying utility scale is probably not consistent among respondents. However, there are two approaches that strengthen the ability to comply with foundations of Economic Welfare Theory. The first modification is to drop the scale in the econometric analysis and only use the information of preferred choice. And secondly, employ a transformation function for rating scores in order to standardize the utility scale (see Equation 5.12), where R is the rating score of individual i for option j and ϕ is the transformation function. This analysis could then follow a regression technique of Ordinary Least Squares (OLS) if the assumption holds for cardinality[3] in the rating scale.

$$R_{ij}(X_{ij}) = \phi[V_{ij}(X_{ij})] \tag{5.12}$$

Usually a rating scale of 1 to 10 is used. The contingent rating model may then assume an additive specification of the utility function with relevant attributes (see Equation 5.13), where the individual's overall evaluation Y (rating of the alternative) is described by the part-worth β_{1i}, β_{2j} and β_{3k} associated with levels i $(i = 1, 2, ..., n)$, j $(j = 1, 2, ..., m)$ and k $(k = 1, 2, ..., p)$ for the attributes 1, 2 and 3, and the presence of the attribute level through the dummy variables D_{1i}, D_{2j} and D_{3k} (Steenkamp, 1987; cited in Bateman et al., 2002). The assumption is that the sum of the part-worths represents the total value of an alternative. A Tobit model can generally be used for estimations (Long, 1997) if a Normal distribution of observations is assumed with a zero mean and a constant variance.

$$Y = \beta_0 + \sum_{i=1}^{n} \beta^*_{1i} D_{1i} + \sum_{j=1}^{m} \beta^*_{2j} D_{2j} + \sum_{k=1}^{p} \beta^*_{3k} D_{3k} + \epsilon \tag{5.13}$$

[3]The cardinality of a set is a measure of the "number of elements of the set".

Then the Tobit model is applied to obtain maximum-likelihood estimations if homoscedasticity[4] can be assumed.

5.3.2.4. Paired comparison

The technique of paired comparison is a hybrid of choice experiments and contingent rating. Depending on the emphasis placed on its specification, the approaches elaborated on in previous sections can be applied respectively. If the ratings in paired comparisons are re-interpreted as indications about choice, only then choice experimental procedures are applicable. While if it is assumed that a change in rating is related to a change in utilities, then contingent rating routines are employed. The main advantages of this approach are that it makes the task considerably easier for the respondent, and if specified according to choice experimental assumptions, welfare consistent estimates can be produced. Its main drawbacks are that respondent's choices are not consistent among paired choice sets, and if the analysis follows the principals of contingent ratings it is difficult to obtain accurate welfare estimates.

[4] In statistics, a sequence or vector of random variables is homoscedastic if all random variables in the sequence or vector have the same finite variance (also known as homogeneity of variance). The complementary notion is called heteroscedasticity. The assumption of homoscedasticity simplifies mathematical and computational treatment. Serious violations in homoscedasticity may result in overestimating the goodness of fit as measured by the Pearson coefficient.

6. Index assessment of PES participation

PES is a widely discussed innovative economic-policy instrument designed to provide incentives and adequately remunerate positive externalities (Engel et al., 2008; Grieg-Gran et al., 2005; Robertson and Wunder, 2005; Wunder, 2005). Nevertheless, there are several context-specific issues which have troubled policy-makers to make PES fully self-sustaining. There is much to learn, and few examples exist where PES has been applied effectively (Engel et al., 2008; Speranza and van de Sand, 2010; Wunder et al., 2008). Consequently, the analysis of diverse contexts where PES has already been implemented or potentially applied is warrant. For instance, despite the growing importance of the rural-urban interface with respect to environmental policies (Gutman, 2007; Niemelä et al., 2010), few analyses have been carried out on PES in peri-urban areas (e.g., Huang et al., 2011; Landell-Mills and Porras, 2002; Mayrand and Paquin, 2004). Instead, most literature deals with rural-based programs (e.g., Engel et al., 2008; Wunder et al., 2008). Recent trends of population growth, rural exodus and growing mega cities highlight the need for a new rural-urban compact (Gutman, 2007), where urban inhabitants are recognized as the most benefited from ESs (Bolund and Hunhammar, 1999). However, the motivation for ES providers to become actively involved in voluntary conservation schemes, like PES, is not yet well understood.

Mexico provides a clear-cut illustrative example of extreme developments in rural-urban compacts. It is the second Latin American country after Costa Rica (Pagiola, 2008) which has introduced a national PES program (DOF, 2003b; Muñoz Piña et al., 2008). It was initially set-up in 2003 for assuring water provision, which has become an increasingly scarce resource in the country and particularly in Mexico City. Mexico City, the nation's capital, boosts a population of about 9 million inhabitants (the greater metropolitan area of Mexico City has about 20 million) which is heavily dependent on water supply from aquifers, whose main recharge areas are the mountains surrounding the basin. Expansion of the city's infrastructure exerts increasing pressure on these peri-urban areas, with the continuous ES provision from it becoming critical for the city's future (Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005).

A peculiarity of the peri-urban catchment is that it is inhabited by communities which hold its legal land-use right. Hence, a community inscribed in the national PES program participates collectively with all its community members. These members have equal rights of co-determination and land use, and are or could become active land managers and directly influence ES provision. Collectively, these individual potential ES providers "voluntarily" agree to participate in the national PES program with their commons through a simple majority - 50 percent plus one vote in the General Assembly. However, the simple majority may apply in absolute terms, i.e. considering all community members inscribed in the RAN, or under certain conditions in relative terms, i.e. only considering those community members inscribed in the RAN and present in the General Assembly. This means that a situation can occur where the acceptance of participation in a PES program is not backed by a prior informed "broad" consent and may pave the way for asymmetric information problems. In fact, this circumstance could create a number of extreme situations such as a majority in absolute terms is actually against program participation, or the group against PES participation consists exclusively of those community members directly dependent on active land-use management on the commons but per se constitutes the minority. Accordingly, it is interesting to note that only a limited number of members recognize their active involvement in the program. This is an issue with strong policy implications because stakeholders' perceptions and attitudes are paramount in achieving the successful application of policy instruments such as PES (Coulibaly-Lingani et al., 2011; Wossink and van Wenum, 2003) which are based on the voluntary and conditional exchange of ESs.

This research project found that within a common property regime, considerable heterogeneity exists in various dimensions of sustainable livelihood capitals. It is of particular concern, therefore, whether the group recognizing its PES participation is likely to maintain or improve ES provisions. This concern is questioned by the results presented here because, for example, the dimension natural capital signals that community members actively taking advantage of the commons i.e. by working or cultivating a land parcel (and thus directly targeted by PES participation) are less likely to have in-depth knowledge or at least recognize that such a program is applied on the commons. This occurs despite the fact that the communities receive payments for already 10 years.

While most studies on PES participation deal with individual landholders in rural settings (e.g., Zbinden and Lee, 2005), only a few studies explore the peri-urban context where ES providers collectively own and manage natural resources. Furthermore, although existing literature identifies a number of variables which theoretically determine participation in a PES program (Engel et al., 2008; Pagiola et al., 2005; Zbinden and Lee, 2005), none of the studies reviewed refer to a single case of a common property regime, and more specifically, whether a community member of a recipient community in Mexico recognizes PES participation. By analyzing the level of recognized participation and variables which influence it within a recipient community indicates if the concept of voluntary participation is applicable and includes active involvement of the whole community. Thus, the distinction between formal participation and actual recognition among community members is of particular interest in contexts where land is owned and managed collectively. This is because the enforcement of program rules likely depends on the active involvement of a vast majority of community members with equal rights of access to the commons and co-determination in the General Assembly. The presence of different "groups" (e.g., characterized by different livelihood capitals) within a community is likely influencing the enforcement of, for example, land use restrictions. It is possible that only a limited recognition of PES participation coupled with a small lead in the General Assembly (50% + 1 vote in absolute or relative terms) is suceptible to ineffective and/or inefficient PES participation. Therefore, it might be carefully assumed that those community members not recognizing their PES participation have also not voted in favor of the PES program in the General Assembly. Thus, this chapter will analyze the socio-economic variables which influence the community member's recognition of participation in a PES program within a peri-urban context of common property and occurance of adverse selection.

The remainder of this chapter is organized in four sections. The first section gives a brief description of the Mexican PES scheme, defining the area of study, recapitulating the research objective, question and hypothesis, and elaborating on materials and methods used in this study. The second section gives an overview of the participants included in the study, and explains the SLA process including the selection of variables, a description of the model and related hypotheses. Third, the results of a descriptive data analysis and index development are presented. And lastly, a discussion of the results obtained, highlighting aspects of relevance for PES design, is presented.

6.1. Background

In response to deforestation and forest degradation, as well as growing water scarcity in specific river basins, the Mexican government established a national program of PSAH in 2003 (Muñoz Piña et al., 2008). The PSAH has aimed to strengthen forest conservation and management practices across the country, paying particular attention to forested areas located in critical watersheds and areas facing serious deforestation risk (Muñoz Piña et al., 2008). In 2004, the government implemented a complementary program of PSA-CABSA, and in 2006 these two programs were merged into a single policy framework known as PSA, where hydrological, biodiversity, carbon and agro-forestry services still followed their individual procedural rule (Corbera et al., 2009). The scope of this program has recently be reduced to direct support for the first two concepts - hydrology and biodiversity (see Section 3.3).

Mexico's PES program is considered to be one of the largest in the world, managed by CONAFOR and covering around 2.27 million hectares in 2009 (Alix-García et al., 2010). The most prevalent participants are *ejidos* and agrarian communities, and to a much lesser degree small private property landowners (Muñoz Piña et al., 2008). The predominance of rural communities as ES providers is a key characteristic of Mexico's PES program in contrast to similar initiatives in Latin America, given the fact that approximately 70 percent of the country's forests are owned by these communities (Bray, 2012; Bray and Merino-Pérez, 2002, 2004; CONABIO, 2006; Muñoz Piña et al., 2008). In brief, they are common property regimes where a group of families have usufruct rights over farming lands while they share access, withdrawal, management, and exclusion rights over agriculture and forest areas (see Section

3.1.3). Community authorities and an assembly of principal right-holders govern the use of the common land and make decisions on its usage, determing, for example, timber extraction quotas, access rules for villagers who do not hold formal land rights and the system of benefit-sharing when forest concessionaries or PES also make use of the forest commons.

Given a general interest in understanding the context where PES works, more and more scientific literature has been published in recent years. Researchers have been keen to analyze how PES can be used to overcome the profound conflict between conservation of natural capital and economic development based on the intensification of capital depletion. While conservation is desirable from a perspective of "global community", unsustainable natural resource use is often the sole viable option for rural-coined communities to escape from "poverty". Thus, a number of authors have argued (e.g., Echeverría, 2010; Tognetti et al., 2004; Wunder, 2008) that the structure of compensation for landowners, for example in the form of opportunity cost calculation (Pagiola, 2008), is probably the most decisive factor for determining program participation. Others advocated that non-economic added value factors may equally explain active involvement. For example, Kosoy et al. (2008) studied four cases of PES in Mexican *ejidos* in the rural area of the Lacandon Forest (in the State of Chiapas located in southeastern Mexico) and found that payments also increased the community's ability to organize itself internally and provided land tenure security, where the latter has also been confirmed in other contexts (Godoy, 1992; Hyman, 1983; Schuck et al., 2002; Tognetti et al., 2004; Wunder, 2008; Zbinden and Lee, 2005). Furthermore, Kosoy et al. (2008) have emphasized that a relatively strong incentive for participation of Mexican common property regimes is tied to heritage, related to the belief that future generations will have access to resources as well as diversifying their productive activities.

Communal landownership, on the other hand, also represents a limiting factor for the program's efficiency, since payments are made to the community (ES seller) and not directly to individual community members (potential ES providers) who could obtain potential gains from activities of deforestation or degradation. The distribution and benefit-sharing arrangements in PES have been left to formal and informal community institutions (Muñoz Piña et al., 2008), who cope with this situation in different manners. Braña et al. (2005; cited in Muñoz Piña et al., 2008) have found that communities receiving PES payments realized disbursements in three main forms: investing in public goods, dividing payments equally among community members or applying a mixed strategy. Nonetheless, the problem that few community members actually knew the specific conditions of the contractual agreement existed (Muñoz Piña et al., 2008), similar to the cases presented in this study, and CONAFOR found it difficult to explain to beneficiaries of the program its underlying principles (Braña et al., 2005; cited in Muñoz Piña et al., 2008). Perhaps, the limited availability of financial resources earmarked for monitoring and communicating with participating ES providers has hampered the program's successful implementation (Kelley et al., 2003; Kosoy et al., 2008). Therefore, it is questionable whether all community members are able to benefit equally from payments and if the community members who actually drive deforestation and degradation internally (and/or have a direct impact on ES provision through their land management practice) are actively participating. It has been suggested that the existing diversity of socio-ecological contexts in Mexico makes it virtually impossible to identify a single institutional design which would work well in every circumstance (Corbera et al., 2009), so that flawed cases of application most probably exist.

In order to elaborate on these issues, this research selected the MRW of Mexico City as a study area (see Section 3.2). This region is subject to the national PES program. The two cases of common property considered are the agrarian community of Magdalena Atlitic and the *ejido* of San Nicolás Totolapan, both of which have participated in the national PES scheme since its start. These communities enrolled communal land[1] in the program for a period of five years, between 2003 and 2007. The community Magdalena Atlitic enrolled a total of 1,362.89 hectares of land and San Nicolás registered 1,095.12 hectares. Both received an annual payment of MXN 300 per hectare (USD 27.3) for the concept of hydrological services. Likewise, both communities renewed their participation for the commitment period of 2008 to 2012. While the agrarian community of Magdalena Atlitic enrolled 1,450.49 hectares (+87.6 ha), the *ejido* of San Nicolás managed to enroll 1,319.87 hectares (+224.75 ha). Both received an annual payment of MXN 382 per hectare (USD 32.2) for the concept of hydrological services (Community Presidents and CONAFOR, pers. comm., 2010). Hence, both communities increased the area subject to PES but received the lowest available payment level in both periods of operation. The rules for PES rejected the enrollment of greater extensions of communal land since some parts of the watershed claimed by the communities are in dispute and/or lack land titles (Ávila Akerberg, 2004, 2009) which limited the number of hectares which the participating communities were permitted to register.

6.1.1. Objective of this chapter

The stakeholders' perspective on PES activities is a central concern of this study. Generally, it is assumed that stakeholders consist of an (minimum one) ES seller and an (minimum one) ES buyer who follow their proper agenda. I.e., ES sellers may pursue a certain livelihood strategy with a combination of available livelihood assets in order to achieve a sustainable livelihood outcome, while ES buyers are often concerned with processes and application of policies which restrict socially undesirable livelihood strategies. Both pursue their objectives within a determined context of vulnerability, for example in the framework of GCC. The interaction of these two perspectives is a key concern of several interdisciplinary research projects. Given such a broad context, this research project has purposefully chosen to limit its scope. Therefore, its focus is confined to investigate socio-economic conditions within

[1] Presumably, at the time of program enrollment no plots were included which formally or informally were assigned to individual members of the community in order to obtain gains from active land use.

peri-urban communities that cause - and may be interpreted as - adverse selection of PES contracts designed to maintain the forest cover. It is assumed that adverse selection implies the violation of the conditionality condition expressed in the PES definition from Wunder (2005) and the additionality condition of any carbon regime. The lack of information on the buyers' side of the likelihood of adequate ES provision of potential ES sellers grouped in a common property regime might provoke the undesired effect that only those community members of the group who decide to participate reveal a risk-averse strategy by not changing their land-use practice anyway (Asquith et al., 2008; Pagiola, 2008; Robertson and Wunder, 2005; Zbinden and Lee, 2005). Therefore, this study is interested to analyze the implications of environmental contracts such as PES-REDD. Because no PES-REDD program is yet operational in Mexico, this research has had to adapt and elaborates on the possibility that ES sellers (providers) may adversely chose to participate in Mexico's national PES program under the concept of hydrological services.

The specific research objective, question and hypothesis are explained below. The construction of indexes allows for assessing if and why adverse selection of ES sellers occurs. Understanding case-specific conditions helps to identify drawbacks under the current national PES program and highlights possible implications for any future PES-REDD design.

Objective The objective of this research is to analyze how the national PES program is designed to secure the permanence of positive externalities provided by forests in Mexico. The intention is to detect if voluntary participation under a common property regime is susceptible to adverse selection of individual ES sellers (providers) which are actively involved in the PES scheme using indexes constructed with Principal Component Analysis.

Question The specific research question is: How is a PES contract recognized by a recipient community in practice? Does the PES scheme in Mexico match the general definition of PES and adequately address the issue of additionality and conditionality - factors which set PES apart from other environmental policy instruments?

Hypothesis The principal hypothesis of this study is that the objective of Mexico's national PES program and the conditions necessary to obtain incentive payments are misunderstood and insufficiently diffused among community members. The PES program is treated as a subsidy by communities and its use is adversely selected, resulting in the lack of effective change in the management of the natural resource base. The fact that the PES program is administered by the government implies that budgetary constraints and equity concerns play a determining role. Equity concerns are likely to put the original idea of PES in danger, loading it with objectives that do not increase its effectiveness.

6.1.2. Method selection

This research study uses a case study approach for the investigation of adverse selection in two communities (an *ejido* and an agrarian community) assuming that it reduces the effectiveness and efficiency of a PES program. The selected method for constructing various indexes to detect the appropriation of a PES program builds on PCA as described in Section 5.1. PCA allows for the analysis of socio-economic conditions within communities that most influence the recognition of participation of community members in the national PES program. The concept of SLA, as explained in the Section 4.2, helps to identify the principal dimensions of livelihood assets that shape decision-making. Five indexes have been constructed that relate to the human, social, financial, physical and natural capital available to a household. In addition, marginalization is aggregated to the set of indexes as a sixth dimension for two reasons: first, it has been detected that the poorest of the poor are not participating as much as the rest (Muñoz Piña et al., 2008) although they are explicitly targeted with the Rules of Operation (DOF, 2011), and second, the Index of Marginalization developed by CONAPO (2005a) and used for targeting provides an interesting opportunity to include this case study in a broader regional context of vulnerability and explicity combining human and physical capital. The main instrument used to collect the input data for the PCA is a semi-structured questionnaire applied in individual interviews of community members. The interviews covered relevant aspects of current PES contracting practices within a peri-urban location where ES sellers (in both the *ejido* and agrarian community) are also potential ES providers in a Mexican REDD regime. The questionnaire helped, for example, to identify alternative land-use options that make up a typical landowner's decision-making matrix. Furthermore, it revealed the dissemination of knowledge about PES contracts and its influence on the active involvement of ES sellers.

6.2. Index assessment process

The process of evaluating whether Mexico's national PES program is susceptible to adverse selection or not involved two principal steps. First, the data was collected through a semi-structured questionnaire, and second, the summarized data (cleaned and codified) served as an input for PCA allowing for constructing indexes. The SLA was the main guide and input for the design of the questionnaire, while the PCA was used to process the data and construct indexes which help answer the research question. Operationalization of the concept of SLA was straight forward, as can be seen in Figure 6.1. The details of the survey and the SLA model are explained in the remainder of this section.

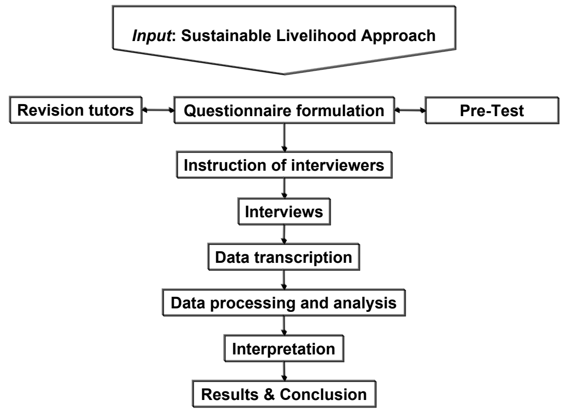


Figure 6.1.: Index Assessment Process

6.2.1. Survey

The survey basically included two groups for polling information: researchers (administration) and community members (interviewees). The administration's task was to design, coordinate and apply interviews to a group of selected community members belonging to two communities. The questionnaire format was designed in a collaborative effort by a research team (Kurt Christoph Neitzel, PhD Student from the Faculty of Economics and Angela Caro Borrero, MSc Student from the Faculty of Science; both at the UNAM) to analyze various aspects related to PES as an instrument for the conservation of water and forest carbon stock benefits in peri-urban locations. The questionnaire was constructed and applied in a team effort in order to maximize the information collected from the survey. Data was analyzed individually ex post.

The sample instrument

It was determined that *vis-à-vis* interviews using a semi-structured questionnaire best served the purpose of the study in order to collect data highlighted in the SLA concept. This information was later processed for the construction of indexes to help to explain observed phenomena in the realm of adverse selection. The advantage of this approach is the systematic collection of qualitative and quantitative data on socio-economic relations (Schnell et al., 1993) which can be compared across interviews on a household level, to better understand their influence on decision-making. After formulating a preliminary version based on input from the SLA literature[2], the questionnaire underwent a two-stage revision and adjustment process. First,

[2]An alternative approach for the construction of the questionnaire could have been a participatory approach. In a workshop format members of the community would have been confronted with the question which variables influence most livelihood assets (human, natural, physical, financial and social capital). Afterwards, community members would have been asked to rank these variables according to their perceived importance.

professors and students familiar with the study site provided their remarks on content and wording. After adjustments were made, the second step involved a test of the questionnaire in the field on five community members. Input from the test was used to further refine the questionnaire to obtain the final version. The questionnaire (the Spanish version) is included in Appendix E and divided into eight sections: A. Filter/Identification; B. Human capital; C. Natural capital; D. Physical capital; E. Social capital; F. Financial capital; G. Livelihood strategies; and H. Livelihood outcomes.

The sample survey

The sample survey is a quantitative approach used for the collection of data to be processed and analyzed statistically as deemed necessary for the construction of an index. It is characterized by a sampling design that corresponds to the specific conditions of the object (or subject) of study and the limitations of the research such as time constrictions, budget constraints and geographic outreach. The sample design refers mainly to the identification of the sample population (sampling frame), sample unit (observation unit), sample intensity (sample size), and selection process of the sample unit.

The sample population of a survey is the sum of all individual units that may be selected for a sample. The intention is to obtain through a sampling approach representative information about the population without collecting data from all individuals. This survey targeted community members who formally participated through their community membership in the national PES program. The population of interest was selected from several communities in the periphery of Mexico City. In the end, the agrarian community of Magdalena Atlitic and the *ejido* of San Nicolás Totolapan, both located in southwestern Mexico City (see Section 3.2) and participants of the national PES program, were selected for this survey[3].

The definition of the sample unit for a survey depends on the interest of the research, which for socio-economic applications is often a single household. More recently, socio-economic studies are also interested in gender issues, so that male and female interviewees are surveyed separately in order to reveal differences in gender perception. The observation unit for this survey is the single household as well. Interviews were conducted with the household's family head or partner (interviewee). The family head is defined as the household member who is listed in the RAN (usually male) as community member and is of particular interest since s/he has a voice and vote in the General Assembly where decisions regarding the PES program are made. Female and male interviewees were not selected from the same household in order to cover a greater variety of households differentiated by gender perception. Although initially an equal number of male and female interviews were planned, this could not be carried out for reasons explained below.

[3]No additional non-PES community was selected for true comparison (control group).

The sampling intensity assures a "representative" crosscut of all potential subgroups present in the population of interest. The sample size may depend on two sampling criteria: (i) budget and time constraints, or (ii) statistical representation. While the first approach is rather random, the latter is scientifically sound. The identification of a representative sample size can be determined through a calculation based on information available on the "true" or "expected" variability within the population. For the statistical approach of the determination of sample size, social science frequently applies the formula proposed by Yamane (1967). However, limiting factors such as budget and time make it frequently necessary to limit the percentage of observation units sampled from the total population, and consequently limit the statistical power of statements made based on the presented results. Such is the case of this survey, where two barriers made necessary adaptations: (i) in one community the population size could not be clearly determined, and (ii) time and budget constraints limited survey options. Therefore, the sampling intensity was set at 10 percent in each community.

The manner in which individual sample units were selected ends the explaination of the survey design. In general, the observation unit was determined by using different selection processes which can roughly be divided into random and non-random sampling techniques (Bateman et al., 2002). Most studies intend to guarantee a random selection of observation units for statistical soundness, to avoid bias. Random sampling refers to a process where all individuals of a population share the equal probability of entering into the sample theoretically, even though there are different forms of research design. The circumstances in the communities included here presented a major challenge for the research team to obtain a representative result. The main obstacles were identifying the sample size and the random selection of the sample. Since no updated list of community members with home addresses was available, random sampling of interview partners was not possible. This is a problem frequently faced by social scientists, particularly in rural settings. According to Smith (1983), non-random sampling can be used for inference in social science only when the selected sample is representative of the sub-population under study, which is presumably the case here, given that decisions on community issues are made by regular attendees of the General Assemblies. Therefore, a "convenience non-random sampling" was applied. Kelley et al. (2003) defined this as the "sample made up by the easiest subjects to recruit". Community presidents, the first source of contact with the sites, suggested that the research team should take advantage of the community assemblies. Therefore, the research team coordinated with community authorities and scheduled site visits with the general assemblies (held monthly) and presidency meetings (held on an irregular basis) where "active" community members gathered. Interviews could not be carried out during the meetings since non-members of the community are prohibited and the duration of the meetings is unpredictable. Hence, the research team was limited to holding interviews prior to the assembly, and asked arriving community members if they would participate in the survey. This process made it complicated to comply with the intention to survey an equal number of male and female community members, because inclusion depended on community members' willingness to participate *ad hoc*. Community members agreeing to be interviewed were given a brief explanation regarding the purpose of the survey prior. It was emphasized that their participation was totally voluntary, that their responses would be anonymous and that they were not obligated to answer any question they did not want to. Furthermore, the research team decided to make use of additional interviewers (students from the UNAM) who were trained for that specific purpose to maximize the limited opportunities of interaction with community members. Since interviews lasted, on average, between 30 and 45 minutes a single interviewer could only complete one to three interviews per site visit. Given that interviews had to be carried out when the communities held their General Assemblies (once per month), meetings of the auxiliary commissions (every two weeks) and other meetings (irregular), several days of interviews had to be scheduled[4].

Magdalena Atlitic A total of 41 interviews were completede in the agrarian community, of which 12 interviewees were female. Determining the sample size for Magdalena Atlitic was particularly difficult since it was not possible to obtain a precise number of community members who were alive and active in the community. This has important implications for understanding the dynamics in the community and the quality of the social capital in particular. The community currently has 1,779 formally registered community members, so-called *comuneros*, in the RAN. Notwithstanding, most of them are not interested in community affairs, are deceased, or have probably migrated abroad or within Mexico. The communal authority estimates that about 800 to 900 community members are interested in the community in a broad sense. About 200 to 250 community members actively participate in the General Assembly (although this number fluctuates). Due to these circumstances, determing a specific sample size is debatable. In the end, an intermediate value of 10 percent of 400 was decided upon, but finally depended on the willingness of community members to participate.

San Nicolás Totolapan This research study includes 36 interviews from the *ejido*, of which 11 interviewees were female. Five interviews were not completed due to time constraints. The decision on the sample size in the case of San Nicolás was less difficult since an accurate number of community members alive and active in the community could be confirmed through personal communication with the authority. Compared to the Magdalena Atlitic, thid most likely has a positive impact on the quality of the social organization. The community has 336 formal community members, so-called *ejidatarios*, currently registered in the RAN, the same number of which is active in the community. There is anecdotal evidence that some community members have sold their registration number to other *ejidatarios* so that a few individuals may be counted double. This should not affect the sample intensity, and if, likely

[4] The consultation process lasted approximately 10 months, from October 24^{th}, 2010 until August 28^{th}, 2011.

improves the validity of the results.

6.2.2. Index assumptions

Construction of indexes were built, based on the works of Henry et al. (2003) and Zeller et al. (2001) using the approach for the development of a poverty index assessment tool. Adopting their process (see Section 5.1), the intention was to build various indexes for different components (livelihood capitals) of the SLA (see Section 4.2) and determine their relationship with the recognized participation of individual ES sellers in the communities inscribed in the national PES program who benefit from payments for hydrological services. This model is based on the assumption that indexes of different socio-economic dimensions explain the conditions under which ES sellers recognize their participation in a PES scheme. This approach points to the fact that community members are participating in a PES program who, amongst others, do not depend directly on communal natural capital, and that they do not have the means to employ sufficient proper human capital in order to change land-use practices, thus making them adversely select the PES program whose screening effort is not able to detect or avoid this asymmetric information problem. Hence, the model tests each index to see if community members explicitly recognize their participation in a PES program. Therefore, the tested variable is recognized participation in PES and explained by a group of variables comprising the different indexes. In addition, results are contrasted with two common property regimes - an agrarian community (Magdalena Atlitic) and an *ejido* (San Nicolás Totolapan), in order to reveal whether the type of common property has an influence on the results.

Hypothesis for participation status

As stated above, the objective of this research project is to elucidate the distinction between formal participation and actual recognition among community members where land is owned and managed collectively. In order to analyze this issue, response to the following question was analyzed: "Do you currently participate in a PES scheme?" [PESPART1][5]. Participation is defined as the enrollment of communal land in the national PES program by the communities of Magdalena Atlitic and San Nicolás Totolapan, which implies that all community members form part of the program. Consequently, recognition refers to community members' awareness of PES participation. The hypothesis here is that PES program participation is not always voluntary, as pointed out by accepted definitions of PES, as supported by Wunder (2005). It is argued that common property regimes, as those found in rural-urban compacts, are not necessarily formed by homogenous livelihoods so that their distinct endowment of capitals explains recognized PES participation and reveals problems of adverse selection.

[5] This question was asked at the beginning of the questionnaire (see Appendix E Section A. Filter/Identification) and answers were later compared with responses to more detailed questions about the policy instrument (see Appendix E Section F. Financial capital) reflecting the interviewee's level of knowledge.

Hypotheses for indexes and dimensions

The information collected in semi-structured interviews was used to define a set of variables to determine whether or not a community member recognizes their participation in the PES program. In addition to variables derived from the SLA, other variables theoretically affecting the propensity of PES participation, suggested in the literature (e.g., Asquith and Wunder, 2009; Echeverría, 2010; Martínez, 2008; Tognetti et al., 2004; Zbinden and Lee, 2005), were considered as well and tested for relevance in the studied socio-ecosystem. These variables are related to the eligibility, desire, ability and competitiveness of potential ES sellers to participate (Engel et al., 2008; Pagiola et al., 2005). Accordingly, variables were identified which indicate willful adverse selection towards participating in the national PES program. The following paragraphs elaborate on the inclusion and hypotheses of categories employed for the construction of six indexes: human capital, natural capital, physical capital, financial capital, social capital and marginalization.

Human capital It is generally accepted in socio-economic studies that increased human capital in the form of good health status, a capacity to work and higher levels of formal education result in a greater well-being (e.g., CONAPO, 2005a; DFID, 1999; Henry et al., 2003; Zeller et al., 2001). It was expected that variables within these categories play a central role within this research, since authors investigating the participation of agents in environmental programs frequently include aspects of human capital in their analyses. Dimensions reported in the literature which might explain PES adoption are personal characteristics of the head of the household such as age and education (Ayuk, 1997; Chambers and Foster, 1983; Echeverría, 2010; Nagubadi et al., 1996; Rahm and Huffman, 1984; Thacher et al., 1996; Tognetti et al., 2004; Zbinden and Lee, 2005), capacity to participate (Pagiola et al., 2005; Wunder, 2008), and demand, availability and location of labor force for land management (Ayuk, 1997; Neupane et al., 2002; Scherr, 1992; Thacher et al., 1996). As far as possible, these variables or proxies of it were employed for constructing a human capital index. A number of variables for human capital were obtained from the questionnaire (see Appendix F), and used to explore correlations that indicate their suitability for the development of an index. It is hypothesized that variables related to education, workforce, age and health status in particular play a major role in this context (see Table 6.1). As a benchmark indicator, the variable representing the "Percentage of adults with secondary schooling" [(B) ADULTSEC] was selected since it is assumed that the level of knowledge and cognitive capacity to understand abstract contents such as PES program rules influence human capital and PES participation alike.

Natural capital In environmental economic studies, the natural resource base is the main object of interest. Natural capital is frequently analyzed in categories such as land tenure rights, access, size, value, benefit and perception (e.g., DFID, 1999; Ostrom, 1990). The

Table 6.1.: Human capital - hypotheses

Index	**Hypothesis**
Human capital	It is assumed that a greater degree of human capital has mixed implications but generally relates negatively to recognized PES participation.
Dimension	**Hypotheses**
Education	Related variables provide an indication of knowledge and a high level of income. It is assumed that higher levels of education among community members causes greater recognition of PES participation.
Workforce	Related variables provide an indication of the available workforce in the household. It is expected that larger households are capable of cultivating natural capital so that they are less likely to recognize participation.
Age	Related variables provide an indication of adults' experience, skill level and ability to work. It is expected that older community members have a greater probability of recognizing participation, while younger members are still capable of cultivating natural capital.
Health	Related variables provide an indication about the welfare and degree of vulnerability. It is assumed that adequate access to health services relate positively to recognized PES participation.

characteristics of natural capital available to households affect the degree of well-being. It is generally accepted that with increased well-being the direct need for resource extraction from natural capital tends to decrease, which has implications for conditionality and additionality of payments. Because natural resources are the subject of PES payments, this livelihood capital is expected to play a central role for the outcome of this investigation. Authors investigating the participation of agents in environmental programs, therefore, include in their analyses aspects of natural capital in order to explain program adoption. Dimensions reported in the literature which might explain active involvement in PES are land tenure or landownership (Godoy, 1992; Hyman, 1983; Kosoy et al., 2008; Schuck et al., 2002; Tognetti et al., 2004; Wunder, 2008; Zbinden and Lee, 2005), land size or location of the managed area (Ayuk, 1997; Caveness and Kurtz, 1993; Chambers and Foster, 1983; Nagubadi et al., 1996; Nowak, 1987; Thacher et al., 1996; Zbinden and Lee, 2005), land quality (Adesina and Chianu, 2002; Mortensen et al., 1988; Zbinden and Lee, 2005), and perception of various dimensions of ES (Echeverría, 2010). This research study includes some of the same variables or proxies for the construction of the index for natural capital. Several variables were obtained from the application of the questionnaire (see Appendix F). The set of polled variables is used to explore correlations in order to verify their suitability for the development of the index. It is hypothesized that those variables in particular play a role that represent the management status of land resources and the perception of risk related to discontinued ES provision (see Table 6.2). The variable "Income and/or subsistence benefits from NTFP activities on communal land" [(G) ECNTFP] was selected as a benchmark indicator since it appears to predict if a household has access to communal land and extracts goods with the aim of increasing the welfare of the livelihood. Hence, a higher degree of natural capital dependence by a particular household actually implies that the PES program should target these community members.

Table 6.2.: Natural capital - hypotheses

Index	Hypothesis
Natural capital	It is assumed that a greater degree of natural capital has mixed implications but higher dependence generally relates negatively to recognized PES participation.
Dimension	**Hypotheses**
Management	Related variables provide an indication of the management status of common property such as land size cultivated and activities (income or subsistence) implemented on it. It is assumed that higher levels of community members' natural resource extraction cause less recognition of PES participation.
Loss-risk	Related variables indicate the perceived risk for natural capital and specific goods and services such as water supply to get lost. It is expected that greater perceived risk for ES provision creates a greater probability of recognition of PES participation.

Physical capital In the SLA concept, various gains are obtained from physical capital with associated implications for livelihood. Important concerns in the peri-urban context most likely include access to transportation, access to information, value of total assets reflecting the household's wealth, environmental impact of dwellings, provision of secure shelter, and threat levels of natural disasters due to inadequate housing. Authors investigating the individual adoption of environmental programs by agents include aspects of physical capital indirectly in their analyses. Dimensions which may have explanatory power for PES participation include the capacity to participate (Pagiola et al., 2005; Wunder, 2008), and the access and diffusion of information (Adesina and Chianu, 2002; Adesina et al., 2000; Arnold, 1992; Hosier, 1989; Hyman, 1983; Thacher et al., 1996; Zbinden and Lee, 2005). This research study employs similar variables (or proxies) obtained from the applied questionnaire, using several ordinal and ratio-scaled variables for the construction of a physical capital index (see Appendix F). The group of variables is used to identify correlations indicating aptitude for index development. It is hypothesized that variables indicating housing conditions, available assets and security will play a major role (see Table 6.3). The benchmark indicator used for the index is the "Ratio of persons per room" [(D) MEMROOMS] since it is assumed that this variable indicates if a household has to cope with inadequate housing conditions reflecting lower levels of well-being.

Financial capital Socio-economic studies (e.g., Chambers and Conway, 1991; DFID, 1999) reveal that increased financial capital in the form of diverse financial sources result in a greater well-being and resilience of the household. Authors investigating the participation of agents in environmental programs frequently include in their analyses aspects of financial capital in order to explain program adoption. They indicate the importance of dimensions such as opportunity costs (Engel et al., 2008), monetary income and personal debt (Thacher et al., 1996; Wunder, 2008; Zbinden and Lee, 2005), the proportion of households with savings (Engel and Palmer, 2008), the type and amount of compensation for landowners (Echeverría, 2010; Tognetti et al., 2004; Wunder, 2008), and processes and management at the community member level, such as

Table 6.3.: Physical capital - hypotheses

Index	**Hypothesis**
Physical capital	It is assumed that a higher degree of physical capital relates positively to recognized PES participation.
Dimension	**Hypotheses**
Housing	Related variables indicate if people are living under humane conditions, with a low impact on their environment as reflected by adequate sanitary installations. It is assumed that better housing of community members causes greater recognition of PES participation.
Assets	Related variables indicate the welfare of a household and its ability to use its endowment in order to pursue livelihood strategies and/or build resilience against shock. It is expected that more available assets create a greater probability of recognition of PES participation.
Security	Related variables indicate if a house is located in a safe area in terms of delinquency. It is expected that a greater perceived security concern creates a lower probability of recognition of PES participation.

contribution to the household income, strengthening and diversification of productive activities, ensuring access to research and projects (Kosoy et al., 2008). This research study employs several of these variables (or proxies) for the construction of a financial capital index, which have been obtained from the applied questionnaire (see Appendix F). This set of variables contributes to discovering correlations which justify their use in the index construction. It is hypothesized that variables indicating income and access to financial resources play a role (see Table 6.4). The variable "Available income per household member" [(H) INCOMON] has been selected as a benchmark indicator since it is believed to best reflect available financial resources for the household and allows for comparison with amounts paid from PES.

Table 6.4.: Financial capital - hypotheses

Index	**Hypothesis**
Financial capital	It is assumed that a higher degree of financial capital generally relates positively to recognized PES participation.
Dimension	**Hypotheses**
Income	Related variables indicate the welfare of a household and income distribution among household members to infer the significance of PES payments. It is assumed that higher income on a household and individual level causes greater recognition of PES participation.
Assets	Related variables indicate the possibility of a household to convert assets into financial resources. It is expected that more significant financial assets create a higher probability of recognition of PES participation.
Sources	Related variables indicate the possibility of a household to obtain financial resources. It is expected that a stable income source creates a greater probability of recognition of PES participation.

Social capital In social studies (e.g., Ostrom, 1990; Ostrom and Ahn, 2003), it is widely acknowledged that social capital is able to extend and enrich other disciplines such as economics and its foundations of neoclassic theory in several ways. It is suggested that social capital in the form of networks, connectedness, ability to organize and group membership result in a greater well-being and ability to cooperate in the sustainable use of a scarce natural resource such as common property. Hence, social capital is expected to play a central role for this research in order to investigate the participation of agents in environmental programs. Dimensions reported in the literature which might contribute to the analysis of PES adoption include the form of governance and processes of decision-making (Tognetti et al., 2004), capacity to organize internally (Echeverría, 2010; Kosoy et al., 2008; Rosa et al., 2004; Robertson and Wunder, 2005; Wunder and Albán, 2008), communal leadership (Echeverría, 2010), trust and institutional agreements (Tognetti et al., 2004), access and diffusion of information (Adesina and Chianu, 2002; Adesina et al., 2000; Arnold, 1992; Hosier, 1989; Hyman, 1983; Thacher et al., 1996; Zbinden and Lee, 2005), processes and management at the community level including rules of forest management, collective conservation values, consensus on the use of PES income, a small size of the community (Kosoy et al., 2008), and the right to participate (Pagiola et al., 2005; Wunder, 2008). This study has adopted some of these variables or proxies of the same in the construction of a social capital index. A number of variables for social capital have been obtained through the application of the questionnaire (see Appendix F). They are used to explore correlations which indicate their suitability for the development of a social index. It is hypothesized that the variables indicating cultural heritage, trust in "natural resource administrators", and land conflicts will play a particularly strong role (see Table 6.5). This study uses the variable "Respect of own cultural heritage at 2 levels" [(H) HERIT2] as a benchmark indicator for the analysis because it is assumed that it best reflects the empathy of community members with their community, and thus natural capital in the form of common land property.

Table 6.5.: Social capital - hypotheses

Index	**Hypothesis**
Social capital	It is assumed that a higher degree of social capital generally relates positively to recognized PES participation.
Dimension	**Hypotheses**
Culture	Related variables indicate the importance of cultural heritage which has shaped land tenure significantly since the Agrarian Reform. It is assumed that higher degrees of cultural awareness cause greater recognition of PES participation.
Trust	Related variables indicate the trust community members have for different (internal and external) institutions responsible for the regulation of natural resource management. A general problem in forest governance is corruption. It is expected that greater trust in institutions creates a higher probability of recognition of PES participation.
Conflict	Related variables indicate the level of (internal and external) land-use conflict, which is an explicit eligibility criterion under the national PES program. The presence or absence might indicate the level of collectivity. It is expected that land conflict reduces the probability of recognition of PES participation.

Marginalization The dimension of marginalization within Mexico's national context is of particular interest because it is used for targeting PES payments. Although PES has been hypothesized to contribute positively to alleviate several dimensions of marginalization, empirical evidence has been rare and ambiguous (e.g., Engel et al., 2008; Landell-Mills and Porras, 2002). In order to elaborate on this interaction within the study context, this research uses indicators measuring urban marginalization through the index developed by CONAPO (2005a). This was adopted since the national PES program explicitly establishes the objective of targeting marginalized groups through this index in order to contribute to rural development (DOF, 2011). Muñoz Piña et al. (2008) found evidence that in Mexico's national PES scheme, the poorest potential ES providers are not involved to the degree of other participants. The question, therefore, is if this outcome will also be detected in the study area or if marginalized groups are not eligible participants but most likely those affecting ES provision (e.g., illegal dwellers). CONAPO (2005a) uses four dimensions to explain urban marginalization: education, health, housing and assets. This research study employs these dimensions and associated variables in order to integrate them on the community level within the Index of Urban Marginalization of 2005. A number of variables allowing their integration was determined by the application of the questionnaire (see Appendix F). It is hypothesized that these dimensions of urban marginalization indicate that PES participants in a peri-urban context are actually better-off economically (see Table 6.6).

Table 6.6.: Urban marginalization - hypotheses

Index	**Hypothesis**
Marginalization	It is assumed that a higher degree of marginalization generally relates negatively to recognized PES participation.
Dimension	**Hypotheses**
Education	Related variables indicat the capacity and capability of improved welfare, and of a household's ability to understand abstract policy programs such as PES. This dimension draws on human capital. It is assumed that higher levels of education cause greater recognition of PES participation.
Health	Related variables indicate a household's vulnerability and degree of resilience against health "shocks". This dimension draws on human capital. It is expected that a better health status within a household creates also a higher probability of recognition of PES participation.
Housing	Related variables indicate the quality of housing, which has an impact on dignified living, environment and health. This dimension draws on physical capital. It is expected that better shelter quality increases the probability of recognition of PES participation.
Assets	Related variables indicate the level of a household's welfare. This dimension draws on physical and financial capital. It is expected that high quality asset endowment increases the probability of recognition of PES participation.

6.3. PCA results

The application of semi-structured interviews provides the necessary input to further explore the dynamics of socio-economic conditions in communities in order to explain why a community member recognizes her/his participation in the national PES program. In-depth analysis is needed to elaborate meaningful explanation and interpretation of the data. Data processing is based on the PCA method presented in Section 5.1 and inspired by Henry et al. (2003) and Zeller et al. (2001). Standard statistical procedures have been selected for this purpose using SPSS (Version 16) as the main processing software. Survey data were processed in four main steps. In the first part, the data of selected variables were analyzed by employing descriptive statistics in order to gain information about the data set (compare with Section 5.1.1). The second step investigated the strength of correlations among variables in order to reduce the data set for further processing (compare with Section 5.1.2.1). After sufficient information on correlations were gathered, the third step involved constructing the index itself so as to explain the different components comprising the dimensions of livelihoods (compare with Section 5.1.2.2). In the final step, the relation between the indexes and the "participation status" variable was tested to explain recognized participation in a practiced PES scheme (compare with Section 5.1.2.3). The intention was to use these PCA index models to reveal if the national PES program was susceptible to adverse selection at the individual community member level with implications for the common property regime as a whole.

6.3.1. Descriptive data

The objective of descriptive data analysis is to summarize meaningful data sets so they can be used for the development of an index assessment tool. Hence, the descriptive data analysis is an intermediate step towards the development of an index (compare with Section 5.1.1). Descriptive statistics describe the main features of the quantitative data set collected for that purpose. The analysis aims to summarize the obtained data in nominal, ordinal, interval and ratio-scaled variables grouped into human capital, natural capital, physical capital, financial capital, social capital and marginalization (see Appendix F). An analysis of the differences in terms of socio-economic characteristics improves the understanding of how the index dimensions influence recognized participation (PES and non-PES). The information provides the researcher with an understanding that contributes to the interpretation of quantitative findings. Differences between groups ("non-PES" not recognizing participation versus "PES" recognizing participation) are tested using both the Chi-square test in combination with cross-tabulations and the T-test of differences between means. The decision of which test to apply depends on the data scale used for the measurement of the variable.

The nominal and ordinal variables were analyzed using the Chi-square test. Descriptive analysis of the relationship between two variables involves cross-tabulation tables in order to identify patterns of responses that differ by the individual PES participation status, and the Chi-square test is used to test whether differences in responses between sample groups are significant at ≤ 0.05 (or ≤ 0.10). In contrast, interval and ratio-scaled variables were analyzed using the Independent Samples T-test. The test is used to determine the difference of means between the two sample groups, in this case PES participants and non-participants. This test reveals whether the variables are not independent of one another. If significant differences are found in the samples, they are interpreted as representative for the total population. The group means are considered different at a significance level of ≤ 0.05 (or ≤ 0.10). The variables (indicators) to test for significant differences between PES participants and non-PES participants are grouped into five livelihood capitals (human, natural, physical, financial and social) and only significant relations are exposed below. The dimension of marginalization has been excluded because: (i) the index is constructed at the community and not individual level; (ii) index dimensions were already included in the five capitals; and (iii) the index variables were already predetermined.

Human capital A descriptive analysis of the nominal and ordinal indicators for human capital shows that "Marital status of the household head" [MARSTAT] and "Bad health status of household members at 2 levels" [HEALTH1] demonstrated significant differences (at ≤ 0.10) between PES participants and non-participants (see Table 6.7). The cross-tabulation indicates for MARSTAT that non-participation in PES is more pronounced in households where the household head has a partner, while in the group of PES participants, the distribution appears to be equal among the two categories. In the case of HEALTH1 the cross-tabulation indicates that PES non-participation is more frequent in households which do not face health problems, although this holds true for households participating in PES as well but the difference is less striking.

The interval and ratio-scaled variables contained in the group of human capital with significant difference for the T-test are shown in Table 6.7. The descriptive statistics indicate that "Age of spouse" [SPOUAGE], "Family size" [FAMSIZE], "Number of children <18 yrs" [NUMCHILD], "Number of work force 18-60 yrs" [NUMWF], "Number of older >60 yrs" [NUMOLDER], "Average age of adults" [ADULTAGE], "Dependency ratio of child to work force" [CHILDWF] and "Dependency ratio of older to work force" [OLDERWF] explain significant differences between PES participants and non-participants at a significance level of ≤ 0.05 (or ≤ 0.10). The statistics for SPOUAGE, NUMOLDER, ADULTAGE and OLDERWF indicate that households which recognize their PES participation tend to have an older spouse of the household head, older family members in absolute terms, higher average adult ages and a greater dependency of older to work force. The variables FAMSIZE, NUMCHILD, NUMWF and CHILDWF reveal that households unaware of their participation in the PES program have larger families, more children, more workforce available and a greater dependency of children to the workforce.

Natural capital A descriptive analysis of the nominal and ordinal indicators for natural capital shows that "Household members drink water from the river" [WATERDRI], "Impact of houses and restaurants on the quality of water at 2 levels" [WATERQL2], "River at risk to run

Table 6.7.: Human capital: Chi-square and T-test

Variable	Chi-square	Answer	non-PES	%	PES	%	Total	%
MARSTAT	0.077	Single	8	26.7	22	46.8	30	39.0
		Couple	22	73.3	25	53.2	47	61.0
		Total	*30*	*100.0*	*47*	*100.0*	*77*	*100.0*
HEALTH1	0.057	No	23	85.2	29	64.4	52	72.2
		Yes	4	14.8	16	35.6	20	27.8
		Total	*27*	*100.0*	*45*	*100.0*	*72*	*100.0*
Variable	**T-test**	**Group**	**N**	**Mean**		**Std. deviation**		**Std. error mean**
SPOUAGE	0.007	non-PES	22	50.73		13.618		2.903
		PES	24	60.62		9.445		1.928
FAMSIZE	0.042	non-PES	30	4.43		2.128		0.389
		PES	47	3.47		1.718		0.251
NUMCHILD	0.003	non-PES	30	0.97		1.189		0.217
		PES	47	0.34		0.600		0.088
NUMWF	0.028	non-PES	30	2.33		1.918		0.350
		PES	47	1.43		1.331		0.194
NUMOLDER	0.040	non-PES	30	1.13		1.074		0.196
		PES	47	1.70		1.284		0.187
ADULTAGE	0.071	non-PES	30	47.337		13.065		2.385
		PES	47	52.897		12.702		1.852
CHILDWF	0.032	non-PES	26	0.573		0.741		0.145
		PES	34	0.220		0.368		0.063
OLDERWF	0.015	non-PES	26	0.503		0.711		0.139
		PES	34	1.011		0.859		0.147

dry" [RUNDRY], "Favors conservation of communal land but with management plan" [LANDMGMT], "Favors open-access to communal land" [LANDOA], "Potential NTFP benefits from communal land" [PONTFP], "Income or subsistence benefits from NTFP activities on communal land" [ECNTFP], "Income or subsistence benefits from livestock activities on communal land" [ECLIVEST], "Income or subsistence benefits from agricultural activities on communal land" [ECAGRI], and "Daily living affected by pest and diseases" [PESTDISE] demonstrated significant differences (at ≤ 0.05 and ≤ 0.10) between PES participants and non-participants (see Table 6.8). The cross-tabulation indicates for WATERDRI that non-participation in PES is more pronounced in households where family members drink water from the river, while in the group of PES participants the distribution appears to be equal among the two categories. In the case of WATERQL2 and RUNDRY the cross-tabulation indicates that the majority of the non-PES group thinks that houses and restaurants near the river have a negative impact on the water quality and the river is at risk to run dry. The same holds for the PES-group but this difference is less pronounced. For the variable LANDMGMT, the data indicate that PES participants tend not to be in favor of a conservation approach with planned management for common land property, while for non-participants this is the preferred option. The variable LANDOA reveals that interviewees who do not recognize their PES participation are against a land management policy of open-access, while PES participants do not reveal a unique preference. For the variable PONTFP, the data set shows that most non-participants and participants believe that common natural property has the potential to deliver NTFP, although in the group of PES participants a substantial number believes that this is not the case. This relationship also holds true for PES non-participants in the case of the variable ECNTFP, but among the group of PES participants the previous relation is inverted and most community members do not gain any income or subsistence benefits from NTFP activities on common property. Households that do not recognize their participation in the PES program are equally divided between groups that gain income or subsistence benefits from livestock [ECLIVST] and agricultural [ECAGRI] activities on common property, and those that do not pursue such activities. However, the picture changes for PES participants where the majority is not involved in livestock activities, where two third actually benefit from agricultural activities on common land property. The last variable PESTDISE relating to "primary sector" hazards shows that most PES non-participants state that they are not affected by this problem, while half of the PES participants consider this a threat.

Interval and ratio-scaled variables contained within the natural capital grouping with significant difference for the T-test are shown in Table 6.8. Descriptive statistics indicate that "Size of landholdings per person" [PARSIZPE] and "Value of landholdings per person" [PARVALPE] explain significant differences between PES participants and non-participants at a significance level of ≤ 0.10. The statistics for PARSIZPE and PARVALPE are similar because a homogeneous price per hectare was assumed. A price of MXN 80 per m^2 was applied and derived from the real estate sector. Hence, both variables indicate that in the group of non-participants considerably more family members depend on the family's landholdings in relative terms compared to households that recognize their PES participation.

Physical capital A descriptive analysis of the nominal and ordinal indicators for physical capital demonstrates that "Quality of sanitary water connection in the house at 2 levels (toilet with flush)" [SAWATER2] and "Risk of disasters near the residents" [DISASTER] explain significant differences (at ≤ 0.10; for DISASTER slightly higher) between PES participants and non-participants (see Table 6.9). The cross-tabulation indicates for SAWATER2 that in the group of PES non-participants one-third has no toilet with flush, while in the group of PES participants the majority has adequate sanitary installations. The variable DISASTER shows that the majority of non-participants believes that their residence is located in an area where natural disasters such as landslides could affect them, while among households participating in PES the perception is balanced.

Interval and ratio-scaled variables contained in the group of physical capital with significant difference for the T-test are shown in Table 6.9. Descriptive statistics indicate that only the variable for "Ratio persons per room" [MEMROOMS] explains significant differences between PES participants and non-participants at a significance level of ≤ 0.10. The statistics for

Table 6.8.: Natural capital: Chi-square and T-test

Variable	Chi-square	Answer	non-PES	%	PES	%	Total	%
WATERDRI	0.027	No	6	20.0	21	44.7	27	35.1
		Yes	24	80.0	26	55.3	50	64.9
		Total	*30*	*100.0*	*47*	*100.0*	*77*	*100.0*
WATERQL2	0.044	Positive	1	3.3	9	19.1	10	13.0
		Negative	29	96.7	38	80.9	67	87.0
		Total	*30*	*100.0*	*47*	*100.0*	*77*	*100.0*
RUNDRY	0.085	No	2	6.7	10	21.3	12	15.6
		Yes	28	93.3	37	78.7	65	84.4
		Total	*30*	*100.0*	*47*	*100.0*	*77*	*100.0*
LANDMGMT	0.032	No	8	33.3	16	64.0	24	49.0
		Yes	16	66.7	9	36.0	25	51.0
		Total	*24*	*100.0*	*25*	*100.0*	*49*	*100.0*
LANDOA	0.032	No	19	79.2	13	50.0	32	64.0
		Yes	5	20.8	13	50.0	18	36.0
		Total	*24*	*100.0*	*26*	*100.0*	*50*	*100.0*
PONTFP	0.011	No	1	3.7	12	27.9	13	18.6
		Yes	26	96.3	31	72.1	57	81.4
		Total	*27*	*100.0*	*43*	*100.0*	*70*	*100.0*
ECNTFP	0.004	No	8	29.6	28	65.1	36	51.4
		Yes	19	70.4	15	34.9	34	48.6
		Total	*27*	*100.0*	*43*	*100.0*	*70*	*100.0*
ECLIVEST	0.003	No	12	44.4	34	79.1	46	65.7
		Yes	15	55.6	9	20.9	24	34.3
		Total	*27*	*100.0*	*43*	*100.0*	*70*	*100.0*
ECAGRI	0.109	No	14	51.9	14	32.6	28	40.0
		Yes	13	48.1	29	67.4	42	60.0
		Total	*27*	*100.0*	*43*	*100.0*	*70*	*100.0*
PESTDISE	0.054	No	20	74.1	23	51.1	43	59.7
		Yes	7	25.9	22	48.9	29	40.3
		Total	*27*	*100.0*	*45*	*100.0*	*72*	*100.0*
Variable	**T-test**	**Group**	**N**	**Mean**		**Std. deviation**		**Std. error mean**
PARSIZPE	0.067	non-PES	30	0.160		0.237		0.043
		PES	46	0.389		0.644		0.095
PARVALPE	0.067	non-PES	30	128,394.4		189,702.3		34,634.7
		PES	46	311,375.3		516,199.2		76,109.4

MEMROOMS highlight that households recognizing their PES participation tend to have less household members inhabiting a single room.

Financial capital Nominal and ordinal indicators for financial capital partially draw attention to aspects of PES program details as an alternative source of income. Descriptive analysis shows that "Participant of PES that receives compensation for conservation" [PESPART2], "Knowing the correct name of the PES program" [PRONAME], "Knowing the correct name of the PES administrator" [GOBNAME], "Knowing the PES's objective" [PESOBJ], "Received capacity-building from PES" [PESCAP], "Knowing the land characteristics for land enroll-

Table 6.9.: Physical capital: Chi-square and T-test

Variable	Chi-square	Answer	non-PES	%	PES	%	Total	%
SAWATER2	0.099	No	10	33.3	8	17.0	18	23.4
		Yes	20	66.7	39	83.0	59	76.6
		Total	*30*	*100.0*	*47*	*100.0*	*77*	*100.0*
DISASTER	0.109	No	8	29.6	22	48.9	30	41.7
		Yes	19	70.4	23	51.1	42	58.3
		Total	*27*	*100.0*	*45*	*100.0*	*72*	*100.0*
Variable	**T-test**	**Group**	**N**	**Mean**		**Std. deviation**		**Std. error mean**
MEMROOMS	0.090	non-PES	30	1.222		0.771		0.140
		PES	46	0.937		0.587		0.086

ment in PES" [PESLAND], "Community changed management due to PES" [PESMGMT], "Knowing the activities encouraged by PES" [PESACT], "PES benefits used for family expenses" [PESFAM], "Employment status (regular work) of the household head" [LABSTAT] and "Household head works inside the community" [WORKLOC] demonstrated significant differences (at ≤ 0.05 and ≤ 0.10) between PES participants and non-participants (see Table 6.10). In the case of PESPART2, cross-tabulation indicates that PES non-participants acknowledge receiving compensation payments more frequently, while for households recognizing their participation the opposite is the case. Cross-tabulation indicates for PRONAME and GOBNAME that PES participants and non-participants alike are unable to provide the correct name of the PES program and/or the institution running it. Five variables - PESOBJ, PESCAP, PESLAND, PESMGMT and PESACT - reveal a similar response pattern, indicating that, as was the case for the previous two PES-related variables, community members actually have little reliable knowledge of the attributes related the PES program. The five variables under consideration show that the majority of interviewees recognizing their PES participation state that they have no significant knowledge of program details, while the majority of PES non-participants actually claims to have appropriate knowledge. The variable PESFAM shows that participants and non-participants both use program benefits for family expenses. Finally, the variables LABSTAT and WORKLOC show that in the group of PES non-participants the majority of heads of households have regular jobs and are working inside the community, while interviewees recognizing their PES participation report a balanced distribution among these categories.

Interval and ratio-scaled variables contained in the group of financial capital with significant difference for the T-test are shown in Table 6.10. Descriptive statistics indicate that "Income in MXN per person" [INCOMOPE] and "Income in MXN per adult" [INCOMOAD] explain significant differences between PES participants and non-participants at a significance level of ≤ 0.10 (INCOMOAD slightly higher). The statistics for INCOMOPE and INCOMOAD reveal that households recognizing their PES participation tend to have more income available per individual household member and for the adults of each household.

Table 6.10.: Financial capital: Chi-square and T-test

Variable	Chi-square	Answer	non-PES	%	PES	%	Total	%
PESPART2	0.000	No	8	27.6	35	76.1	43	57.3
		Yes	21	72.4	11	23.9	32	42.7
		Total	*29*	*100.0*	*46*	*100.0*	*75*	*100.0*
PRONAME	0.062	No	24	82.8	44	95.7	68	90.7
		Yes	5	17.2	2	4.3	7	9.3
		Total	*29*	*100.0*	*46*	*100.0*	*75*	*100.0*
GOBNAME	0.005	No	20	69.0	43	93.5	63	84.0
		Yes	9	31.0	3	6.5	12	16.0
		Total	*29*	*100.0*	*46*	*100.0*	*75*	*100.0*
PESOBJ	0.001	No	5	17.2	26	56.5	31	41.3
		Yes	24	82.8	20	43.5	44	58.7
		Total	*29*	*100.0*	*46*	*100.0*	*75*	*100.0*
PESCAP	0.007	No	11	37.9	32	69.6	43	57.3
		Yes	18	62.1	14	30.4	32	42.7
		Total	*29*	*100.0*	*46*	*100.0*	*75*	*100.0*
PESLAND	0.001	No	11	39.3	35	77.8	46	63.0
		Yes	17	60.7	10	22.2	27	37.0
		Total	*28*	*100.0*	*45*	*100.0*	*73*	*100.0*
PESMGMT	0.014	No	6	24.0	13	59.1	19	40.4
		Yes	19	76.0	9	40.9	28	59.6
		Total	*25*	*100.0*	*22*	*100.0*	*47*	*100.0*
PESACT	0.000	No	3	10.7	30	66.7	33	45.2
		Yes	25	89.3	15	33.3	40	54.8
		Total	*28*	*100.0*	*45*	*100.0*	*73*	*100.0*
PESFAM	0.078	No	4	17.4	8	42.1	12	28.6
		Yes	19	82.6	11	57.9	30	71.4
		Total	*23*	*100.0*	*19*	*100.0*	*42*	*100.0*
LABSTAT	0.086	No	8	28.6	22	48.9	30	41.1
		Yes	20	71.4	23	51.1	43	58.9
		Total	*28*	*100.0*	*45*	*100.0*	*73*	*100.0*
WORKLOC	0.025	No	6	21.4	21	47.7	27	37.5
		Yes	22	78.6	23	52.3	45	62.5
		Total	*28*	*100.0*	*44*	*100.0*	*72*	*100.0*
Variable	**T-test**	**Group**	**N**	**Mean**		**Std. deviation**		**Std. error mean**
INCOMOPE	0.052	non-PES	27	844.6		489.1		94.1
		PES	41	1,482.4		1,624.2		253.6
INCOMOAD	0.116	non-PES	27	1,135.5		762.9		146.8
		PES	41	1,599.0		1,604.6		250.5

Social capital A descriptive analysis of the nominal and ordinal indicators for social capital shows that "Community type" [EJICOM], "Household members are organized in a group (different from community)" [GRMEMBER], "Trust in CONAGUA at 2 levels" [CONAGUA2], "Trust in NGOs at 5 levels" [NGO1], "Trust in NGOs at 2 levels" [NGO2], "Respect of own cultural heritage at 2 levels" [HERIT2], "Internal land conflict in the community" [CONFLIC1], "External land conflict in the community" [CONFLIC2] and "Daily living affected by corruption" [CORRUPT] demonstrated significant differences (at ≤ 0.05 and ≤ 0.10) between PES participants and non-participants (see Table 6.11). Cross-tabulation indicates for EJICOM that two-third of *ejidatarios* recognize their PES participation, versus only about half for *comuneros*. In the case of the variable GRMEMBER, most PES participants state that household members are not organized in another group, while in the case of non-participants about one-third of households have family members that are active in other groups. The variables CONAGUA2, NGO1 and NGO2 reveal if community members trust CONAGUA and NGOs dealing with environmental issues. Cross-tabulation indicates that PES non-participants tend to distrust CONAGUA but trust NGOs, while PES participants have a tendency to distrust NGOs and are divided regarding CONAGUA. The variable HERIT2 shows that three-fifths of PES non-participants have the feeling that their cultural heritage is not respected by society, while for PES participants this relationship is inverted. Conflict referring to land, internally (CONFLIC1) and externally (CONFLIC2), follows a similar pattern of responses between the two PES groups. While PES non-participants tend to perceive that both conflict types affect them, PES participants do not have this perception. The variable CORRUPT uncovers that both groups believe that they are affected directly by corruption, although the division is more pronounced among interviewees that do not recognize their PES participation.

There has only been one interval variable collected that can be associated with social capital. This number is low because the dimension comprising it is generally difficult to identify with adequate interval and ratio-scaled indicators. Descriptive statistics for the sole variable analyzed "Number of attendance in the General Assembly per year " [ASSEMBLY] is unable to explain significant differences between PES participants and non-participants (see Table 6.11). Statistics for ASSEMBLY show a mere trend that households recognizing their PES participation attend the General Assembly more frequently.

6.3.2. Index development

Indexes are constructed to measure a specific socio-economic dimension based on a composite of variables collected for this purpose. A set of quantitative data is screened for interrelations that jointly provide a stronger statement on the selected socio-economic characteristics such as the five livelihood assets and marginalization. This demands a specific path of steps to construct the different indexes (see Section 5.1). In the following, the results of the two principal stages are presented. First, the filtration of indicators for the indexes calculating coefficients of linear correlation among variables and selecting those variables that have plausible and statistically significant correlation coefficients[6], and second, the use of PCA to estimate the index.

[6] Variables for the Urban Marginalization Index are excluded here because they are predetermined by CONAPO (2005a) and calculated on the Geostatistics Base Area (AGEB, for its Spanish acronym) level.

Table 6.11.: Social capital: Chi-square and T-test

Variable	Chi-square	Answer	non-PES	%	PES	%	Total	%
EJICOM	0.059	Agr. community	20	66.7	21	44.7	41	53.2
		Ejido	10	33.3	26	55.3	36	46.8
		Total	*30*	*100.0*	*47*	*100.0*	*77*	*100.0*
GRMEMBER	0.007	No	19	63.3	41	89.1	60	78.9
		Yes	11	36.7	5	10.9	16	21.1
		Total	*30*	*100.0*	*46*	*100.0*	*76*	*100.0*
CONAGUA2	0.044	No	23	76.7	23	53.5	46	63.0
		Yes	7	23.3	20	46.5	27	37.0
		Total	*30*	*100.0*	*43*	*100.0*	*73*	*100.0*
NGO1	0.098	Strongly disagree	2	9.1	13	31.0	15	23.4
		Disagree	2	9.1	6	14.3	8	12.5
		Indifferent	5	22.7	11	26.2	16	25.0
		Agree	9	40.9	6	14.3	15	23.4
		Strongly agree	4	18.2	6	14.3	10	15.6
		Total	*22*	*100.0*	*42*	*100.0*	*64*	*100.0*
NGO2	0.017	No	9	40.9	30	71.4	39	60.9
		Yes	13	59.1	12	28.6	25	39.1
		Total	*22*	*100.0*	*42*	*100.0*	*64*	*100.0*
HERIT2	0.059	No	17	63.0	18	40.0	35	48.6
		Yes	10	37.0	27	60.0	37	51.4
		Total	*27*	*100.0*	*45*	*100.0*	*72*	*100.0*
CONFLIC1	0.006	No	11	40.7	33	73.3	44	61.1
		Yes	16	59.3	12	26.7	28	38.9
		Total	*27*	*100.0*	*45*	*100.0*	*72*	*100.0*
CONFLIC2	0.006	No	9	33.3	30	66.7	39	54.2
		Yes	18	66.7	15	33.3	33	45.8
		Total	*27*	*100.0*	*45*	*100.0*	*72*	*100.0*
CORRUPT	0.023	No	3	11.1	16	35.6	19	26.4
		Yes	24	88.9	29	64.4	53	73.6
		Total	*27*	*100.0*	*45*	*100.0*	*72*	*100.0*
Variable	**T-test**	**Group**	**N**	**Mean**		**Std. deviation**		**Std. error mean**
ASSEMBLY	0.636	non-PES	30	8.77		3.390		0.619
		PES	47	9.15		3.526		0.514

Linear correlation coefficient

Determining which combination of indicators proves the most instrumental in measuring relative socio-economic dimensions in the area of the survey differs in ways that are somewhat predictable. Therefore, the first step is to identify the strongest individual indicators which distinguish relative levels of socio-economic dimensions linked to selected benchmark indicators. The statistical procedure of filtering indicators follows a two-step approach (compare with Section 5.1.2.1): first, linear correlation coefficients are calculated, and second, variables are selected based on plausible correlations and significance testing. The linear correlation coefficient procedure is the primary means of filtering indicators for the index components in order to determine which variables best appear to capture relative differences among households. Testing the level and direction of correlations with the benchmark indicator for each index component among a wide array of ordinal, interval and ratio-scaled variables (see Appendix F) is the primary means of determining the strength of index component indicators. Pearson's Linear Correlation Coefficient is a statistical procedure used to measure the degree to which two variables are associated and the direction of the relationship. The results of this first filtering process are shown in Table 6.12 with the selected benchmark indicator placed at the top next to the analyzed dimension. Due to the reduced sample size (N=77), it was decided to include variables up to a significance level of ≤ 0.10, which is indicated by the test of significance available for Pearson's Correlation.

Table 6.12.: Correlation coefficient: benchmark versus indicators

Index	**Indicator**	*r*	**p**	**n**	**Index**	**Indicator**	*r*	**p**	**n**
Human	ADULTSEC				Natural	ECNTFP			
1	SPOUAGE	-0.343	0.020	46	1	WORKSIZE	0.200	0.099	69
2	FAMISIZE	0.276	0.015	77	2	WLVALUE	0.200	0.099	69
3	NUMADULT	0.232	0.043	77	3	RUNDRY	0.215	0.075	70
4	NUMWF	0.355	0.002	77	4	PONTFP	0.317	0.007	70
5	ADULTAGE	-0.368	0.001	77	5	POLIVEST	0.257	0.032	70
6	ADULTPRI	-0.509	0.000	77	6	POAGRI	0.239	0.046	70
7	CHILDEDU	0.382	0.080	22	7	ECFOREST	0.398	0.001	70
8	SECONEDU	-0.487	0.000	77	8	ECLIVEST	0.442	0.000	70
9	HCARE	-0.255	0.025	77	9	RAINFALL	-0.213	0.077	70
10	WORKLOC	-0.199	0.094	72	10	TEMPER	-0.248	0.039	70
11	HEALTH1	0.242	0.041	72	11	CLIMACHA	-0.227	0.059	70
12	HEALTH2	0.206	0.082	72					
Physical	MEMROOMS				Financial	INCOMOPE			
1	FLOOR1	-0.205	0.076	76	1	VALASPER	0.291	0.016	68
2	ROOMS	-0.461	0.000	76	2	VALASADU	0.218	0.074	68
3	ROSLEEP	0.583	0.000	76	3	WORKLOC	-0.320	0.008	68
4	OVERCROW	0.711	0.000	76	4	ECONOPT	-0.215	0.078	68
5	SAWATER1	0.572	0.000	76	5	INCOVARI	-0.208	0.089	68
6	SAWATER2	-0.534	0.000	76	6	INCOMON	0.652	0.000	68
7	ELECTRIC	-0.244	0.052	76	7	INCOMOHH	0.652	0.000	68
8	ACCREFRI	-0.283	0.014	75	8	INCOMOAD	0.964	0.000	68
9	VALASPER	-0.328	0.004	75					
10	VALASADU	-0.225	0.052	75					
11	SECURE3	0.208	0.082	71					
Social	HERIT2								
1	CONAGUA1	0.312	0.009	69					
2	CONAGUA2	0.374	0.002	69					
3	CONAFOR2	0.200	0.111	65					
4	UCHAP2	-0.223	0.084	61					
5	COMISAR2	0.215	0.076	69					
6	CONFLIC1	-0.193	0.104	72					
7	CONFLIC3	-0.203	0.087	72					
8	CORRUPT	-0.393	0.001	72					
9	STATEINT	-0.452	0.000	72					

r: correlation coefficient; p: level of significance; n: observations from N=77

PCA to estimate an index

The PCA method is applied to determine how information from various indicators is most effectively combined in order to measure a household's relative status for each index. The end result of the PCA is a single index that assigns each sample household a specific value, called a score, representing the household's SLA component status in relation to all other households in the sample. The intension is to create an index from the combination of individual indicators that correlate significantly with each other for the different indexes based on shared underlying components. The models which represent the indexes meet performance requirements that make them statistically reliable. For each index a "best-fit model" has been developed through trial and error, and continual scrutiny of variables so as to determine the combination that yields the most logical results. Therefore, the lists of variables correlated with the benchmark indicator for each index dimension (see Table 6.12) have been screened systematically by checking and revising four main SPSS output tables (compare with Section 5.1.2.2): (i) KMO and Bartlett's Test, (ii) Component Matrix, (iii) Total Variance Explained, and (iv) Communalities. The results for the six dimensions are displayed in the following section. It is important to note that only cases in which interviewees do not recognize their PES participation [PESPART1] are used in the analysis for the construction of the index (n=30) except for the marginalization index.

Human capital index The human capital index is summarized in Table 6.13. PCA results show that the variables "Percentage of adults with secondary schooling" [ADULTSEC], "Family size" [FAMSIZE], "Number of work force (18-60 yrs)" [NUMWF], "Average age of adults" [ADULTAGE] and "Access to health care insurance" [HCARE] constitute this index. The component loadings for ADULTSEC, FAMSIZE and NUMWF indicate their positive contribution to a higher human index score, while for ADULTAGE and HCARE the loading signs are negative.

Natural capital index The natural capital index is summarized in Table 6.14. The PCA results show that the variables "Income or subsistence benefits from NTFP activities on communal land" [ECNTFP], "Land parcel (ha) worked or cultivated" [WORKSIZE], "River at risk to run dry" [RUNDRY], "Income or subsistence benefits from forestry activities on communal land" [ECFOREST] and "Income or subsistence benefits from livestock activities on communal land" [ECLIVEST] constitute the elements making up this index. The component loadings for all variables indicate a positive contribution to a higher natural index score.

Physical capital index The physical capital index is summarized in Table 6.15. The PCA results show that the variables "Ratio persons per room" [MEMROOMS], "Main flooring material at 3 levels" [FLOOR1], "Quality of sanitary water connection in the house at 3

Table 6.13.: Human capital index

KMO and Bartlett's Test		Total Variance Explained	
KMO	0.769	Eigen value	3.140
Bartlett's Test	0.000	% of Variance	62.791
Component Matrix		**Communalities**	
Variable	Loading	Variable	Extract
ADULTSEC	0.775	ADULTSEC	0.601
FAMSIZE	0.830	FAMSIZE	0.689
NUMWF	0.875	NUMWF	0.765
ADULTAGE	-0.824	ADULTAGE	0.679
HCARE	-0.636	HCARE	0.405

Table 6.14.: Natural capital index

KMO and Bartlett's Test		Total Variance Explained	
KMO	0.713	Eigen value	2.401
Bartlett's Test	0.006	% of Variance	48.013
Component Matrix		**Communalities**	
Variable	Loading	Variable	Extract
ECNTFP	0.723	ECNTFP	0.523
WORKSIZE	0.631	WORKSIZE	0.398
RUNDRY	0.569	RUNDRY	0.324
ECFOREST	0.708	ECFOREST	0.501
ECLIVEST	0.809	ECLIVEST	0.655

levels" [SAWATER1], "Value of assets per person" [VALASPER] and "Daily living affected by security concerns" [SECURE3] constitute this index. The component loadings for the physical capital index have to be interpreted inversely because component loading of the benchmark indicator MEMROOMS is positive. This does not generally indicate a higher physical standard. Hence, the variables FLOOR1 and VALASPER, although they show negative signs, indicate a positive contribution to a higher physical index score, while the variables MEMROOMS, SAWATER1 and SECURE3, although showing positive signs, reduce the physical index score.

Financial capital index The financial capital index is summarized in Table 6.16. The PCA results show that the variables "Income (MXN) per person" [INCOMOPE], "Value (MXN) of assets per adult" [VALASAD], "Household head works inside the community" [WORKLOC] and "Monthly income range" [INCOMON] make up this index. The component loadings for INCOMOPE, VALASAD, and INCOMON indicate their positive contribution to a higher

Table 6.15.: Physical capital index

KMO and Bartlett's Test		**Total Variance Explained**	
KMO	0.669	Eigen value	2.322
Bartlett's Test	0.004	% of Variance	46.447
Component Matrix		**Communalities**	
Variable	Loading	Variable	Extract
MEMROOMS	0.685	MEMROOMS	0.822
FLOOR1	-0.614	FLOOR1	0.761
SAWATER1	0.812	SAWATER1	0.779
VALASPER	-0.716	VALASPER	0.687
SECURE3	0.551	SECURE3	0.303

Note: Component loadings must be inverted for interpretation.

financial index score, while component loading for WORKLOC has a negative sign.

Table 6.16.: Financial capital index

KMO and Bartlett's Test		**Total Variance Explained**	
KMO	0.567	Eigen value	1.811
Bartlett's Test	0.052	% of Variance	45.285
Component Matrix		**Communalities**	
Variable	Loading	Variable	Extract
INCOMOPE	0.739	INCOMOPE	0.791
VALASAD	0.640	VALASAD	0.439
WORKLOC	-0.404	WORKLOC	0.881
INCOMON	0.832	INCOMON	0.703

Social capital index The social capital index is summarized in Table 6.17. The PCA results reveal that the variables "Respect of own cultural heritage at 2 levels" [HERIT2], "Trust in CONAGUA at 2 levels" [CONAGUA2], "Trust in CONAFOR at 2 levels" [CONAFOR2], "Trust in Community Representation at 2 levels" [COMISAR2] and "Internal land conflict in the community" [CONFLIC1] make up this index. Component loadings for HERIT2, CONAGUA2, CONAFOR2 and COMISAR2 indicate a positive contribution to a higher social index score, while for CONFLIC1, the sign of component loading is negative.

Marginalization index The marginalization index is summarized in Table 6.18. In this analysis, the data from 39,172 urban AGEBs (CONAPO, 2005a) and the aggregate values from the two studied communities (see Appendix F) have been used. The PCA results show that the

Table 6.17.: Social capital index

KMO and Bartlett's Test		**Total Variance Explained**	
KMO	0.621	Eigen value	2.124
Bartlett's Test	0.045	% of Variance	42.482
Component Matrix		**Communalities**	
Variable	Loading	Variable	Extract
HERIT2	0.425	HERIT2	0.277
CONAGUA2	0.653	CONAGUA2	0.780
CONAFOR2	0.697	CONAFOR2	0.745
COMISAR2	0.832	COMISAR2	0.737
CONFLIC1	-0.764	CONFLIC1	0.650

variables "Percentage of population 6 to 14 years with no schooling" [CHILDEDU], "Percentage of population > 14 years without completed secondary schooling" [SECONEDU], "Percentage of population without healthcare insurance" [HCARE], "Percentage of deceased children of women aged 15 to 49 years" [DCHILD], "Percentage of private homes without running water inside the dwelling" [WATERAV2], "Percentage of private homes without drainage connected to the public network or septic tank" [DRAIN2], "Percentage of private homes without toilet flush" [SAWATER2], "Percentage of dwellings with dirt floors" [FLOOR2], "Percentage of private homes with some level of overcrowding" [OVERCROW] and "Percentage of private homes without a refrigerator" [ACCREFRI] form this index. Component loadings for all variables indicate a positive contribution to a higher marginalization index score.

6.3.3. Results

The final models from the PCA are used to incorporate the full sample size. The index scores are recalculated by increasing the observations from the 30 PES non-participants to the full sample of 77 interviewees (30 PES non-participants + 47 PES participants), saved as a standardized value of the indexes and grouped into rankings for interpretation (compare with Section 5.1.2.3). The index variables are analyzed through four main tests where the outcome represents the final results of this analysis. First, an Independent Samples T-test of means is run in order to prove that the two groups of interviewees (those recognizing their PES participation and those who don't) have significantly different index scores for the considered socio-economic dimensions. Second, a graph is plotted with the sample's cumulative frequency of index scores separated by participation status in order to graphically verify the difference between the two groups (PES versus non-PES). Third, mean index scores between the two studied community types are graphically compared in order to identify differences at

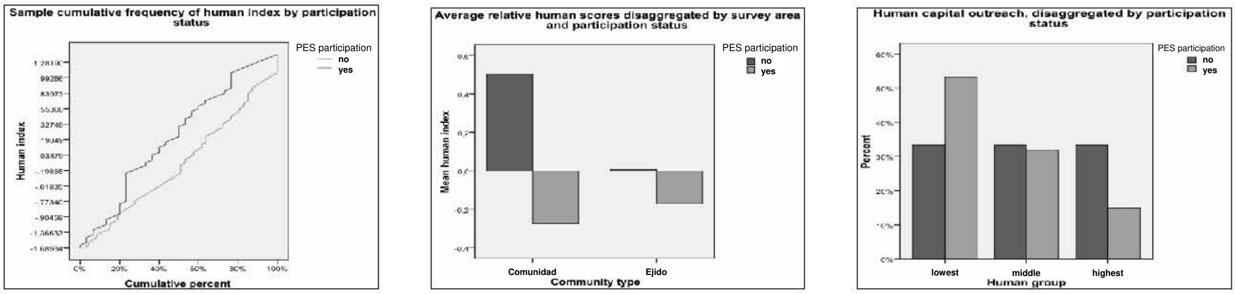
Table 6.18.: Marginalization index

KMO and Bartlett's Test		**Total Variance Explained**	
KMO	0.921	Eigen value	6.164
Bartlett's Test	0.000	% of Variance	61.639
Component Matrix		**Communalities**	
Variable	Loading	Variable	Extract
CHILDEDU	0.563	CHILDEDU	0.316
SECONEDU	0.846	SECONEDU	0.716
HCARE	0.741	HCARE	0.550
DCHILD	0.625	DCHILD	0.391
WATERAV2	0.822	WATERAV2	0.676
DRAIN2	0.732	DRAIN2	0.536
SAWATER2	0.918	SAWATER2	0.844
FLOOR2	0.807	FLOOR2	0.651
OVERCROW	0.856	OVERCROW	0.732
ACCREFRI	0.867	ACCREFRI	0.752

the cluster level (*ejido* versus agrarian community). And fourth, tercile groupings[7] are used to demonstrate the difference of the index outreach disaggregated by participation status. A final analysis and representation of the results changes slightly in the case of the marginalization index because the data were analyzed at the community level and compared with data at the AGEB level. A frequency table of quintile groupings is provided for the marginalization index using AGEBs of the Federal District of Mexico (Mexico City).

Human capital index Results for the human capital index are graphically summarized in Figure 6.2. The statistics show that the mean index score for the group of PES non-participants is 0.338 (n=30; σ=1.179; SEM=0.215) and for PES participants -0.216 (n=47; σ=0.807; SEM=0.117). The Independent Samples T-test demonstrates that the difference of the mean values between the groups is significant with a p=0.017 (Levene's Test for Equality of Variances = 0.189), which confirms the impression illustrated in Figure 6.2(a). Figure 6.2(b) reflects that in both communities interviewees recognizing PES participation tend to have negative mean index scores, while the group of non-participants report a positive mean index value greater in the agrarian community, and only slightly above zero for the *ejido*. Overall results for the three human index groups reveals that households with low index scores tend to be more likely to recognize PES participation (see Figure 6.2(c)).

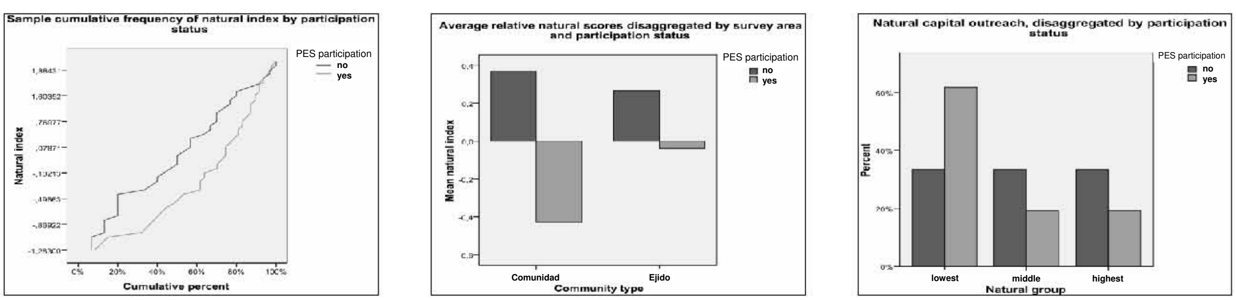
[7] Terciles are used because the sample is relatively small.



(a) (b) (c)

Figure 6.2.: Human capital index: (a) Cumulative frequency (b) Average scores (c) Terciles

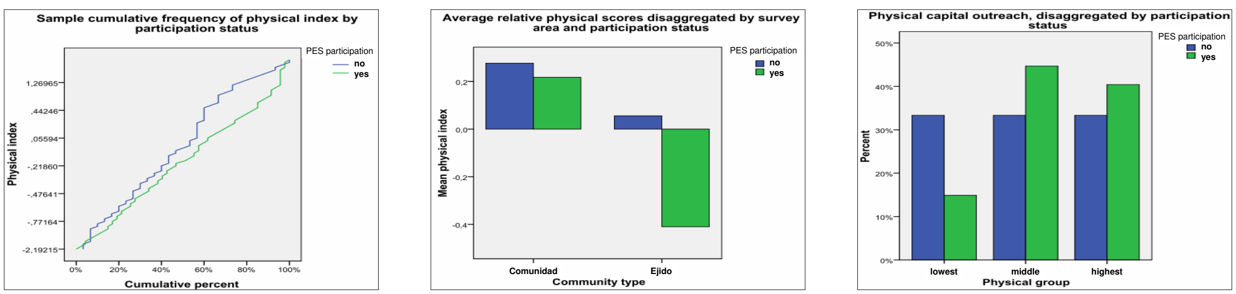
Natural capital index The outcome of the natural capital index is summarized in Figure 6.3. Statistics for the index reveal that the mean value for PES non-participants is 0.332 (n=30; σ=0.988; SEM=0.180) and for the group of PES participants -0.212 (n=47; σ=0.958; SEM=0.139). The Independent Samples T-test demonstrates that the difference in the mean values between the two groups is significant with a p=0.019 (Levene's Test for Equality of Variances = 0.543), which is confirmed graphically in Figure 6.3(a). Figure 6.3(b) indicates that in both communities interviewees not recognizing PES participation tend to have positive mean index scores, while in the group of PES participants a negative mean index value is greater in the agrarian community and only slightly below zero for the *ejido*. The overall result for the three natural index groups shows that households with low index scores tend to be more likely to recognize PES participation (see Figure 6.3(c)).



(a) (b) (c)

Figure 6.3.: Natural capital index: (a) Cumulative frequency (b) Average scores (c) Terciles

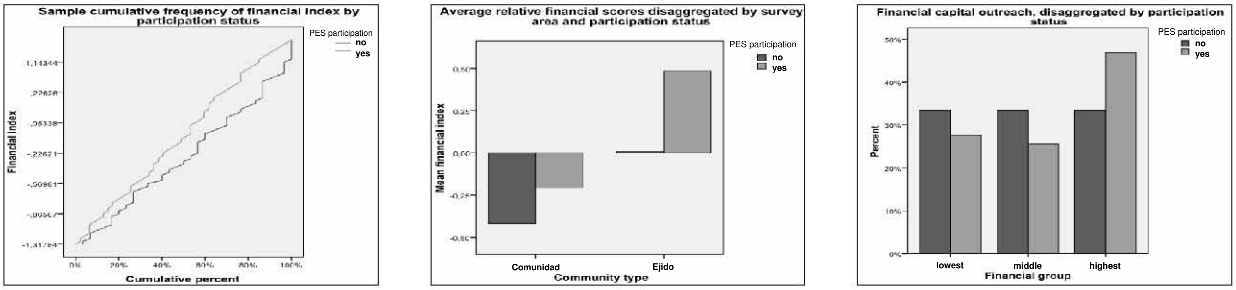
Physical capital index Figure 6.4 graphically summarizes the results of the physical capital index. Index statistics indicate that the mean value of the group of PES non-participants is 0.203 (n=30; σ=1.105; SEM=0.201) and for PES participants -0.129 (n=47; σ=0.915; SEM=0.133). The Independent Samples T-test demonstrates that the difference between the mean values of the two groups is not significant: p=0.156 (Levene's Test for Equality of Variances = 0.066). When analyzing index scores above zero, the mean value for the group of PES non-participants is 1.162 (n=14; σ=0.643; SEM=0.171) and PES participants 0.605 (n=20; σ=0.794; SEM=0.177), and the Independent Samples T-test demonstrates that the difference between the mean values of the two groups is significant with a p=0.038 (Levene's Test for Equality of Variances = 0.997), which confirms the graphical result of Figure 6.4(a). Figure 6.4(b) indicates that in both communities interviewees not recognizing PES participation tend to have positive mean index scores, although this trend is smaller among *ejido* members. In the PES participant group the result of the mean index value is the opposite, where the agrarian community reveals positive index scores, while the *ejido* has negative index values. The overall result for the three physical index groups indicates that households recognizing their PES participation tend to be concentrated in the middle and highest categories (see Figure 6.4(c)).



(a) (b) (c)

Figure 6.4.: Physical capital index: (a) Cumulative frequency (b) Average scores (c) Terciles
Note: (a) and (b) must be inverted for interpretation.

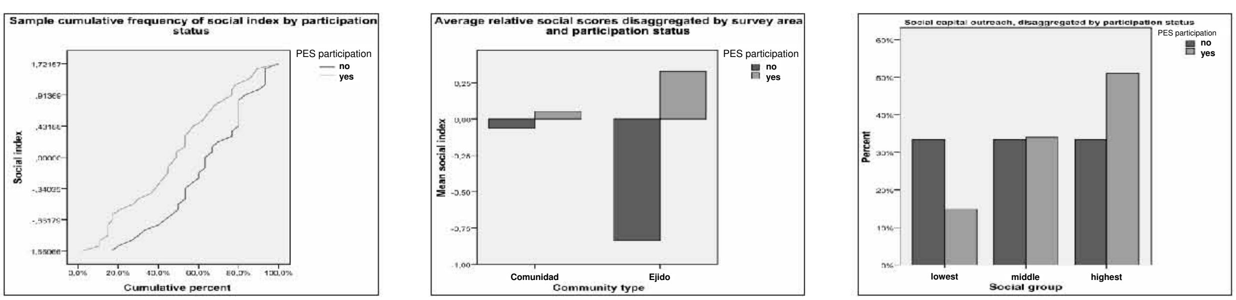
Financial capital index The financial capital index is summarized in Figure 6.5. The statistics show that the mean value for the group of PES non-participants is -0.275 (n=30; σ=0.616; SEM=0.112) and for PES participants 0.175 (n=47; σ=1.144; SEM=0.166). The Independent Samples T-test demonstrates that the difference between the mean values of the groups is significant with a p=0.028 (Levene's Test for Equality of Variances = 0.020), which is also affirmed by Figure 6.5(a). Figure 6.5(b) shows the opposite tendency between the two communities for both groups. Interviewees not recognizing PES participation tend to have a negative mean index score in the case of the agrarian community, while members of the *ejido* have a value slightly higher than zero. In the group of PES participants, the result is similar, although the negative mean index score is lower in the agrarian community and the positive value is considerably higher in the *ejido* group. The result for the tercile grouping indicates that households recognizing their PES participation tend to be in the highest category (see Figure 6.5(c)).



(a) (b) (c)

Figure 6.5.: Financial capital index: (a) Cumulative frequency (b) Average scores (c) Terciles

Social capital index The results for the social capital index are graphically summarized in Figure 6.6. The statistics indicate that the mean value of the PES non-participant group is -0.320 (n=30; σ=1.018; SEM=0.185) and for PES participants 0.204 (n=47; σ=0.931; SEM=0.135). The Independent Samples T-test reveals that the difference between the mean values of the groups is significant with a p=0.023 (Levene's Test for Equality of Variances = 0.714), which confirms the difference depicted in Figure 6.6(a). Figure 6.6(b) indicates that in both communities the tendencies are equal, although more striking in the case of the *ejido* group. Interviewees who do not recognizing PES participation tend to have a negative mean index score, while for PES participants the mean index value is positive. The results for the three social index groups demonstrates that households with a high social index scores tend to more likely recognize PES participation (see Figure 6.6(c)).



(a) (b) (c)

Figure 6.6.: Social capital index: (a) Cumulative frequency (b) Average scores (c) Terciles

Marginalization index The marginalization index for the Federal District of Mexico (Mexico City) is summarized in Table 6.19 based on the data provided by CONAPO (2005a) and complemented with data collected at the community level. The table shows the quintile grouping of the index for Mexico City: very low, low, middle, high and very high. The frequency table indicates that three-quarter (>75%) of the urban AGEBs in Mexico City have very low or low signs of urban marginalization. However, nearly 10 percent (8.1%) of the urban AGEBs in Mexico City show high or very high signs of urban marginalization. The results reveal that the index score of the *ejido* San Nicolás Totolapan places it in the percentile of low marginalization and the index score of the agrarian community Magdalena Atlitic places it in the percentile of middle marginalization.

Table 6.19.: Marginalization in Mexico City

Group	**Frequency**	**Percent**	**Cumulative %**
Very low	909	38.6	38.6
Low*	884	37.5	76.1
Middle**	372	15.8	91.9
High	159	6.7	98.6
Very high	33	1.4	100.0
Total	*2,357*	*100.0*	

**ejido* San Nicolás Totolapan **agrarian community Magdalena Atlitic
Source: modified from CONAPO (2005a)

6.4. Discussion

Three points of interest related to the general orientation of the program make this case study particularly interesting for analyzing the effects of PES payments. First, enrolled common property is already protected, since it forms part of Mexico City's SC and contains in addition ANPs where stakeholders may have achieved the inclusion by arguing that the PES program is a "way to ease the pain of enforcing regulations on poor communities" (Muñoz Piña et al., 2008). Second, despite the fact that the natural capital of the studied communities is already strictly protected and government institutions should have no problem accessing the area for control (i.e., it is not a remote forest), the ecologically valuable area is decreasing as remote-sensing studies (e.g., Schteingart and Salazar, 2005) and INE's Deforestation Risk Index suggest. Third, the lowest payable amount based on national averages for maize cultivation (Muñoz Piña et al., 2008) probably does not adequately reflect the land value in the periphery of Mexico City. Hence, these objective caveats of adequate PES application suggest that the conditional ES provision and additionality of payments is not necessarily guaranteed. It is likely that the program has to deal with problems of adverse selection in the peri-urban context of common property regimes in Mexico City. Therefore, a more profound analysis of impact at the individual community member level and their active involvement in the program has the potential of clarifying the nature of the problem and contributing to potential solutions.

The results presented reveal that enrollment in a PES scheme is not *per se* completely voluntary in the context of Mexican common property regimes. Although it is a joint decision of individual ES providers grouped in a collective, results indicate that a significant difference of recognized participation exists within recipient communities. From the total sample (N=77) it was found that 39 percent (n=30) did not recognize any PES participation compared to 61 percent (n=47) that actually did. This outcome demonstrates that the condition of voluntary participation, as stipulated by the PES definition of Wunder (2005), is likely to be flawed in the context of common property regimes.

Analyzing several dimensions of sustainable livelihood within the two recipient communities in the periphery of Mexico City helps to explain this deviation and further show that the program has probably been adversely selected by a majority of community members, if it is assumed that this group (PES participants) is identical to those recognizing their PES participation. The index results reveal that the majority of community members recognizing their PES participation are actually less likely to have a direct influence on ES provision (see Figure 6.7), which points to a second breach of the PES definition from Wunder (2005) in terms of conditionality. The indexes indicate the impact of PES payments on the livelihoods that are actively participating and highlight their relation to the appropriation of the national PES program.

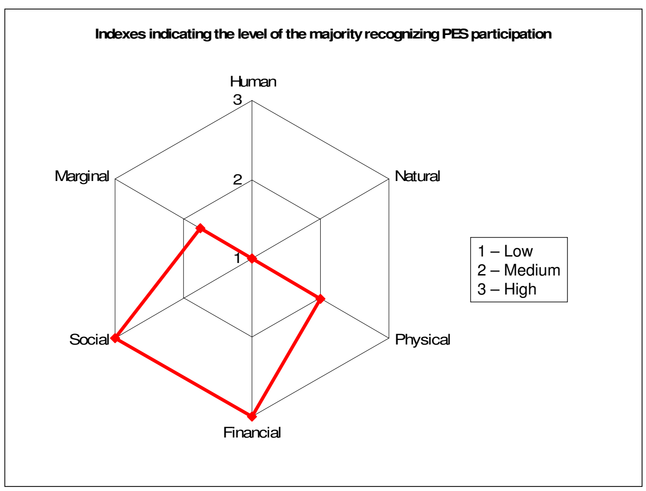


Figure 6.7.: Index assessment of PES participation

The discussion and interpretation of the study results derived from the index assessment is the subject of this section. Each of the six indexes is discussed separately and elaborates on the implication of three aspects: (i) index scores, (ii) index variables, and (iii) adverse selection.

Human index

Assessment of the human index reveals that livelihoods with a lower human capital generally recognize PES participation (see Figure 6.2(c)), a result which was expected (see Table 6.1). Yet not all of the four dimensions included in the index assessment (education, workforce, age and health) related as expected to recognized participation, however, this did not affect the overall outcome of the index. The low level of human capital in the group of interviewees recognizing their PES participation shows that those households may have adverse motivation for recognizing their participation. The implication of lower index scores is that a community member recognizing PES participation tends to live in a household where the educational level of the adults is below the secondary level, family size and available workforce is relatively small, and adults are on average older and have access to healthcare services. Hence, this group is actually less likely to have the capacity to directly cause environmental damage or improve ES provision. This revealed discrepancy questions if the program, in its current form, is able to attract those in a common property regime who actually have the ability to assure conditionality.

The education variable ADULTSEC contributes positively to higher index scores (see Table 6.13). yet, given the results from the human capital index assessment (see Figure 6.2) it can be concluded that a higher educational level among community members does not necessarily cause greater recognition of PES participation, which is the opposite of what was expected (see Table 6.1). Hence, the reported effect that higher education facilitates information acquisition and raises environmental awareness in the context of conservation programs (Illukpitiya, 2005; Rico García-Amado et al., 2011; Teklewold and Köhlin, 2010) was not confirmed by this study.

There are two assumptions which may explain this outcome. First, given the proximity of an available labor market (in Mexico City), a higher education level implies less active involvement in aspects referring to natural resource management, or simply does not judge the program design overall as beneficial. Second, lower levels of education among adults is a phenomena of older community members with a greater interest in cultural heritage, greater dependence on additional income sources and/or interest in subsidy-like programs. The possibility that community members with higher levels of education do not appreciate program benefits while older community members actually do may suggest that problems of adverse selection, indeed, do exist.

Workforce variables FAMSIZE and NUMWF contribute positively to higher index scores (see Table 6.13). Given the results of the human capital index assessment (see Figure 6.2) it can be concluded that a larger household with a greater number of members able to work does not cause greater recognition of PES participation, which is consistent with the formulated assumption (see Table 6.1). Big families are likely to be under greater pressure to generate more income while a higher proportion of household members able to work may increase the probability of actively managing the commons. Hence, the outcome indicates that adverse selection of program participation may occur as community members recognizing their PES participation are less likely to represent an active driver of ES provision change due to their limited available labor force.

The age variable ADULTAGE contributes negatively to higher index scores (see Table 6.13). The fact that household heads in the sample were on average 59 years old confirms that both rural (Warman, 2001) and peri-urban areas managed by common property regimes in Mexico are aging. Based on the results of the human capital index assessment (see Figure 6.2), it can be concluded that a household with relatively older adults exhibits greater recognition of PES participation, which is consistent with the formulated hypothesis (see Table 6.1). This outcome confirms that younger households are less actively involved in the PES program, which is complementary to the observations made for education. The impact of age might be explained by the circumstance that the older the community member the greater the concern to leave the natural resource as a heritage for future generations (Rico García-Amado et al., 2011). Another interpretation, actually indicating adverse selection, is that the elderly have less physical capacity to exploit natural capital. Hence, the older the community member the greater the probability that her/his income opportunities from agriculture or other activities decreases. It is reasonable to infer that additional income from other government programs is highly appreciated and therefore explains recognition of participation.

The health variable HCARE contributes negatively to higher index scores (see Table 6.13), which at first sight seems surprising. This can be explained by the fact that governmental health insurance programs such as *Seguro Popular* (CNPSS, 2012) have targeted poorer and often older groups, which is consistent with the age variable. Given the results from the human capital index assessment (see Figure 6.2) it can be concluded that a household having access to a health care program increases the likelihood for PES recognition, which is congruent with what was expected (see Table 6.1). This outcome supports the assumption that primarily older community members recognize PES participation and probably adversely select it as a risk reducing strategy regarding vulnerability.

Natural index

The assessment of the natural index reveals that livelihoods with lower natural capital generally recognize PES participation (see Figure 6.3(c)), which is the expected outcome (see Table 6.2). This is because the dimension of management included in the index assessment related to recognized participation as expected. The low level of natural capital dependency in the group of interviewees recognizing their PES participation shows that those households may have an adverse motivation to recognize their participation. A community member recognizing PES participation tends to live in a household where members do not work or cultivate large land parcels and do not obtain subsistence and/or commercial benefits from resource extraction such as NTFP, forest products and/or livestock, and thus are not aware of the risk of the river running dry. These community members do not actually maintain or improve ES provision with their land-use management because they do not rely on it. This revealed discrepancy questions if the program in its current format is able to attract people in a common property regime who are actually managing land resources and can guarantee conditionality.

The management variables WORKSIZE, ECNTFP, ECFOREST, ECLIVEST contribute positively to higher index scores (see Table 6.14). Given the results of the natural capital index assessment (see Figure 6.3), it can be concluded that a higher level of dependency on natural capital in the form of resource extraction does not necessarily cause greater recognition of PES participation, which was the expected outcome (see Table 6.1). This may suggest that working a land parcel implies greater opportunity costs relative to the PES offer. The generally accepted theory states that the economic amount paid for ES must be greater than or at least equal to the opportunity costs of not using the natural resource (Bergen et al., 2002; Claassen et al., 2008; Engel et al., 2008; Ferraro, 2008; Ibarra Gené, 2007). In addition, the PES offer may be interpreted as a risk factor in the decision-making of the "active land manager", since s/he may fear a "cold" expropriation (Dobbs and Pretty, 2008), causing the program to undermine the "landowner's" usual (cultural) activity. Similarly, Kosoy et al. (2008) point out that the economic incentive of PES is not always the strongest motivation for participation. It is likely that households farming small landholdings more intensively are less interested in participating in PES (Wunder and Albán, 2008). It seems that preserving their local traditions, such as cultivating and maintaining their heritage, are stronger incentives. The mindset is deeply rooted in the ability to work and cultivate the land, so once the land use is restricted there is a lower level of perceived ownership. In the Mexican culture, "the land belongs to the tiller" which justifies landownership, a highly politically charged sector since the Revolution of 1910. It is likely that not working the land for conservation purposes comes into conflict with the rationale of justifying landownership. Nonetheless, working and cultivating the land is at odds with the conservation objectives of the PES program, making it likely that those who wish to maintain this tradition either for consumption purposes or as a lucrative source of income are not interested in conservation programs. Thus, the logic behind cultivation preferences surpass pure monetary opportunity cost considerations. ES sellers (providers) are typically limited in the magnitude (hectares) of annual LUC. It is worth noting that interviewees mentioned that the size of their managed plots does not usually exceed two hectares. Thus, it may also be that offering low per hectare payments relative to conservation opportunity costs encourage interested recipients to enroll unthreatened areas and maintain BAU as a type of internal leakage of community members whose opportunity costs are low or even negative (Pagiola, 2008). A lack of information on the buyers' side regarding the likelihood of adequate ES provision by potential ES sellers (providers) seems to provoke the undesired effect that the latter adopt a risk-averse strategy by enrolling parcels that had probably not changed anyway (Asquith et al., 2008; Pagiola, 2008; Robertson and Wunder, 2005; Zbinden and Lee, 2005). It is difficult to judge if in some cases this might still have a positive effect on landholders who perceive PES as a risk reducing strategy so that it effectively lowers the costs necessary to induce adoption (Claassen et al., 2008). Relatively small per hectare payments can still be attractive where at any point in time only a minor share (with manageable incremental gains) of a relatively large area is threatened by LUC (Wunder and Albán, 2008). Under such circumstances, payment might at least buffer the pressure of urban sprawl and favor the conservation of land use (Murillo-Hernández, 2008).

Since the program remunerates the provision of hydrological services, the respective perception of ES sellers (providers) relative to the threat of continued ES provision is of particular interest. It seems appealing to assume that with increasing environmental awareness, the desire to participate in programs conserving resources has increased. Awareness of the relation between forests and water is rather strong in Mexican society (Muñoz Piña et al., 2008) and many Central American countries (Pagiola, 2008). Interestingly enough, the loss risk variable RUNDRY contributes positively to higher index scores (see Table 6.14). Given the results of the natural capital index assessment (see Figure 6.3), it can be concluded that a higher level of perceived risk regarding the depletion of ES water does not necessarily cause greater recognition of PES participation, which is the opposite of the expected outcome (see Table 6.1). The relation was not expected because the river is a landmark within the polygon of the community and assumed to implicitly increase the recognition of PES as a conservation instrument. One explanation might be related to the management dimension discussed earlier, concluding that those community members dependant on activities related to the river (irrigation in agriculture, trout breeding, cattle, tourism, small restaurants) have a greater awareness regarding the problems affecting the quantity of water flow in the river. But this, as such, does not suffice to induce recognition. The relationship between land use and water provision is poorly understood (Asquith et al., 2008; Bennett, 2008; Pagiola, 2008; Wunder and Albán, 2008) and is probably not well communicated to community members, so that recognition remains low. This is a problem when justifying payoffs and creating direct links with ES buyers. In the cases analyzed, the buyer is still the government, although the initial idea was, after an interim period, to switch to a user-financed scheme (Muñoz Piña et al., 2008), confirming the difficulty of successful PES application.

Physical index

The assessment of the physical index revealed that livelihoods with medium to higher physical capital generally recognize PES participation (see Figure 6.4(c)), which is consistent with the formulated hypothesis (see Table 6.3). The dimensions (housing, assets and security) included in the index assessment related, as expected, to recognized participation. However, the medium to high level of physical capital in the group of interviewees recognizing their PES participation shows that those households may have an adverse motivation for recognizing their participation. A community member recognizing PES participation tends to live in a house with adequate space for its inhabitants, solid flooring and running water supply in the house. Furthermore, the value of assets per household member tends to be higher and the interviewees consider the location where s/he is living as safe. They actually seem to be better-off and do not negatively influence ES provision with inadequate housing conditions. This reveals the possibility that other actors in the periphery of Mexico City may have a more negative impact on water quality as also indicated by the results of the Urban Marginalization Index. Thus, it may be assumed that conditionality is more strongly influenced by non-PES participants and probably by other groups inhabiting the catchment's area.

Housing is the emotional and physical space where family members structure and strengthen their ties in different stages of life (CONAPO, 2005a). The quality of housing also indicates if settlements have been established illegally or negatively impact the environment, which is a common problem in the studied peri-urban area which challenges environmental policies (Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005). The housing variables MEMROOMS and SAWATER1 contribute negatively, while FLOOR1 concurs positively to higher index scores (see Table 6.15). Given the results from the physical capital index assessment (see Figure 6.4), it can be concluded that a better housing level causes greater recognition of PES participation, which is consistent with the expected outcome (see Table 6.3). The problem though is on the other end where those community members living in dwellings with insufficient space, dirt floors and inadequate sanitary installations are exposed to greater impediments in the sphere of education, recreation and health (CONAPO, 2005a). Although those with inadequate housing tend to have a negative environmental impact they do not demonstrate program appropriation.

The admission of assets that are easily convertible indicate the level of a household's well-being, similar to the dimension of housing (Chambers and Conway, 1991; DFID, 1999). The asset variable VALASPER contributes positively to higher index scores (see Table 6.15). Furthermore, the results of the physical capital index assessment (see Figure 6.4) reveal that a higher asset endowment per household member causes greater recognition of PES participation, which is consistent with the expected outcome (see Table 6.3). However, the outcome also denotes that poorer households do not appropriate the environmental program. In fact, it seems that those community members not living in risk areas with negative impact on the watershed tend to be more likely to select program participation.

Living in an area which is relatively secure in a peri-urban context indicates, similar to the previous dimensions, if interviewees are likely to live in a high risk area which from an environmental perspective is negative for the watershed. Accordingly, the security variable SECURE3 contributes negatively to higher index scores (see Table 6.15). Given the results of the physical capital index assessment (see Figure 6.4) it can be deduced that perceived security causes greater recognition of PES participation, which is consistent with the expected outcome (see Table 6.3). This outcome reaffirms that the program is not capable of attracting those community members who live under less favorable conditions as suggested by the marginalization index within the regional context.

Financial index

The assessment of the financial index revealed that livelihoods with higher financial capital generally recognize PES participation (see Figure 6.5(c)), which is consistent with the formulated hypothesis (see Table 6.4). This is because the three dimensions (income, assets and sources) included in the index assessment related as expected to recognized participation. The high level of financial capital concentrated in the group of interviewees recognizing their PES participation demonstrates that those households may have an adverse motivation to recognize their participation. A community member recognizing PES participation tends to have a higher income (also per household member), has higher asset values per adult living in the household, and works outside the community. This indicates that these households are actually less likely to depend on direct resource extraction from the commons as they tend to be better-off and work outside the community. This brings up the question if the program currently appeals to those community members of a common property regime who require diversification of their income portfolio in order to guarantee conditionality.

The income variables INCOMON and INCOMOPE contribute positively to higher index scores (see Table 6.16). Given the results obtained from the financial capital index assessment (see Figure 6.5), it can be concluded that more available income for the household and its members relates to greater recognition of PES participation, which is congruent with the assumption made (see Table 6.4). Presumably, a community member with a higher income perceives payment only as an additional income that is insignificant, while community members of lower income ranks perceive it as a threat to their income and subsistence activities that are based on resource extraction. Hence, a community member only gets actively involved in a PES program when s/he does not derive a relatively high income from the activities a conservation program intends to restrict (Claassen et al., 2008; Engel et al., 2008; Ferraro, 2008), or does not obtain income from any of these activities at all. In the latter case, the opportunity costs are zero and a payment, in addition to being inefficient (as in the first case), is also ineffective. It cannot be confirmed if community members of lower income ranks perceive the PES program as an opportunity to diversify and complement their income portfolio. These results indicate that lower income groups are less interested in information on, and participation in the PES, which contrasts with the additional objective of the program to alleviate poverty.

Access to assets which are easily convertible in order to confront crisis indicate the level of a household's vulnerability (Chambers and Conway, 1991; DFID, 1999). The liquid assets variable VALASAD contributes positively to higher index scores (see Table 6.16), which can be interpreted to mean that households are less vulnerable and probably better-off. Given the results from the financial capital index assessment (see Figure 6.5), it can be concluded that higher asset values per adult relates to greater recognition of PES participation, which corresponds to the formulated assumption (see Table 6.4). Hence, the program is not able to reach out for those who are financially worse-off, reaffirming the outcome above. The program fails to attract those who probably most desire livelihood alternatives. In the end, the question is who is more likely to improve conditionality.

The variable WORKLOC has a negative impact on higher index scores (see Table 6.16) indicating that income alternatives in the city are more attractive. Given the results from the financial capital index assessment (see Figure 6.5) it can be concluded that working inside the community decreases the recognition of PES participation, which confirms the initial hypothesis (see Table 6.4). This suggests that community members might have adversely selected to participate in the PSAH. This program is clearly unable to attract those whose main income sources come from activities within common property, even though they are probably not better-off. The outcome denotes that for this group, given their livelihood situation, opportunity costs are higher than PES payment levels suggest because a market for different goods and services is quite close (Engel and Palmer, 2008).

Social index

The assessment of the social index revealed that livelihoods with higher social capital generally recognize PES participation (see Figure 6.6(c)), which is consistent with the formulated hypothesis (see Table 6.5). The dimensions (culture, trust and conflict) included in the index assessment related as expected to recognized participation. The high level of social capital in the group of interviewees recognizing their PES participation shows that those households may not have an adverse motivation to recognize their participation, but still demonstrates that the other group may limit conditionality. Community members recognizing PES participation tends to perceive that their cultural heritage is respected, trust community authorities (the internal institution), trust CONAGUA and CONAFOR (external institutions), and are not affected by internal land conflict. This contributes to a feeling of inclusion and explains why no problems of internal land conflict are perceived. On the flip side, this may explain why they are not actively involved in land-use management and, therefore, generally agree with the practices of environmental programs such as PSAH. However, it seems that the ability to build on social capital may help to guarantee conditionality.

The cultural variable HERIT2 relates positively to higher index scores (see Table 6.17). Given the results of the social capital index assessment (see Figure 6.6), it can be concluded that being confident in one's own cultural heritage is respected, increases the recognition of PES participation, which is in-line with the formulated assumption (see Table 6.5). Common property regimes in the periphery are under considerable pressure (Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005) and face difficulties to get organized (Ramos, 2008). Thus, PES program participation may effectively stimulate the capacity to self-organize (Echeverría, 2010) building on the motivation provided by heritage (Kosoy et al., 2008).

Challenges in the implementation of PES programs arise from the slow process of building trust between an ES seller (provider) and an ES buyer (user) (Asquith et al., 2008). In the Mexican context, the trust issue is typically allocated to the governmental (external) administration and the formal (internal) representation of the common property regime. In the case of the studied communities, the external institution responsible for the administration of PSAH is CONAFOR, while CONAGUA is in charge of all further issues related to water. The trust variables CONAGUA2, CONAFOR2 and COMISAR2 relate positively to higher index scores (see Table 6.17). Given the results from the social capital index assessment (see Figure 6.6) it can be concluded that having faith in the institutions controlling the payment and natural resource management increases the likelihood that interviewees recognize the program, which confirms the formulated hypothesis (see Table 6.5). However, interviewees confused the institution making the PES payment and were not able to provide specific details on it (Caro Borrero, 2012). Given these circumstances, it can be argued that the presence of CONAFOR as the principal who executes and monitors the program, is rather low and felt as a distant and alien institution, which may actually indicate a reduction of conditionality. It is worse to point out that CONAFOR only earmarks eight percent of its total funds assigned to PES for managing, assessing and monitoring the forest program (see Section 3.3). In contrast, those not recognizing their PES participation may not trust institutional arrangements as both legal and illegal active land users, fearing that such programs are the first step to increasing general regulations of LUC and leading to expropriation (Robertson and Wunder, 2005). Plus, this may not be balanced by the risk that other environmental policies could become more restrictive in the future (Skerratt, 1998). In fact, Ramos (2008) has indicated that the institutional trust (internally and externally) of communities in that area is rather low. For example, community representatives feel that the government is interested in the MRW for all the benefits it produces, especially the provision of water to Mexico City's sectors with higher socio-economic levels (Community's President, pers. comm., 2010). This may hamper the introduction and implementation of any environmental program, and presumably affects the performance of the PES program. Equally, Corbera and Brown (2008) reveal that in Mexico the forest carbon market is hampered by a lack of organization in the government and civil society, as well as deficient interactions with the institutions of common property regimes. The degree of community members' perceived "corruption" regarding institutions handling payments from the program in a non-transparent manner or when not performing as expected, discourages active individual involvement, which, in turn, causes misinformation or a lack of information among community members.

The conflict variable CONFLIC1 relates negatively to higher index scores (see Table 6.17). Given the results of the social capital index assessment (see Figure 6.6), it can be concluded that perceiving internal conflicts related to land reduces the recognition of PES participation, which affirms the proposed hypothesis (see Table 6.5). Although collective action is feasible if a critical mass of people cooperates (Runge, 1986), naturally common property regimes raise issues of benefit-sharing structures among and within communities (Rojahn and Engel, 2005; cited in Engel et al., 2008). Accordingly, the fact that people declared the existence of internal conflicts regarding land use, and that those interviewees tend not to recognize their PES participation casts doubt on conditionality as they are likely to be active users of the commons experimenting personal hardship.

Marginalization index

Assessment of the marginalization index primarily serves to put studied communities in a broader regional context and determine if their level of marginalization has an impact on ES provisions. This assessment reveals that both recipient communities have medium to low levels of marginalization (see Table 6.19), which is consistent with the formulated hypothesis (see Table 6.6). The dimensions (education, health, housing and assets) included in the index assessment related as expected to recognized participation. The low to medium levels of urban marginalization in the two communities participating in PSAH shows that it does not target those households which may have a negative impact on ES provision, nor benefit significantly in terms of alleviation of poverty. Community members recognizing PES participation tend to have a medium education, better access to the health system, adequate housing and basic household accessories. Given that the peri-urban location as such indicates marginalization, it implies that the scoring system of CONAFOR itself adversely selected these communities or at least supported their selection. The outcome shows that from a perspective of marginalization most likely other groups exert pressure on the watershed through, for instance, illegal urbanization and/or inadequate housing in high risk areas with no connection to public services. This revealed discrepancy questions if the program in its current format is able to significantly improve conditionality in this context.

Access to education is one of the principal means enabling people to achieve their desired goals in life. Participation in the national education system is fundamental to acquire skills which enable favorable placement in the labor market, a more active role in the development of families and communities, and the adequate enforcement of human rights. Article 3 of the Mexican Constitution stipulates free access to basic education (preschool, primary and secondary) is a right of every Mexican (CONAPO, 2005a). However, persistent lags and dropout rates confirm social situations of exclusion. The intensity of urban marginalization, caused by a lack of participation and/or shorter times of enrollment in the education system is recorded for those people in the age of basic schooling who are not attending school, as well as youth and adults who did not complete secondary education (CONAPO, 2005a). Accordingly, the education variables CHILDEDU and SECONEDU relate positively to higher index scores (see Table 6.18). Given the results of the marginalization index assessment (see Table 6.19), it can be concluded that higher levels of education not only reduce urban marginalization but also increase the recognition of PES participation, which confirms the formulated hypothesis (see Table 6.6).

Health is an essential condition for the welfare of the population. Access to health services significantly increases the probability of overcoming diseases and illness and foster preventive care and self-care, giving people greater opportunities to enjoy a long and healthy life. Article 4 of the Mexican Constitution stipulates the right to health protection (CONAPO, 2005a). Yet in reality, a significant number of people do not have access to health care, in the form of medical services public or private health institutions. Premature mortality is the most extreme manifestation of how social exclusion impacts families and communities (CONAPO, 2005a). Hence, the health variables HCARE and DCHILD[8] relate positively to higher index scores (see Table 6.18). Given the results of the marginalization index assessment (see Table 6.19), it can be concluded that better medical care reduces urban marginalization and increases recognition of PES participation, which confirms the formulated hypothesis (see Table 6.6).

Article 4 of the Mexican Constitution stipulates the right to decent and proper housing, which favors the process of family integration in an environment of respect for individuals, without overcrowding, an educational setting suitable for the population attending school, reducing health risks, and facilitating access to information systems (CONAPO, 2005a). It is assumed that the population living in dwellings with dirt floors, no piped in water, inadequate drainage, inadequate sanitary and insufficient space is exposed to greater impediments which inhibit the possibility of a long and healthy life, and represent serious obstacles to access, for example, education, employment and recreation (CONAPO, 2005a). The housing variables WATERAV2, DRAIN2, SAWATER2, FLOOR2 and OVERCROW[9] relate positively to higher index scores (see Table 6.18). Based on the results of the marginalization index assessment (see Table 6.19), it can be concluded that higher levels of housing conditions reduce urban marginalization while at the same time increase the recognition of PES participation, which confirms the formulated hypothesis (see Table 6.6).

Although information on the income level of the employed population was collected directly, it was cross-checked with a proxy variable to calculate urban marginalization. The suggested proxy variable of CONAPO (2005a) indirectly detects the inability of households to acquire basic durable consumer goods such as electronic refrigerators. This has a negative impact in terms of development opportunities since the lack of a refrigerator has serious implications for the hygiene, health and economy of a household, seeing as how it significantly reduces the ability to keep food safe for long periods of time, thereby increasing the risk of gastrointestinal disease, and preventing a more efficient management of household expenditure for food pur-

[8]Questions related to infant mortality at birth were not included so as not to offend interviewees and acknowledge the limited scope of this research study.

[9]According to the United Nations Program for Human Settlements (UN-HABITAT, 2003), habitational overcrowding refers to three or more occupants residing in a single room.

chases (CONAPO, 2005a). The asset variable ACCREFRI relates positively to higher index scores (see Table 6.18). Given the results of the marginalization index assessment (see Table 6.19), it can be concluded that access to an import household accessory such as a refrigerator does not only reduce urban marginalization but also increases the recognition of PES participation, which confirms the formulated hypothesis (see Table 6.6).

7. Delphi analysis for PES-REDD design

The concept of REDD is a relatively new approach developed to mitigate GCC. The idea is that a REDD mechanism finances related activities to avoid the release of GHG emissions caused by LUC. The main components of a generic REDD mechanism are still under discussion (e.g., Keller, 2008; Parker et al., 2009) as well as its implementation procedures. Currently, the international community has focused more on "REDD Readiness" of potential REDD host-countries, such as those supported by the World Bank's FCPF and the UN-REDD Program. There is much work to be done regarding strategies to make REDD operational on local levels where activities are effectively implemented. Among possibilities under discussion is a PES approach to create incentives for forest owners to maintain or improve the forest carbon stocks, over which they exert control (Ogonowski et al., 2009). Consequently, REDD can still be considered in its "wild west" stage of development and implementation, and is still in need of much analysis of the diverse contexts in which it may be applied.

Mexico represents a particularly interesting case, since in this country forest ownership is mainly characterized by common property. Furthermore, Mexico has a vested interest in REDD (SEMARNAT, 2009) and currently preparing a REDD readiness plan (CONAFOR, 2010b), which makes this study particularly relevant. It is legal land-use rights of communities which adds considerable complexity to the case. As a community inscribed in a hypothetical PES-REDD program participates collectively with all their members, several issues come up which impact the probability of adverse selection and moral hazard on an individual level. This is an interesting issue that touches on several aspects of permanence, some of which are common to any REDD approach and others rather country-specific. Hence, analyzing the implications of permanence for a Mexican REDD carbon regime is of great concern from a policy-maker's perspective. The opinion of national and international experts offer valuable initial insights for the design of a PES-REDD program and contract attributes to help guarantee the permanence of forest carbon stocks.

The remainder of this chapter is structured into four sections. The first, narrates the background in greater detail highlighting the research objective, question and hypothesis, and elaborating on the material and methods used to obtain experts' answers to critical design questions which address permanence in a PES-REDD scheme. The second section goes into detail about the participants of the study, the Delphi process and the measures used for the analysis. The third section presents the results of the inquiry, drawing attention to the evolution of experts' participation and obtained forescasts for a set of submitted questions. This section conlcudes with a discussion including implications.

7.1. Background

This chapter reviews the compatibility of PES and REDD on the policy level, and more specifically the importance of contract attributes which guarantee the permanence of forest carbon stocks. In this case, REDD is understood to be an ES embedded within an international mechanism allocating financial and technical resources that mitigate GCC (see Section 2.3). Since it is likely that REDD benefits, in terms of forest carbon stocks maintained or enhanced, are created on a local level, it seems logical to explore PES as an economic policy instrument for assuring these benefits through direct incentives on the same level (Ogonowski et al., 2009). Hence, PES is considered an environmental contract and instrument used to channel compensations, most likely financial in nature, to ES providers who create a positive externality (see Section 2.2). The use of PES-REDD contracts may be a viable option to align a global mechanism with detailed domestic policies for assisting recipient countries in their implementation of REDD policies that aim to achieve national REDD goals, for example, within the framework of an international post-2012 Kyoto agreement.

The Mexican government has continuously fostered efforts to promote REDD politically in the attempt to establish a national REDD program in the future (see Section 3.4). Two developments are of particular interest to understand the current stage of REDD readiness preparation and related gaps in applying the concept. First, governmental institutions with civil society involvement are elaborating a national REDD strategy, and second, five pilot sites have been identified to test approaches and obtain immediate feedback for course corrections. Theoretic work currently focuses on five strategic lines of action, including: (i) institutional arrangements and public policies; (ii) reference level and MRV systems; (iii) financial schemes; (iv) capacity building; and (v) communication and participation strategies. Although these are important pillars, little thought has been given so far to the issue of permanence, which is key for the long-term success of GCC mitigation.

The main problem is that the value of carbon benefits from LULUCF activities has been questioned due to the issue of impermanence and policy-makers are uncertain how to deal with this. As LULUCF activities rarely exhibit characteristics where ES sellers can assure ex ante to the ES buyer a 100 percent permanence for an indefinite period of time, additional arguments, especially for policy-makers, are necessary to justify their role in GCC policy regimes. The "temporary" issue of forest carbon stock becomes fundamental for any PES-REDD scheme and two sets of arguments exist that may justify their market integration despite this concern. The first line of reasoning is challenging the definiton of permanence as applied currently in GCC mitigation discussions. In the compliance market, it is accepted that the substitution of fossil fuels by renewable energies is permanent. However, authors like Herzog et al. (2003) argue that this is a flawed assumption as it neglects the problem of intergenerational commitment. The counter argument is that price-paths may change so that "a shirking generation could go back to use fossil fuels without restraint, as long as they remain in the ground". This implies that "conventional" ER would not effectively be better than ER through LULUCF activities. Hence, real permanence is only warranted from today's perspective when: (i) alternatives are invented to substitute fossil fuels that are much more desirable so that future generations have no reason to go back to using these sources again; (ii) all fossil fuels are excavated and burnt, and carbon is permanently sequestered in a form which would never be released into the atmosphere; or (iii) administrating resources in a responsible manner and trust coming generations to do the same.

The second set of arguments in favor of forest carbon credits is that there is a value in delaying emissions regardless of the long-term fate of sequestered carbon or avoided emission (Marland et al., 2001). Common justifications found in the literature regarding the positive value of temporary storage are, but not limited to, six main considerations. The first argument is that of "buying time" for learning and technological advancement and deployment (Marland et al., 2001; Aukland and Moura-Costa, 2002; Marshall and Kelly, 2010). The assumption is that a backstop technology will be invented in the future actually making the permanence discussion obsolete. The second point is the "time-path" argument, where slowing the rise of temperature (Aukland and Moura-Costa, 2002; Marshall and Kelly, 2010), or altering the path of emissions (Marshall and Kelly, 2010) by temporarily withholding carbon avoids peaks in GCC. Then aggregate emission damages will decrease and represent a value to the global society (Marshall and Kelly, 2010). The third reason refers to the "conversion" of temporary to permanent stored carbon over time (Marshall and Kelly, 2010). This argument envisions that it is possible that LULUCF activities considered impermanent today may reveal permanent characteristics over time. A fourth consideration is advocating that temporary storage may act as an "insurance" (Aukland and Moura-Costa, 2002). Looking at mitigation activities that way makes it possible to introduce limited periods of contractual arrangements. And last, treating permanence of forest carbon stocks more flexibly warrants the "sovereignity" of participants (Aukland and Moura-Costa, 2002). The idea is that host-countries and ES sellers alike will not be limited in terms of future land use and are able to respond to future developmental paths so that they will be more willing to cooperate in GCC negotiations.

If one or both lines of argumentation are accepted at the political level, several challenges of permanence have still important policy implications when contracting individuals or communities. Certain components and decision options have already been pointed out in the literature (see Section 2.4). Among the issues REDD initiatives must address are three principal components: (i) time frames and carbon accounting schemes; (ii) treatment of carbon stock reversals; and (iii) payment structures. From a policy-maker's perspective it is necessary to analyze these options and evaluate which may work best in the country-specific circumstances.

7.1.1. Objective of this chapter

In economic theory, markets coordinate supply and demand side for the exchange of well-defined goods or services in a way that prices and quantities reach an equilibrium where the joint surplus is maximized. This equilibrium is generally cosindered optimal on both sides. Nonetheless, as already pointed out, several ESs and particularly those labelled public goods do not generally enter into consideration for production and utility (consumption) functions. Hence, the provision of several ESs decrease if depleted or degraded directly or indirectly by the prevailing market structure. Therefore, environmental policy-makers are interested in applying the idea of markets in order to optimize the provision of certain environmental goods and services that are at risk such as forest carbon stocks. since such environmental markets have not yet evolved and related contracts are probably too complex to draft, their future arrangement is unclear. Considerable planning effort must be made ex ante. Policy-makers and interest groups who want such markets to emerge are typically involved in the initial design stage. These stakeholders contribute different perspectives and experiences to several components for a future market set-up. In the case of a PES-REDD scheme, designers, for example, would review various contract attributes related to permanence. Policy decisions regarding these attributes are likely to reveal an inherent tradeoff between contractual strictness (ex ante) and flexibility (ex post) in the design of PES-REDD contracts offered to local ES providers. This chapter provides an overview of these attributes and highlights experts' opinions which allow for forecasting future contract drafting.

The specific research objective, question and hypothesis are presented below. A Delphi analysis reviews stakeholders' perspectives regarding PES-REDD contract attributes relevant for guaranteeing the permanence of forest carbon stocks. Given that this review is limited to the perspective of policy-makers, the results are further used as input for the experimental design employed in Chapter 8 where actual ES providers (sellers) are asked to state their preference regarding several alternatives for land use, including a PES-REDD option which reflects the outcome of this analysis.

Objective The research objective is to predict those attributes of the PES-REDD contract design which guarantee the permanence of positive externalities derived from forest carbon stocks in Mexico. A survey of a panel of experts helped construct a PES-REDD contract profile based on the Delphi Method.

Question The specific research question is: What are the tradeoffs between environmental integrity (accounting for permanence) and contractual flexibility to enforce such contracts (liability for reversals) in order to guarantee the permanence of forest carbon stocks through PES-REDD contracts?

Hypothesis The research hypothesis is that the resulting PES-REDD contract profile reflects the policy designers' desire to secure the permanence of the ES. The effectiveness of a PES-REDD contract will depend on the ability to avoid ES sellers' (providers') adverse selection ex ante and moral hazard ex post among other factors. It is assumed that adverse selection can be avoided with an adequate definition of additionality, stipulation of eligibility criteria for ES sellers (providers), and employment of justified time frames. As for moral hazard, it is assumed that this can be avoided by adequately accounting for environmental benefits, adjusting the payment structure for the ES and enforcing contracts by adaquate sanctions, among others.

7.1.2. Method selection

The Delphi Method has been used by various authors in order to elicit expert opinions regarding the valorization of environmental issues (e.g., Curtis, 2004; Herrerías Aristi et al., 2007). The intention of Delphi is to deepen the knowledge of a complex problem (Needmam et al., 1990; cited in Landeta Rodríguez, 1999). In this case, the problem is permanence. In this research study, the Delphi Method is employed to obtain opinions and predictions of experts for the design of a PES-REDD contract. It is assumed that the theorem: the error of the group will be less than the average error of the individuals (Dalkey, 1975). Delphi is useful given its "policy-design" perspective. A Policy Delphi is generally used to explore complex socio-political issues (Rauch, 1979; cited in Landeta Rodríguez, 1999), in this case the adequate design of a PES-REDD contract. This approach helps to overcome planning and decision-making problems in order to obtain, refine, and communicate the informed judgments of knowledgeable people (Ludlow, 1975), although it is not expected to provide clear-cut resolutions of the issues at hand (Turoff, 1975). The two main inconveniences of a Policy Delphi are the recruitment of a group that truly represents all interests of an issue, and secondly adjustment to the limited amount of time available for a complete and free exchange of opinions (Turoff, 1975). Thus, a Policy Delphi, although not able to replace collective *vis-á-vis* decision-making (Turoff, 1975), provides an effective exchange of knowledge (Ludlow, 1975) useful for analyzing decision options.

The use of a Policy Delphi for this study is justified because the criteria for permanence in a Mexican REDD regime are lacking structure and distinct perspectives still remain. Hence, the validity of any decision made in this regard is justified because of the intensity of the conflict ex ante (Rauch, 1979; cited in Landeta Rodríguez, 1999). However, consensus is, although desirable, consensus is not required even if it is likely to occur among subgroups. A web-based survey design with a structured questionnaire was applied to investigate contract timescales, structures, incentives and sanctions underlying an envisioned PES-REDD contract. This survey was carried out with individuals involved in the design, analysis and application of such policies. Based on the theoretical foundation presented in Section 5.2, a web-based Delphi tool was programmed as a support instrument for the Delphi inquiry where administrators and experts interacted: `www.eqdelphi.com`. The results obtained facilitated a better understanding of how "policy-makers" manage adverse selection and moral hazard, and how a PES-REDD contract is likely to look like from a policy-makers' perspective.

7.2. The Delphi process

The Delphi is applied in a process of repeated interaction between the survey administrators and a panel of experts in order to obtain a judgement on a future Mexican REDD regime dealing with permanence. The evolution of the opinions throughout the Delphi process was tracked by the customized web-based Delphi tool. This section recapitulates the recruitment of participants, stages of the process, forms of inquiry employed for the collection of data and the use of the different statistical measures for the calculation of central tendencies and dispersion of opinions.

7.2.1. Participants of the Delphi

Participants in a Delphi process are generally divided into administrators and group of experts. The Delphi administration has the important task of designing, coordinating and analyzing the complete inquiry cycle. The administration is made up of two researchers[1], both with an academic background in environmental science and environmental economics. Thus, following the recommendation of Turoff (1975) and Landeta Rodríguez (1999), this survey has included at least two individuals managing the process.

Potential experts are deemed as such since they are engaged in the two main research issues: PES and/or REDD. Involvement is broadly defined and includes related activities on various levels. This study regarded interest and motivation to work on this research topic more important than the actual quality and/or quantity of written material when evaluating the participants' expertise. However, Sackman (1975) highlights the pitfalls inherent in the voluntary participation of panelists pointing out that it may reflect strong motivation and interest or high proportion of personal acquaintances.

Most experts were personally contacted before a formal invitation to participate on the panel was given. The recruitment process began with the identification of potential participants who attended events[2] directly related to REDD and PES, were involved in PES-like contract schemes, and/or were cited in the literature. These individuals participated in related events, confirming their interest, expertise and involvement in the ongoing process of developing REDD as a GCC mitigation strategy. Most events were held in preparation for and forthcoming to

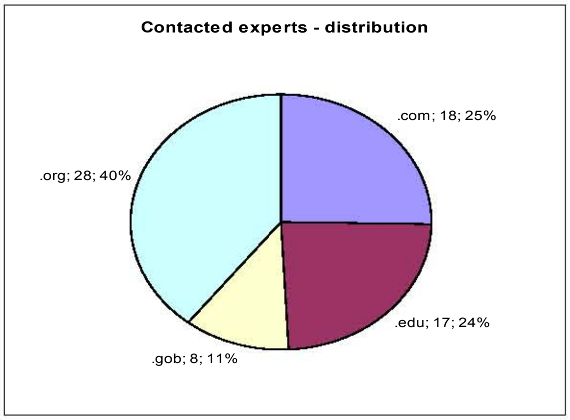
[1]Kurt Christoph Neitzel (PhD Student) from the Faculty of Economics and Dr. Alonso Aguilar (supervisor of this thesis) from the Institute of Economic Research; both at the UNAM.

[2]The term "event" is broadly defined and refers here to workshops, presentations, forums and working groups.

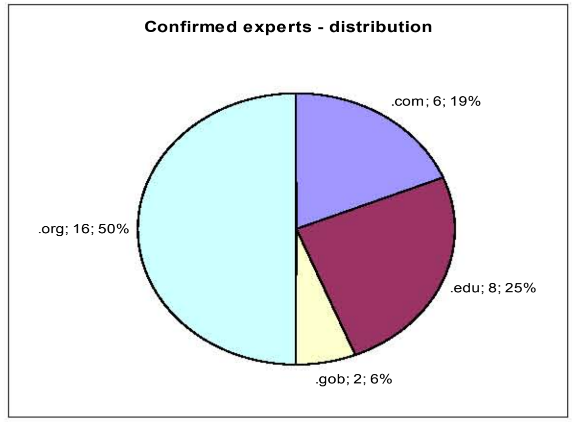
the COP 16 and 17. Another platform of direct interaction provided an already operational expert panel developing CAR's Forest Protocol for Mexico including A/R, IFM and REDD project activities. CAR launched a call for interested stakeholders in April 2010 to participate actively in the process of the protocol formulation in order to expand the geographical scope of eligible offset projects in North America. Interested parties were asked to submit their curriculum together with a letter of motivation. Then, a final expert panel was selected by CAR. Experts collaborated voluntarily, without financial compensation, which implies a high level of commitment.

From the initial list made up of 140 potential candidates, 71 experts were contacted and informed on the object of study, objective, process and expected individual benefit in participation. Potential candidates were informed individually by email. Individuals were asked to indicate their willingness to participate and their preferred mode of answering the questions: web-based, paper-pencil or *vis-à-vis*. A self-evaluation of expertise in the object of study was not requested. From the list of 71 candidates contacted, 34 responded to the request. Two potential experts reported that they were not available, one due to time constraints and the other because s/he did not feel confident enough to make an expert judgement on the subject matter. Thus, the recruitment process concluded with a final list of 32 individuals. Of the 32 experts included in the process, only 28 experts actively participated in the round of inquiries in the form of submitted answers. Four experts eventually dropped out with no explicit explanation. During the Delphi there was an average participation of 21 to 22 experts per round. This low level of participation is attributed mainly to time constraints of the panel members. Only one panelist declared after the first round that s/he was not willing to continue due to a misunderstanding of the study's objective and personal time constraints. In conclusion, the final selection of individuals participating differed only slightly from the 25 people recommended by Astigarraga (2004), making it unnecessary to replace any expert.

The characteristics of the confirmed panelists are included in aggregates to guarantee anonymity. Following the advice of Turoff (1975), a mixed group was recruited. Since the topic of study is a policy issue, the perspective of different stakeholders "typically" involved in the policy-making process were obtained. Representatives from four broad categories were invited (see Figure 7.1): national and international private sector companies (.com), national and international academic and research institutions (.edu), Mexican governmental institutions (.gov), and national and international non-governmental organizations (.org). Although it may seem that .org is overrepresented, it is worth noting that this group is the most heterogenous. Within the group of confirmed participants there were eight women versus 24 men. The geographic distribution of experts reveals that 15 out of 32 were based in Mexico at the time of the inquiry.



(a)



(b)

Figure 7.1.: Contacted experts (a) Confirmed experts (b)

7.2.2. The process

The Delphi Method is a methodological approach used to provide guidance on government action. Since the object of study is related to decision-making on policy issues, the method is referred to as a Policy Delphi. In a three-round inquiry process, a group of experts (people familiar with the topic and likely to have an influence on decision-making) were separately polled to obtain their judgment on PES contract design for REDD. The pattern of sequential communication for this study was predetermined by the available technology (Brockhoff, 1975). It was projected that each of the three rounds would last at least one week. The process began with an invitation to the first round on January 26^{th} and was closed after the last round on March 15^{th}, 2012, which sum up to 64 days of inquiry. The length of the time span was adjusted to the experts request for more time to finish the rounds.

In the first stage of the process, each member of the expert group was invited to participate in the first round answering questions submitted via a web-page link. As recommended by Sackman (1975), the group of experts was presented a generic scenario as a point of departure for their consideration. The expert panel was given a reasonable amount of time (approximately one week) to select their answers and add comments found necessary. Afterwards, the answer choices were returned automatically to the Delphi administrator through the web-based inquiry form. The administrator analyzed the responses and calculated descriptive statistics from the preliminary results of the first round.

In the second stage, the results were presented to the group in a summary statistics format and complemented with additional information submitted by the panelists, with notes of clarfication from the Delphi administration. Individual answers were treated anonymously, but the experts had the chance to review their own previous responses online. Then, they were asked to repeat their choices and comment on the outcome of the round before if they considered it necessary. The Delphi administration did not change or incorporate additional questions during the process. Again the panelists were allotted a reasonable amount of time to answer the questionnaire and submit their answers. The administrator analyzed the responses and calculated descriptive statistics on the preliminary results of the second round.

In the last stage, the results of the previous round were presented to the panel who were asked to repeat the process of the second round. The purpose of the repeated interaction was to reduce the variability in the responses and make the prevision more "certain". The aim of this Policy Delphi was not necessarily to achieve a consensus among the group members but to exchange information (subjective and objective), identify subgroup positions and obtain stability in response choices where possible. Descriptive statistics helped the administrator define and identify to what degree the objective of the study had been attained with a predetermined three round inquiry. The process was terminated with the elaboration of the final report which was sent to the panelists as a reward and in recognition of their collaboration.

7.2.3. Delphi form of inquiry

The Policy Delphi applied to the selected expert panel offered three options for submitting the questions: web-based, paper-pencil and *vis-à-vis*. The different forms did not modify the content of the questions, but were used in order to adapt to the heterogeneity of the expert panel and facilitate (capacity and comfort) the response process. In the end, all experts made use of the web-based tool, except for one expert who had technical problems and chose the "paper-pencil" option, which was received and returned via email. The answers were later integrated into the central web-based database.

The web-based approach relied on the construction of a webpage using a SQL[3] format to design the page. The advantage of an instrument of this sort is threefold. First, the group of experts can answer the questionnaire any time and at any place, as long as they have access to the internet. Second, the possibility of giving the page a sophisticated but intuitive appearance brought credibility to and provoked interest in the inquiry method itself. And third, the application of SQL allowed for the rapid summary of statistics and handling of the database.

The questions formulated for the questionnaire relied heavily on an intensive revision of the literature, researchers' participation in issue-related forums and a discussion process with the tutoring committee of this thesis. Furthermore, as recommended by Turoff (1975), the questionnaire and inquiry tool had been pre-tested on coworkers in a PhD-seminar in the Faculty of Economics at the UNAM and the Tutorial Committee of the PhD-candidate. The question-

[3]SQL is an abbreviation for Structured Query Language - a database computer language designed for managing data in Relational Database Management Systems (RDBMS) based upon relational algebra. Its scope includes data insertion, query, update and delete, schema creation and modification, and data access control. It is the most widely used language for relational databases.

naire (see Appendix G) is made up of 13 questions which relate to measures of confronting adverse selection and moral hazard in hypothetical PES-REDD contract designs in order to guarantee permanence of forest carbon stock. More specifically, the questions are related to the following topics and were submitted in the listed order: LULUCF relevant definitions, adverse selection, time frames of permanence, carbon accounting methodology, reversals, moral hazard, payment structure and administration. The content, therefore, builds mainly on the problems discussed in the "PES" Section 2.2, "REDD" Section 2.3 and "permanence" Section 2.4.

The questionnaire incorporates three types of questions: rank options, scales and open-ended questions. The first question type (rank options) belongs to the group of hierarchized questions. Rank-order questions are used to obtain a preference order from a list of predefined options. The number of options was customized by the administrator. Each option for ranking had a "name" field with a description where the expert is asked to indicate a rank order of the options. The order started with "1" as the most important and ended with "n", the least important. The second type of questions were "scale" questions, belonging to the class of valorization questions. For this type the administrator provided a scale for the answer options. The scale was defined by two endpoints with corresponding labels. Scale-type questions require the expert to answer by indicating the level of agreement with a statement. The Likert-scale, as a common grading system, was used with a 1 to 5 scale, where "1" was labelled "absolutely disagree" and "5" was labelled "absolutely agree". Finally, a numerical quantitative estimate was requested for "open-ended" questions. For that purpose, the administrator indicated the unit of the estimate, and requested the provision of a confidence boundary relative to the estimate. So, this question type required the expert to answer with a number.

Some questions included the option "No opinion" if the expert was unable to make a judgment. This feature was optional and only appeared for certain questions. If displayed, the expert had the option of selecting it when unable to make a judgement on the question. Some experts felt uncomfortable with having to answer every question, coinciding with observations made in other studies (e.g., Ludlow, 1975). In order to avoid this problem, a comment field was provided below each question so that the experts were able to give any type of opinion or criticism. The main idea of the comment field was to offer experts a space to explain their answer choice. Generally, experts were encouraged to provide answers backed by comments specifically if former answer choices represented a significantly different opinion from the rest of the group, for instance, different from the median value of the group.

7.2.4. Statistical measures

This survey calculated summary statistics for each round for two main purposes: first, to provide the expert panel with feedback for their consideration in the subsequent rounds, and second, to guide the Delphi administration through the process and indicate the progress of consolidating opinions within the group (or subgroups) of experts. Different statistical measures were of particular importance for each purpose. It is worth noting that the sample size is too small for statistical validity in a strict sense. The fact that the Delphi method uses very small sample attitudes towards future events at a given time implies that it does not measure these events themselves and remains a second-best "act of faith" (Sackman, 1975). Thus, these measures should be considered within these limitations.

Central tendency The web-based program calculated the central tendency of each answer set form the expert panel. The central tendency was intended to inform the expert of the "average" opinion of the group from the previous round. The main statistic used to describe the central tendency was the median. In probability theory and in statistics, the median is described as the numeric value which separates the higher half of a sample, a population, or a probability distribution from the lower half. The median of a finite list of numbers can be found by arranging all the observations from the lowest to highest value and determining which is in the middle. If there is an even number of observations, then there is no single middle value and the median is usually defined as the mean of the two middle values. Sometimes the median is also referred to as the second quartile (Q_2) or middle quartile that cuts off at the 50 percent point of data or at the 50^{th} percentile. Generally, the median gives a better estimate of the central opinion of a small group since it is not susceptible to the bias of outliers who may influence the mean value, which makes it the preferred measure for the analysis and interpretation of these results.

Dispersion The web-based program also calculated measures of opinion dispersion for each answer set. These were only visible to the administration. The dispersion measures were used in order to inform the administration of the level of "agreement" among the experts in the previous round and between two rounds. Two statistics for the characterization of the dispersion were used: Relative Interquartile Range (RIR) and Variation of the Relative Interquartile Range (RIR-V).

The RIR is used in the Delphi to measure consensus among experts in their answer choices within a specific round. The difference between the upper and lower quartile divided by the median gives an estimate of the consensus (see Equation 5.1 in Section 5.2). The determination of consensus is subjective and depends on the judgment of the administrator. Some studies employ a predetermined value to declare a consensus. However, it is generally expected that a smaller value indicates greater consensus and that the value decreases over time in terms of concluded rounds.

The RIR-V is used in the Delphi as a measure to determine stability reached in the group answer. For that purpose, the difference between the RIR of two subsequent rounds is calculated (see Equation 5.2 in Section 5.2). It is worth noting that stability does not necessarily imply consensus. It indicates if the group as a whole has consolidated its individual opinion on an answer choice to a specific question. It is possible that although the RIR-V reflects a low value, indicating stability, the indicator for consensus shows a high value, indicating that different subgroups and consolidated sub-opinions exist within the expert panel. The indicator is calculated after the second round has been completed and accordingly for subsequent rounds.

7.3. Delphi results

The results of the structured questionnaire in a Delphi format with 13 questions provide the perspective of a group of experts regarding key issues of permanence in a hypothetical REDD regime. This input inspired the construction of a PES-REDD contract profile for the choice experiment elaborated in the following chapter (Chapter 8). The processing of obtained answers builds on the Delphi method presented in Section 5.2. Method-proper statistical procedures are applied using a customized web-page developed expressly for that purpose and EXCEL as the main processing software. This section of the Policy Delphi presentes the results obtained and highlights four outcomes: (i) the evolution of experts' participation; (ii) the evolution of experts' opinions; (iii) the representation of group results; and (iv) the identification of subgroups within the sample.

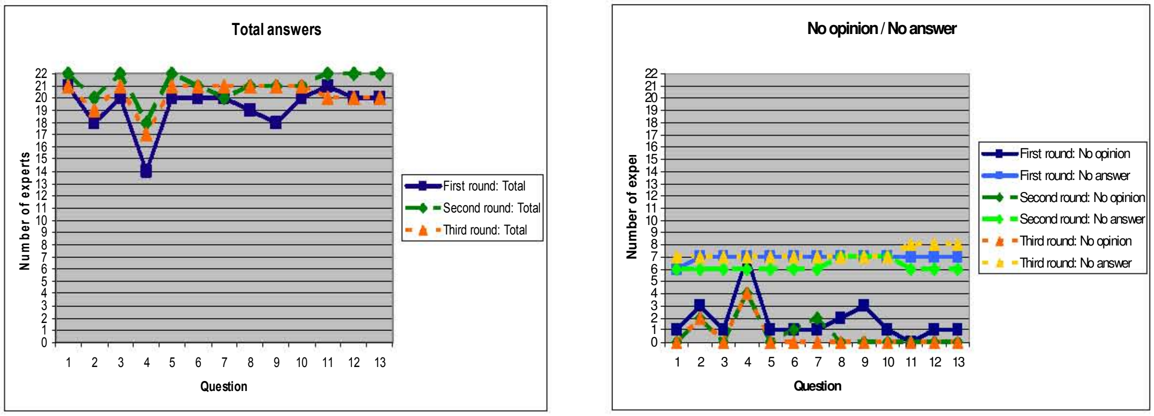
7.3.1. Evolution of participation

Participation in the Delphi process was relatively high with an average of 21 (22) out of 28 experts for the three rounds (see Figure 7.2(a)). Respectively, there were seven (eight) experts within the three rounds who did not answer a given round and there were relatively few experts who were unable to make a judgement (see Figure 7.2(b)).

7.3.2. Delphi group and subgroup results

The final results of the Policy Delphi obtained after the third (last) round are presented in this section. For each question, a table highlights the answer option selected by the majority indicating the central tendency, level of consensus and stability of the group and subgroups[4]. In an additional figure, only the median positions of the group and subgroups are shown. Their form of representation differs only slightly depending on the type of question. For rank-type questions, the medians for all answer options are displayed but only for the third round, while for scale and open-ended questions, the medians of all three rounds are provided.

[4] Only one expert was available from the subgroup representing governmental institutions. Therefore, measures of consensus and stability always appear as zero.



(a) (b)

Figure 7.2.: Participation of experts: (a) Total answers (b) No answer or no opinion

Question 1: What aspects should RED(D)(+)(+) cover explicitly? The objective of the first question was to elaborate on adequate definiton of attributes which form part of the REDD concept. The group of experts was asked to rank the following option alternatives from 1 (the highest preference) to 9 (the lowest preference): O1) Afforestation; O2) Reforestation; O3) Deforestation; O4) Degradation; O5) Enhancement; O6) Sustainable management; O7) Conservation; O8) Social safeguards; and O9) Environmental safeguards. The terms enhancement, sustainable management and conservation refer to the terminology used by the UNFCCC and included in the Cancun Agreement 2010, which suggests their linkage to forest carbon stocks. After the third round, the answers revealed that Option 3 (O3) is considered to play the most important role in the subject matter, even though consensus was not reached in the subgroups of academics and NGOs (see Table 7.1). The other options were ranked after and demonstrated more dispersion among the four subgroups especially for options 7 and 9 (see Figure 7.3).

Result	**Median**	**Consensus**	**Stability**
Option 3	$[\tilde{x}]$	[RIR]	[RIR-V]
Total	1.00	0.00	-1.00
.com	1.00	0.00	0.00
.edu	1.00	1.50	0.50
.gov	1.00	0.00	0.00
.org	1.00	1.50	0.00

Table 7.1.: Delphi Question 1

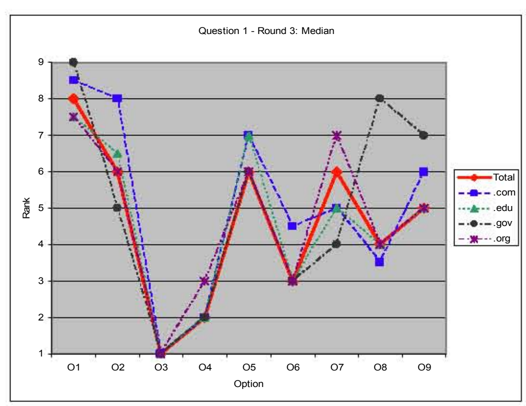


Figure 7.3.: Delphi Question 1

Question 2: What right or access should the seller (provider) have over the Environmental Service (ES) REDD to be considered additional? The second question aims to elaborate on adequate eligibility criteria in order to avoid non-additionality and adverse selection respectively. The group was asked to order six alternative options from 1 (the highest preference) to 6 (the lowest preference): O1) The seller needs some property right over the land likely to provide the ES of forest carbon stocks; O2) The seller has to change and/or improve her/his land-use behavior to provide verifiable carbon sequestration and/or emission avoidance greater than the agreed baseline; O3) The seller has to be the one that can effectively control the land-use patterns within the agreed boundaries; O4) The seller needs to have the right to sell the ES of stored carbon, which implies that the national legislation acknowledges that the ES is provided through forests and regulates the ownership of that service; O5) The seller does not receive any other financial support for the provision of the ES; and O6) The land likely to provide the ES of forest carbon stocks is not otherwise protected (e.g., a National Park). The revealed preferences after the third round show that Option 2 (O2) is favored by the majority, although the consensus in the group and subgroups was relatively low (see Table 7.2). The other options were ranked behind and demonstrated more (although relatively small) dispersion among the four subgroups (see Figure 7.4).

Result	Median	Consensus	Stability
Option 2	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.00	1.50	0.50
.com	1.00	0.75	-0.25
.edu	1.50	1.67	0.67
.gov	2.00	0.00	0.00
.org	1.00	1.25	0.25

Table 7.2.: Delphi Question 2

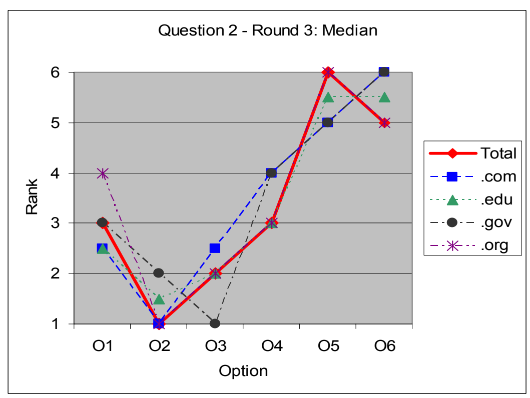


Figure 7.4.: Delphi Question 2

Question 3: What is an adequate time frame in a REDD regime to consider carbon storage in and/or emission avoidance from the biosphere as permanent? This question elaborates on the adequate time frame for permanence. The problem is that time frames which do not allow REDD credits to be considered permanent in a compliance market will probably fail. Therefore, the question asks whether experts can imagine a finite time frame in order to calculate carbon benefits and justify permanence. The measure of central tendency for the third round indicates that the time frame for such an environmental contract should consider 40 years, although the subgroups of NGOs and private sector differed on that answer (see

Table 7.3). The private sector, in particular, was in favor of shorter time frames. In general, the dispersion among the four subgroups is considerable but declined during the process (see Figure 7.5).

Result	**Median**	**Consensus**	**Stability**
40 years	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	40.0	0.50	-0.19
.com	25.0	0.60	-0.40
.edu	40.0	0.38	-0.29
.gov	50.0	0.00	0.00
.org	37.5	1.13	-0.02

Table 7.3.: Delphi Question 3

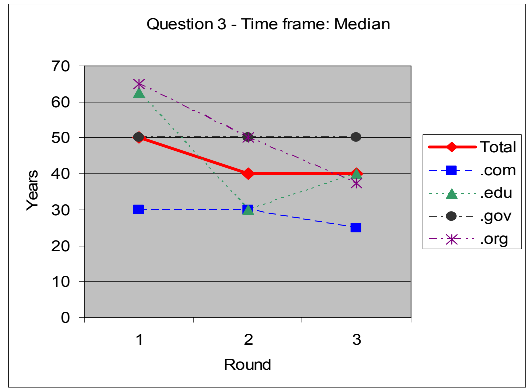


Figure 7.5.: Delphi Question 3

Question 4: Which carbon accounting methods should be used to calculate carbon benefits and/or losses? This question intends to explore the adequate carbon accounting methodolgy for the calculation of permanence. The panel of experts was asked to rank presented alternatives from 1 (the highest preference) to 4 (the lowest preference): O1) Stock-change method; O2) Long-term average; O3) Ton-year accounting; and O4) Linear accounting. After the third round, results revealed that Option 1 (O1) was the most preferred, although there was considerable disagreement among the subgroup of academics (see Table 7.4). The other options were subordinated and demonstrated some minor dispersion among the four subgroups (see Figure 7.6).

Result	**Median**	**Consensus**	**Stability**
Option 1	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.00	0.00	-0.75
.com	1.00	0.50	0.50
.edu	1.00	1.00	0.17
.gov	1.00	0.00	0.00
.org	1.00	0.00	-0.50

Table 7.4.: Delphi Question 4

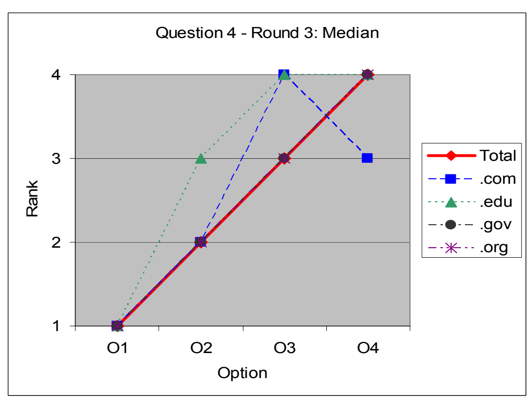


Figure 7.6.: Delphi Question 4

Question 5: Should there be a distinction between unavoidable/unintentional and avoidable/intentional reversals? This question has significant implications for the likelihood of program adoption in terms of equity and environmental integrity for both: ES sellers and ES buyers. From an ex ante perspective, this may have consquences for adverse selection, and from an ex post point of view it affects the consideration of moral hazard. In this question, the experts were asked to indicate on a Likert-scale from 1 (absolutely disagree) to 5 (absolutely agree) if reversal of forest carbon stock should be treated differently depending on the cause of change in credited forest carbon stocks. The expert answers revealed after the third round an absolute agreement for a distinction between the types of reversals and only the subgroup of academics showed some disagreement (see Table 7.5). The dispersion among the four subgroups declined considerable in the last round (see Figure 7.7), which was also reflected in the negative values of the RIR-V.

Result	Median	Consensus	Stability
5	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	5.00	0.20	-0.49
.com	5.00	0.05	-0.95
.edu	4.00	0.75	-0.25
.gov	5.00	0.00	0.00
.org	5.00	0.20	-0.10

Table 7.5.: Delphi Question 5

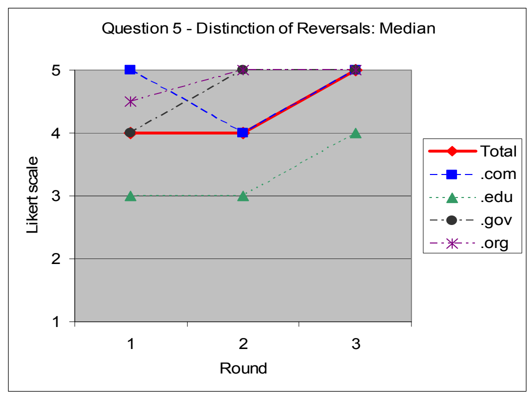


Figure 7.7.: Delphi Question 5

Question 6: Who should have the liability for avoidable reversals? The subject of this question is avoidable reversals of forest carbon stocks during PES contract duration. The group of experts was asked to assign a responsible party for avoidable carbon stock reversals and indicate an order for the submitted alternatives from 1 (the highest preference) to 5 (the lowest preference): O1) Seller (i.e., Ejido, Agrarian Community, Small property); O2) Buyer (i.e., Private Sector); O3) Administrator (i.e., Government); O4) Third party (i.e., Insurer); and O5) Collective (i.e., Aggregator). After the third round, the answers revealed that Option 1 (O1) was the preferred choice with only some, but stable, disunity in the subgroup of NGOs (see Table 7.6). The other options were ranked lower and demonstrated some minor dispersion for Options 3 to 5 among the four subgroups (see Figure 7.8).

Question 7: Who should have the liability for unavoidable reversals? This question explores the determination of liability for unavoidable reversals of forest carbon stocks. The

Result	Median	Consensus	Stability
Option 1	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.00	0.00	0.00
.com	1.00	0.00	0.00
.edu	1.00	0.00	0.00
.gov	1.00	0.00	0.00
.org	1.00	0.75	0.00

Table 7.6.: Delphi Question 6

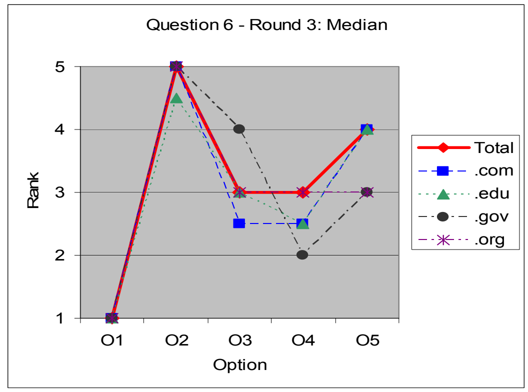


Figure 7.8.: Delphi Question 6

experts were asked to assign a responsible party and rank the options from 1 (the highest preference) to 5 (the lowest preference): O1) Seller (i.e., Ejido, Agrarian Community, Small Property); O2) Buyer (i.e., Private Sector); O3) Administrator (i.e., Government); O4) Third party (i.e., Insurer); and O5) Collective (i.e., Aggregator). After the third round, the responses revealed that Option 4 (O4) was the preferred choice, although considerable overall dissent and instability was detected (see Table 7.7). The other options were ranked lower and demonstrated minor dispersion among the four subgroups so that an absolute ranking of alternatives was possible (see Figure 7.9).

Result	Median	Consensus	Stability
Option 4	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.00	1.00	0.75
.com	1.50	0.67	0.67
.edu	1.50	1.17	0.17
.gov	1.00	0.00	0.00
.org	1.00	0.75	0.75

Table 7.7.: Delphi Question 7

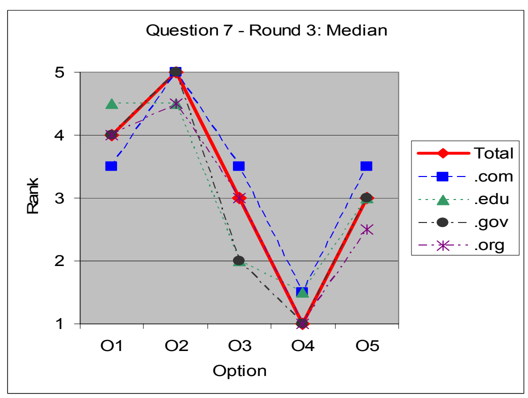


Figure 7.9.: Delphi Question 7

Question 8: What is the liability if an avoidable reversal occurs? The objective of this question was to determine the type of liability for avoidable reversals of forest carbon stock. The panel of experts was asked to indicate an order of preference for five options and rank them from 1 (the highest preference) to 5 (the lowest preference): O1) Retirement of an equivalent quantity of carbon credits from, for example, a buffer pool; O2) Specific performance (i.e., replanting); O3) Monetary penalty; O4) Exclusion from future payments;

and O5) Exclusion from future payments and repayment of benefits. After the third round, the answers revealed that Option 1 (O1) was the preferred choice but with great dissension especially in the subgroup of academic and less NGO experts combined with the extreme opposing position of the government representative (see Table 7.8). The other options were subordinated and showed a great dispersion among the four subgroups (see Figure 7.10).

Result	**Median**	**Consensus**	**Stability**
Option 1	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.00	1.00	-3.00
.com	1.00	0.00	0.00
.edu	1.00	2.25	-1.75
.gov	5.00	0.00	0.00
.org	1.00	0.75	-0.75

Table 7.8.: Delphi Question 8

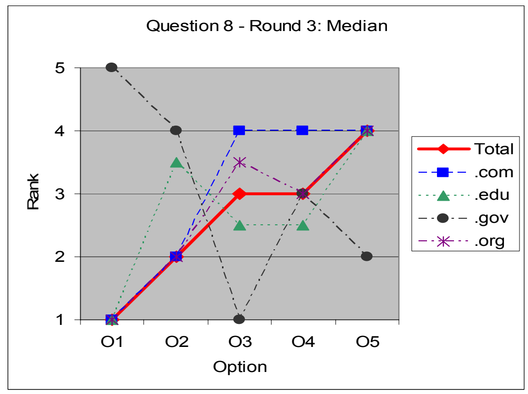


Figure 7.10.: Delphi Question 8

Question 9: What is the liability if an unavoidable reversal occurs? The experts were asked to elaborate on the type of liability for unavoidable reversals of forest carbon stocks. These options had to be ranked from 1 (the highest preference) to 5 (the lowest preference): O1) Retirement of an equivalent quantity of carbon credits from, for example, a buffer pool; O2) Specific performance (i.e., replanting); O3) Monetary penalty; O4) Exclusion from future payments; and O5) Exclusion from future payments and repayment of benefits. The answers after the third round showed that Option 1 (O1) was the preferred choice with considerable consensus except among experts from the subgroup of NGOs (see Table 7.9). The other options were ranked behind and demonstrated a slight dispersion among the four subgroups (see Figure 7.11).

Question 10: What is an adequate price for one ton of CO_2? The question 10 relates to the payment structure of the scheme and more specifically to adequate payment amounts to compensate and incentivize eligible ES sellers. The panel of experts was asked to indicate what they deemed an adequate price in USD per tCO_2 for forest carbon stock benefits created by REDD activities. By the conclusion of the third round, the price for one ton of CO_2 was forecasted at USD 20, although neither consensus nor stability was actually reached (see Table 7.10). The dispersion among the four subgroups remained constant over the three rounds (see Figure 7.12).

Result	Median	Consensus	Stability
Option 1	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.00	1.00	1.00
.com	1.00	0.00	0.00
.edu	1.00	0.00	-2.00
.gov	1.00	0.00	0.00
.org	1.50	0.67	0.67

Table 7.9.: Delphi Question 9

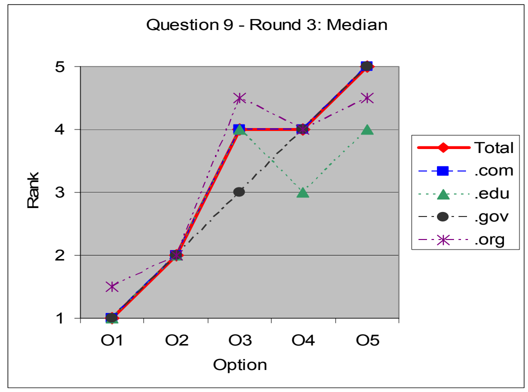


Figure 7.11.: Delphi Question 9

Result	Median	Consensus	Stability
USD 20	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	20.0	0.75	-0.25
.com	27.5	1.45	1.25
.edu	20.0	0.75	-0.79
.gov	20.0	0.00	0.00
.org	17.5	0.79	0.50

Table 7.10.: Delphi Question 10

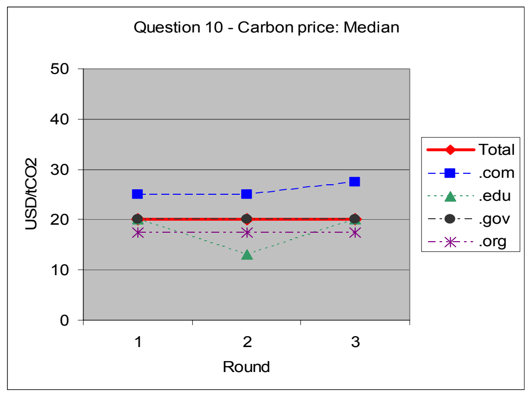


Figure 7.12.: Delphi Question 10

Question 11: How should the price level be determined? This question deals with the payment structure, specifically the method used to determine payment levels. The group of experts had to evaluate four options and rank these alternatives from 1 (the highest preference) to 4 (the lowest preference): O1) Opportunity cost oriented; O2) Market oriented; O3) Auction oriented; and O4) Otherwise fixed by public policy. The last round revealed that Option 2 (O2) was the preferred choice, although a consensus wasn't achieved by the process (see Table 7.11). The other options were subordinated and showed some dispersion among the four subgroups (see Figure 7.13).

Question 12: How should be the payment schedule? This question deals with the payment schedule, which is another dimension of the payment structure. It refers specifically to the reimbursement of REDD credits, i.e., at what point money should be transferred to the seller (provider). Experts were asked to rank the alternatives from 1 (the highest preference) to 5 (the lowest preference): O1) Upfront with contract celebration; O2) Front-loaded; O3) Annuity; O4) Tail-loaded; and O5) Ex post at the end of the contract period. After the third

Result	Median	Consensus	Stability
Option 2	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.00	2.00	1.00
.com	1.00	0.25	-0.75
.edu	2.00	1.38	0.38
.gov	1.00	0.00	0.00
.org	2.00	1.00	0.50

Table 7.11.: Delphi Question 11

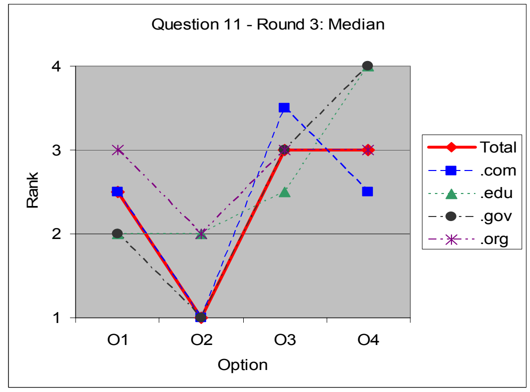


Figure 7.13.: Delphi Question 11

round, the answers revealed that Option 3 (O3) was the preferred choice, with some stable disagreement among experts in the academics and NGOs subgroups; NGOs ranked O3 even second place (see Table 7.12). Other options were ranked lower and showed relatively little dispersion among the four subgroups (see Figure 7.14).

Result	Median	Consensus	Stability
Option 3	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.00	1.25	0.25
.com	1.00	0.25	0.25
.edu	1.00	0.75	-0.25
.gov	1.00	0.00	0.00
.org	2.00	1.00	-0.50

Table 7.12.: Delphi Question 12

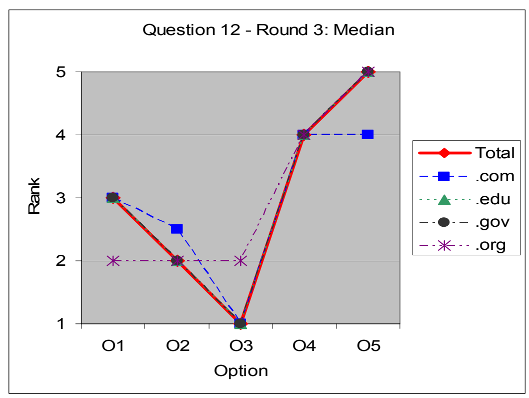


Figure 7.14.: Delphi Question 12

Question 13: Who should administer the REDD in the territory? The last question captures information on the preferred institution or organization administering the PES-REDD scheme. The term administer refers to the general task of coordinating and monitoring REDD efforts on a national scale. Hence, territory refers to the territory of Mexico. However, activities will probably depend on the involvement of common property regimes (ejidos and agrarian communities) which govern an estimated 70 to 80 percent of the Mexican forest resource. The experts were asked to provide, if possible, the name of their preferred institution/organization after ranking alternatives from 1 (the highest preference) to 4 (the lowest preference): O1) Government; O2) Private Sector; O3) Civil Society (NGO); and O4) Intergovernmental Organizations (IGO). The answers after the third round show Option 1 (O1) as the preferred choice, with some stable dissent among experts (see Table 7.13). The other options were ranked lower, but showed a great dispersion among the four subgroups in their assigned ranks (see Figure 7.15).

Result	Median	Consensus	Stability
Option 1	[$\tilde{x}$]	[RIR]	[RIR-V]
Total	1.50	1.33	0.00
.com	2.00	0.38	-0.63
.edu	1.50	1.17	0.50
.gov	1.00	0.00	0.00
.org	1.00	2.00	0.00

Table 7.13.: Delphi Question 13

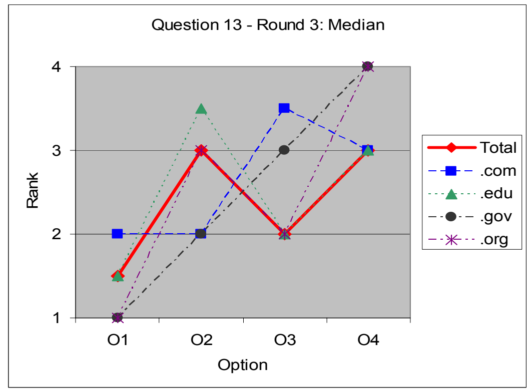


Figure 7.15.: Delphi Question 13

7.4. Discussion

An analysis of the Delphi results reflect an active and controversial discussion on attributes related to the permanence of forest carbon stocks. This section explains the experts' contributions and points out other significant positions that do not reflect the majority of the expert panel. An accurate interpretation of the study results is a difficult task due to the limitations of the study, the correct distinction between subjective and objective information, and errors in the transmission of information between the sender and receiver. Thus, the final interpretation of results is a negotiated and shared reality where a certain degree of oscillatory movement and change within the group of expert responses is inevitable (Scheibe et al., 1975). Analyzing several dimensions of PES-REDD contract attributes in the context of permanence helps to reveal how related attributes are likely to be considered in order to reduce problems of adverse selection and moral hazard. The Policy Delphi revealed that stakeholders typically involved in policy-making do not fully agree on all presented attributes and associated attribute levels (see Figure 7.16), which reaffirms the set of problems for accountability in the AFOLU sector already presented in Section 2.4. The outcome reflects where problems are most severe and how permanence attributes are likely to be integrated into PES-REDD program design from a policy-maker's perspective.

The discussion and interpretation of the study results derived from the Delphi analysis is the subject of this section. For that purpose, the 13 questions are grouped into five categories: adverse selection; time frames and accounting; moral hazard; payment structure; and administration. Although these aspects are strongly interrelated, they are discussed separately

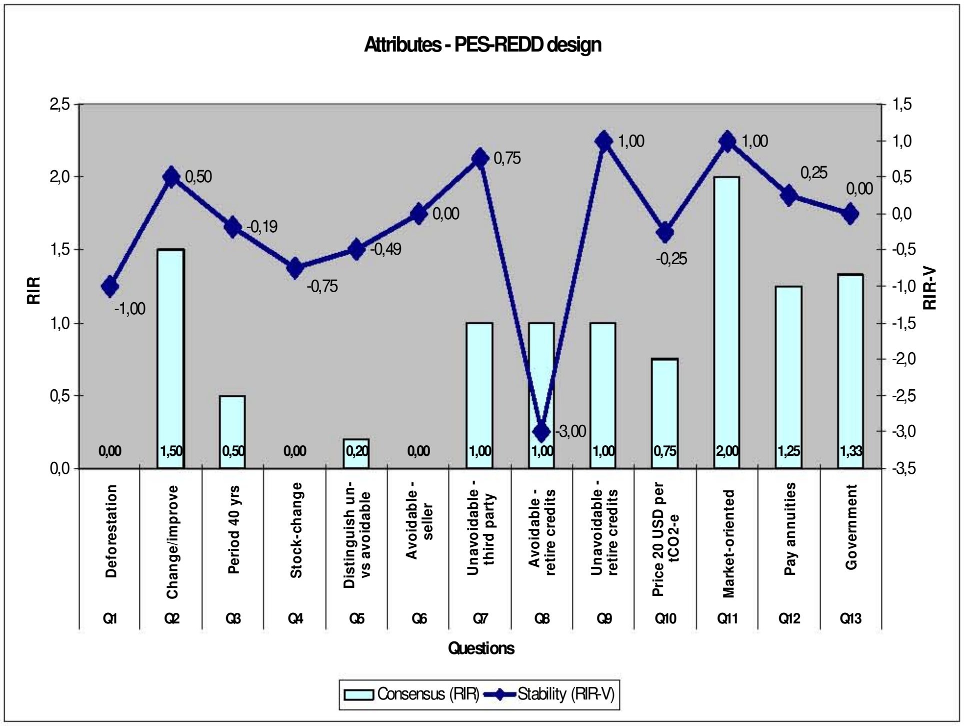


Figure 7.16.: PES-REDD design

to handle the consequences more easily. For each category the implication of three aspects are discussed: (i) preferred attribute level; (ii) consensus and stability; and (iii) impact on permanence.

Adverse selection

The first two questions included on are pinpointing to eligible REDD activities for remuneration. Their function is to determine variables having to do with avoiding adverse selection of any potential ES seller while improving the effectiveness of the payment scheme. Comments from the experts taken from the three rounds of questionning underline a preference for deforestation and degradation as the focus of REDD. This is due to the fact that the effects of these two processes have a major impact on GCC mitigation. In fact, forest degradation could potentially play a greater role in Mexico than deforestation. On the other hand, other carbon-related alternatives have a complementary effect, but experts feel that these may lead to confusion and definitions are not yet sufficiently developed for terms like enhancement, sustainable management and conservation. The latter term, for example, seems to be a catch-all word. Environmental and social safeguards are argued to be of utmost importance as well, but represent more a precondition. It has been emphasized that their integration and application is still not well understood. Experts are concerned that their application may remain desktop-based and limited to "information sharing", although the problems supposedly addressed by the safeguards occur on-the-ground and are context-specific. Despite an agreement on priorities, experts found it difficult to come up with an absolute ranking since they argue that it depends on local circumstances at a subnational level.

While the first question identified the most likely emission source for credit issuance, the answers to the second question elaborated on the specific circumstances for consideration ex ante under which potential ES sellers (providers) are actually likely to have the ability of conditional ES provision, such as reduced deforestation. The ES buyer is usually only interested to contract, and subsequently pay or provide other benefits to, the ES seller when s/he is able to deliver the ES (carbon sequestration and avoided emission). This implies that interested ES sellers (providers) must accept the conditionality of the exchange. However, ES sellers (providers) can only guarantee delivery under specific conditions that must be considered ex ante in the planning stage of context-specific REDD applications, so that the program is not at risk to become adversely selected. The stated preference of experts for a scenario where the seller (provider) has to change and/or improve land use and effectively control land-use patterns has been accompanied by various annotations regarding the distinct dimensions of the question. This criticism principally explains why the indicator for disagreement is relatively high (RIR 1.5) and stable (0.5) so that an absolute ranking remains difficult and coexistence is likely. Although it has been noted that the preferred option implies some sort of property right over the natural resource, some experts feel that access to ES, access rights to ES and the right to sell ESs should be separated from conditionality and additionality since these concepts appear to be fundamentally different. Others acknowledge the potential to reinforce ineffective legislation regarding the protection of forest (e.g., ANPs) by direct incentive schemes such as PES. Furthermore, experts pointed out that different parties, for example landowner, project proponent and seller, might be involved in the creation and commercialization of created carbon benefits in which case the seller is not necessarily the provider, especially in Mexico's context of common land property. Hence, different rights are probably assigned depending on the legal framework. Some experts explicitly recognized the threat that requiring *de-jure* titles by national legislation effectively excludes some people who most need it from receiving REDD benefits. This situation might be exacerbated in the case where poor living conditions of ES sellers (providers) represent an obstacle for entry into international carbon markets, even if they hold land titles. Thus, a market approach has potentially undesirable effects and REDD conceals that it is not an adequate substitute for transforming fossil-based industries. In consequence, eligibility should go beyond carbon.

Time frames and accouting for permanence

Questions number three and four mainly draw attention to the specific periods ES sellers (providers) must commit to the program and approaches for quantifying benefits. Clarity on these issues allow for greater understanding of how any carbon regime deals with permanence of REDD benefits from a technical perspective, and how this affects environmental integrity, efficiency and equity of the payment scheme. The comments on time frames reiterate the idea that two separate issues are of relevance when defining time frames. First, the number of years carbon must be stored in order to be considered "permanent" (e.g., 100 years), and second, the number of years for a crediting period during which credits can be issued based on verified ERs (e.g., 20 years). Hence, it has been argued that a much shorter crediting period should be acceptable, provided there are mechanisms in place ensuring that permanence is maintained through activity continuation, buffer, insurance or replacement. The revealed preference for shorter time frames (40 years) is stable (RIR 0.5 / RIR-V -0.19) and reflects the perception that practical reasons play an important role such as attractiveness and manageability. Accordingly, experts expressed the opinion that time frames should not exceed approximately one lifetime, so that the landowner is not making "legally-binding" decisions for future generations. The literature reports that not making long-term commitments for permanence an explicit objective could also be reasonable in order to minimize ES sellers' fear that PES is the first step towards land appropriation (Asquith et al., 2008). The Mexican NGO SAO provides an extreme example of practice-oriented dealing with permanence. This NGO is active in the domestic VCM. They provide an experience where annual contracts are agreed to and the relationship between the seller (provider) and the buyer (user) is characterized by trust. The provider demonstrates a historic-cultural tradition of conservation that is reinforced through forest carbon credit sales and enterprises are liable for paying guaranteed by their reputation (Bray, 2012). Another perspective is that the selection of a time frame depends on the selected activity. For instance, the avoided emission of one year is permanent while activities increasing carbon stocks in the biosphere depend on the accounting mechanism. Therefore, it might be of interest to distinguish among conditions that require the adaptation of different time frames. Influencing factors are scientific reasoning with regard to atmospheric impacts (e.g., 100 years), socio-economic aspects influencing the adoption of sustainable production systems which self-assure the permanence of ERs, legal dimensions such as a 30-year contract duration for common property regimes (*ejido*) in Mexico (causing an ex ante time frame boundary (CAR, 2010)), and practical considerations for combining these factors. Criticism has been made that there is no real permanence in REDD because the atmospheric impact of emitted carbon requires considerably long or even infinite time frames. Hence, all carbon benefits created through REDD are temporary in nature and should be treated as under the CDM A/R rules. Following this reasoning implies that a strict interpretation of the permanence condition for REDD carbon credits might only be relaxed if seen as a bridge technology in order to achieve a low (or zero) carbon economy. In this scenario, temporary storage has a value and does not require very long time frames such as 100 years, which most practioners consider unrealistic.

The Delphi experts agree with the literature that current practices in the compliance market and VCM, impose stiff regulatory requirements that often lead to marginal returns for ES sellers (providers). This is due to implicitly high transaction costs (e.g., technical requirements, brokerage) and demanding benefit-sharing schemes, especially in the Mexican context where forests are owned collectively by communities often bringing together more than 100 households (e.g., Bray, 2012). In this context, the accounting methodolgy is of great interest since it elaborates on quantification and expected total amount of forest carbon credits. Central tendency measures of answers related to the preferred option of question number four remained unchanged over the three rounds, indicating a high level of consensus (RIR 0.0) and stability (RIR-V -0.75). The stock-change method was selected by most experts since it takes into account all gains and losses of credited carbon. This approach implicitly attaches the "liability at the end" of the contracted period (Moura-Costa, 2002). In contrast, the attractiveness of ton-year accounting decreased notably during the process. The possible low price structure of the approach may explain this tendency so that it would only be an option if current carbon prices increase significantly. In addition, a fifth alternative was suggested for response options, that of a "stock-flow approach" using a "stabilization fund" in order to redistribute benefits and avoid international leakage (Cattaneo, 2008; Griscom and Cortez, 2011). Although this approach is attractive since it takes into account both ER (flow) and conservation (stock), it refers to a redistribution mechansim based on assumed baselines, in which case policy-makers would probably still need to decide on how to account for the benefits of remuneration based on the four alternative answer choices that were included. Furthermore, experts have highlighted that all carbon accounting schemes may have variations depending on their explicit form of application, and that a combination of options may be possible and even attractive. Finally, for an approach to be considered for successful implementation and market acceptance several additional issues must be addresses such as: match voluntary as well as compliance regulations; incentivize participation, especially in the context of common property where many community members are involved; adapt to schedules and required benefit-sharing schemes of individual projects; and assure the financial stability of projects in any higher landscape or sector approach. Two issues explicitly mentioned which any carbon accounting methodology should avoid are: provison of perverse incentives and underestimation of the varied benefits aside from carbon provided by an intact native forest.

Moral hazard

Questions number five to nine explore the responsibility for different types of reversals and the attached liability to compensate for any premature forest carbon loss. Detailed rules assure on the one hand, the environmental integrity of the mechansim and address equity concerns which may also affect adverse selection ex ante, and on the other hand, define circumstances representing moral hazard. In the inquiry, the consideration of moral hazard refers solely to a contract breach in the form of carbon reversals exercised by the ES seller (provider). In this regard, the answers to question five revealed consensus (RIR 0.2) and stability (RIR-V -0.49) that avoidable and unavoidable reversals require separate considerations and consequences. Although most experts indicated that there should be a distinction, some argued quite the contrary that the climate-effect of released carbon is indistinct regardless of the cause of release. If a distinction is made, the conditions will have to be well defined in advance in order to assure accountability and avoid free-riding. Experts pointed out that examples for the distinct considerations can be found in legal practices as well as in the insurance sector. Hence, a legal system capable of making this distinction and enforcing rule infringment for any given case is necessary.

As the majority revealed a preference for treating avoidable and unavoidable reversals separately, responsible parties need to be identified, a concern addressed in questions six and seven. The preference in the case of avoidable reversals was featured by consensus (RIR 0.0) and stability (RIR-V 0.0). The central tendency for liablility of avoidable reversals reflected a preference for the seller (provider), which remained unchanged in the three rounds. However, experts acknowledge that if the seller has to assume 100 percent of the risk very few projects will pass a risk assessment. Furthermore, if common property regimes, common in Mexico, are paid money it is likely that they will spend it immediately since they are poor and will rarely be able to compensate any avoidable loss caused by single community members. Others advocate to assign liability to the buyer's side, since it assures that the mechanism is designed correctly, all risks are insured and all necessary precautions are included. If liability is assigned to the buyer, other experts fear that there will be a low demand. A strong argument has been that in current market settings REDD would compete with other project types that are supposed to be free from such permanence (liability) concerns. A different issue reiterated by some experts is that avoidable reversals might also occur at other levels that do not necessarily relate to the provider. Hence, there might be different types of liability that are placed on different entities depending on who caused the reversal. It is argued, for example, that if REDD is implemented at or linked to higher levels, such as national accounting schemes, the government will also assume a certain degree of liability as well. Given the complexity and controversial argumentation, the number of experts has increased during the process which actually favors an approach where the liability is transferred to insurers or aggregators. This supports those experts who consider avoidable reversals as an inherent risk of doing business. Nevertheless, it has been pointed out that it is rather unlikely that any insurance company would take on the liability for intentional reversals.

In the case of unavoidable reversals, the central tendency of answers in all rounds indicates that a third party solution should be applied. However, this opinion was less consolidated (RIR 1.0) and stable (RIR-V 0.75). The perception grew that the administrator (e.g., government) must be part of the solution, especially when dealing with jurisdictions or higher accounting schemes. On the contrary, some argued that unavoidable reversals should be treated as an inherent "credit risk". The reasoning against buffer accounts and insurance schemes is the problem of pooling different risk levels or risk hedging. In addition, it is argued that the so-called unavoidable reversals are more and more human-induced. Yet, the majority of experts continue to believe that sellers (e.g., *ejido*, agrarian community, small property) should not assure the responsibility for this type of reversals.

Allocating responsabilities for any reversal is the first step to guaranteeing the permanence of forest carbon stocks. But it explicitly raises the issue to specify consequences and determination of liability for any premature loss of created benefits. Even though in PES-practice sanctions are not or only gradual introduced and even less enforced (Asquith et al., 2008), it is advisable not to abandon the "stick" entirely for the "carrot" in order to increase leverage (Wunder and Albán, 2008). Most experts indicated in question eight that for avoidable reversals a retirement solution is preferred, although consensus was relatively low (RIR 1.00), but with a strong tendency towards stability (RIR-V -3.0). Concern has been expressed that the inadequate structure of buffer pools could be a problem if the pool is not organized according to "best insurance practices" and if it mixes deposited credits with different risk levels. Accordingly, it is inadequate that credit issuing standards manage their own buffer pool. Furthermore, it has been argued that a mix of measures is adequate with some sort of "escalation catalog". In general, there has been agreement that strong sanctions, such as exclusion and repayment, are too hard for poor participants, especially in the context of common property if this is related to individual infringement.

As strong resistence prevailed against severe sanctions for avoidable reversals, it is not surprising that the revealed central tendency and answers are similar for question nine. Nonetheless, what was surprising is that the preference for a retirement solution demonstrated an equally low consensus (RIR 1.0) and even decreasing stability (RIR-V 1.0). A particular concern has been that the seller (provider) should not be punished for unavoidable reversals financially or with other strong sanctions because it is perceived as unfair. Instead, most experts feel that a combination of an insurance and restauration scheme would be the most adequate.

Payment structure

Questions 10 to 12 relate to the payment structure of a future PES-REDD scheme in order to provide adequate incentives for ES sellers (providers) to guarantee conditionality. The appropriate identification of payment levels, practices for determining prices and payment schedules most likely impact the effectiveness, efficiency and equity of the design. Experts increasingly agreed (RIR 0.75 and RIR-V -0.25) upon a price of 20 USD per tCO2-e, which is considerably higher than current carbon prices. Nonetheless, four main issues have been raised as to why prices of REDD credits will vary and be relatively low if not regulated otherwise by legislation. First, sellers' (providers') opportunity costs (e.g., agriculture) which may demonstrate a recurrent character and continuously compete with REDD activities is of great importance. Most experts fear that opportunity cost without additional regulations will make REDD activities non-competitive regarding other alternatives so that a pure supply and demand set-up would naturally exclude REDD activities with high opportunity costs. A second dimension is the variation of price according to the type of activity, methodology, and transaction costs. The paid price would have to cover at least the sellers' (providers') implementation costs and not exceed the cost of alternative ER options for the buyer. Third, co-benefits that assure a certain quality of issued credits beyond carbon must be considered. Since the provision of co-benefits will probably increase the costs for implementation, it would be useful to establish guidelines or quotas in order to assure that high quality REDD credits enter the market and compete equally. The last dimension explored is the desire that prices reflect the damage that CO_2 may have on human lives. "Adequate" therefore depends on the amount of CO_2 emissions needed to mitigate GCC and the most correct approach would be to identify an intrinsic value of the ecosystem as a whole.

As indicated above, experts are concerned that forest carbon credits are likely to be undervalued. Hence, the lack of long-run finance in cases where opportunity costs remain above that of desired land use over time becomes a bottle-neck to permanence. Government-financed programs face this issue more than user-financed set-ups (Engel et al., 2008). So, in order to raise sufficient funding experts supported a market-oriented approach as the preferred option for price determination and adaptation, although consensus was extremely low (RIR 2.0) and unstable (RIR-V 1.0). Equally ambiguous was the application of public policy intervention. Experts revealed that a mix could be possible in order to achieve adequate prices in terms of opportunity costs and/or a serious cap in line with science. Several arguments previously elaborated upon also apply here for determining adequate price levels. The best approach is probably a mix of market orientation and price-setting policy (price floor) where the number of permits is limited and their allocation is regulated. Experts upheld that prices should be at least equal to the opportunity costs of deforestation.

The last question on the adequate payment structure relates to the payment schedule, which should be dealt with separately from credit issuance in order to spark interest in participation and maintain incentives high for guaranteeing permanence. The central tendency of answers indicated that a schedule with evenly distributed payments over a certain period was preferred, although consensus was limited (RIR 1.25) but stability was achieved (RIR-V 0.25). This is in-line with other authors who argue that programs designed to counteract a continuous threat level of ES loss require yearly payments to ES sellers in order to guarantee conservation (Pagiola, 2008; Wunder and Albán, 2008). Some even advocate that this should be combined with front-loaded payments in order to support initial and costly activities (e.g., reforestation). Such an approach would foster the creatation of "on-site permanence" by strengthening incentives, improving technical skills, continuing monitoring and enforcing legal requirements (Wunder and Albán, 2008). This may vary by specific project activities as it would be too risky in other contexts (e.g., REDD). Therefore, the schedule of payments probably depends on the level of activities and development of opportunity costs. The incentives should assure a long-term commitment on the part of buyers (users) and sellers (providers) alike. If credits are issued ex post, incentives will have to be provided during the lifetime of the project and adjusted according to sellers' (providers') needs. A contrary position is to restrain from direct payments in the rural context, because they are generally used inadequately, expecially if paid up-front and does not incentivize sustainable development in the short to medium-term.

Administration

The last question draws attention to the administration of the PES-REDD scheme. Trust in institutional arrangements represents an important variable in order to avoid adverse selection and moral hazard. Most experts revealed the perception that the government should take a leading role, for example through the CONAFOR. However, the administration might be split into different tasks which could be realized by distinct institutions. For example, it has been noted that close collaboration between the government and civil society is required with intensive coordination among all stakeholders. Although preference is given to the government, some concern has been expressed about its capacity and capability, especially due to corruption in government institutions and bureaucracy which may retard the progress of REDD activities. This is also reflected in the stated preference for the government where limited (RIR 1.33) but stable (RIR-V 0.0) consensus exists.

8. Choice-experiment of land-use alternatives

The stipulation of contractual arrangements required in PES for assuring the permanence of forest carbon stocks is a challenging task. The activity reducing mitigation strategy REDD+ (Engel et al., 2008) has to cope with providing long-term incentives to the agent (ES provider) and faces the inherent risk that the pressure affecting LUC will increase considerably over time. In order to analyze the problems related to contract formulation, Contract Theory provides an attractive mindset (see Section 4.1). Contract Theory is a sub-discipline of Game Theory where the latter emphasizes the strategic interaction between a small number of "players" (e.g., ES sellers and buyers) in a world where information problems are critical (Bolton and Dewatripont, 2005). From this perspective, the allocation of resources is not solely determined by the price system, but also by contracts between players, which are assumed to be asymmetrically informed. Because this type of model is closer to the reality of environmental policy issues, several authors (e.g., Ferraro, 2008; Wunder, 2008) indicate that policy-makers should draw more attention to this mindset in PES design. The theoretic concept reveals the general tradeoff between flexible and strict contract designs. The tradeoff is commonly between ES buyers wishing to guarantee the permanence of ES provision and flexibility desired by the perspective of ES sellers who act in a highly vulnerable context. These insights help inspire how to balance strict commitment ex ante against flexibility ex post in order to formulate a contract which reduces the uncertainty of the actions of other players. Information asymmetries between parties present the biggest problem because each party has information about itself (private information) which the other does not have, which leads to potential opportunism such as adverse selection of contracts ex ante and moral hazard in contract execution ex post (Ferraro, 2008; Van Aaken, 2009; Wunder and Wertz-Kanounnikoff, 2009; Zabel and Roe, 2009).

Asymmetric information is a main feature of contractual arrangements and indicates that the principal-agent relationship suffers under the problem that parties cannot easily design "optimal" contracts (Bolton and Dewatripont, 2005; Shavell, 1980) which maximize investments of mutual benefit while responding appropriately to changing conditions ex post (Scott and Stephan, 2006). Changing conditions are a frequent feature in natural resource management where most investments are made with a long-term perspective in mind such as is the case under a REDD scheme. The theory is that contracts which are too strict and inflexible may affect the overall surplus of contracting parties (Bolton and Dewatripont, 2005; Burke-White and von Staden, 2007; Van Aaken, 2009). Thus, a dilemma arises between a strong commitment ex ante and flexibility ex post in order to maintain the effectiveness of the contract (Burke-White and von Staden, 2007; Van Aaken, 2009). These problems arise especially in unforeseen crises and create inherent tension. Ex ante both principal (e.g., ES buyer) and agent (e.g., ES seller) want to ensure the commitment of the other, but subsequent events may make inflexible commitments inconsistent with the contractual target of maximizing the mutual benefit of the contracting parties (Van Aaken, 2009). This problem is exacerbated especially in long-term contracts. Thus, the analysis of mechanisms of commitment and flexibility in PES schemes can help to design contracts more "efficiently" for REDD initiatives in Mexico that target common property regimes with such "environmental contracts".

This chapter is subdivided into four main sections. The first section provides the background for a PES-REDD contract, presents the study area, recapitulates the research objective, question and hypothesis, and elaborates on the material and methods used to reveal stated preferences through an experimental design. Secondly, the respondents of the experiment are presented, and the CA process and form of inquiry is explained together with model descriptions and related hypotheses. The third section contains the results from a descriptive data analysis and obtained econometric models which explain the stated preferences for a set of land-use alternatives. This chapter concludes with a discussion of the results.

8.1. Background

Agriculture, livestock and urban development are the main worldwide causes of LUC and subsequent forest loss and degradation. These drivers are also the second largest contributors to increased atmospheric CO_2 concentrations (Millennium Ecosystem Assessment, 2005; Steinfeld et al., 2006). This trend represents a negative externality that directly affects the safety of people and their heritage, with a strong impact on the environment, economy and society (Millennium Ecosystem Assessment, 2005). Current management practices often hamper both individual and society benefits, representing a major challenge, especially for developing countries where the rural-poor generally have little choice but to deplete or degrade natural resources in order to earn a living (Curtis, 2004). Consequently, discussion on this issue focus on approaches capable of reducing human impact of unsustainable management alternatives. This requires the identification of mechanisms and instruments that operate as an assurance against future events, and allow mitigation and adaption to the observed phenomena. Since most decisions on natural resource management are strongly influenced by ESs sold on the market, the non-marketed benefits are often lost or degraded as a result (Millennium Ecosystem Assessment, 2005). A lack of information comes from inefficient markets given that one of the contracting parties does not have any information or insufficient information about the quality of goods and services that are traded (Akerlof, 1970). The intention to put a price on a particular ES, therefore, increases the complexity when the tangibility of direct use decreases (Curtis, 2004). Therefore, research is needed on economic approaches that allow internalizing environmental externalities into land use decision-making and encourage the permanence of a particular ES such as forest carbon stocks.

Given this background, there is a growing consensus that REDD, as a mechanism for forest conservation finance, should play a central role in environmental policies in order to mitigate GCC (Ogonowski et al., 2009; Parker et al., 2009; UNFCCC, 2010). This strategy involves real costs on a local level (opportunity cost from other land-use alternatives) but creates benefits globally (GCC mitigation). Thus, forest conservation policies need to address these global externalities and align local incentives with global benefits. It is important to examine this context in greater detail and its variety of environmental, economic and social circumstances in the territory (Engel et al., 2008). Respectively, the economic policy instrument PES is found to have considerable potential in order to effectively internalize environmental costs and benefits in land use decision-making (Engel et al., 2008; Wunder, 2005). The proper design of a PES scheme must meet the requirements of efficiency, effectiveness, equality and political feasibility (Ogonowski et al., 2009; Parker et al., 2009). A central issue in this regard is that the decision-making processes of the agents controlling these resources and other stakeholders in defining and implementing strategies in order to meet changing conditions have to be well understood (Engel et al., 2008; Millennium Ecosystem Assessment, 2005). Understanding which factors influence land-use decisions in a way that they promote conservation of natural resources and sustainable development remains a major challenge for research (Engel et al., 2008; Palmer and Engel, 2009), especially in developing countries.

Mexico, the study context of this research, represents a challenging case. It is coping with natural resource loss (CONABIO, 2006), even though the Federal Government of Mexico is in favor of an international REDD mechanism to combat this reality (CONAFOR, 2010b). The use of instruments for local forest conservation remains in the phase of "trial and error". Mexico is unique in that around 70 percent of its forest land is held in common property (Bray, 2012; Bray and Merino-Pérez, 2002, 2004; CONABIO, 2006), making this form of ownership significant for preferences related to the use of natural capital. The consideration and active inclusion of agents having direct land-use rights has gained importance (Ogonowski et al., 2009), but so far their participation has been comparatively poor in the formulation and implementation of environmental policies. The importance of these stakeholders is undoubtedly justified specifically in the context of REDD when it should be born in mind that they control and own significant portions of forested areas. These groups have demonstrated in various cases that they are effective forest stewards with their management practices and cosmovisions (Bray, 2012; Bray and Merino-Pérez, 2002, 2004; Murillo-Hernández, 2008; Ogonowski et al., 2009). However, in some cases a PES approach might have ambiguous implications for these groups. In situations where agrarian nuclei are not able to effectively control their land, an international REDD mechanism and national PES scheme might help to reinforce and regain their land-use rights (e.g., Bray, 2012; Kosoy et al., 2008). In situations, where indigenous arrangements and sovereignty work in order to execute effective control, the introduction of a PES-REDD scheme might cause significant noise within the common property regimes. In countries like Mexico, the relationship between national authorities (the principals) and land users (the agents) is sometimes tense and every attempt to regulate traditional user rights will probably be seen as the first step in the direction of narrowing the natural rights to govern their land (Asquith et al., 2008; Dobbs and Pretty, 2008; Ogonowski et al., 2009; Robertson and Wunder, 2005; Wunder et al., 2008). Three aspects might be particularly problematic (Ogonowski et al., 2009): first, imposing rules of do's and don'ts on their land, second, MRV activities on-the-ground, and third, the menace and realization of penalties for non-compliance. These are important aspects in the designing stage. Ensuring that these communities guarantee the permanence of forest carbon stocks despite other land-use alternatives is critical. Hence, investigation is required regarding the mode of PES in the context of a Mexican REDD regime in order to "best" administer the effects of asymmetric information in environmental contracts on a local level.

8.1.1. Objective of this chapter

In a PES-REDD scheme, a principal (e.g., CONAFOR) and an agent (e.g., a common property regime) agree to a contract where the principal hires the agent in order to perform a task that guarantees the permanence of forest carbon stocks. For that purpose, the agent chooses her/his "effort intensity", which is, in the case of Mexico's common property regimes, for example, the number of community members actively involved. The degree of collective action then affects "performance", such as the permanence of forest carbon stocks. Yet, the contracting problem is that effort is costly for the agent (e.g., opportunity costs from other land uses), and the principal has to compensate the agent for incurring these costs. If effort (active involvement of all community members that threaten the forest cover) is unobservable or incurs prohibitively high costs, the best the principal can do is to relate compensation to performance. This compensation scheme will typically entail a loss since performance is only a noisy signal of effort (Bolton and Dewatripont, 2005). If performance in terms of avoided LUC is used as a measure for compensation, the question arises as to what type of contract has to be offered in order to guarantee the compliance of the collective, since a hidden action of an individual would jeopardize performance of the contracted agent - the common property regime. Therefore, it is advantageous to agree ex ante on responsibilities and assigned liabilities in the event that CO_2 is subsequently released in the atmosphere (Marland et al., 2001). Since various issues may provoke non-performance, this chapter needs to define its scope, focusing primarily on the aspect of responsibility and liability resulting from avoidable reversals caused by an individual community member. A two-stage experiment sets out to determine typical problems in contract formulation such as asymmetric information (adverse selection and moral hazard). Revelation of ES seller's preferences in PES contract design is the focus. It receives input from previous chapters where the design of the field experiment is guided by the results obtained from Chapter 6 and 7. The main idea is to elaborate on PES-REDD contract design in order to guarantee the permanence of forest carbon stocks over time. The contract design incorporates ES buyers' desire to secure the permanence of an ES and landowners' decision-making ex ante and under changing land-use alternatives ex post.

The remainder of this section presents the specific research objective, question and hypothesis related to the identification of PES-REDD attributes that support the permanence of forest carbon stocks. Attributes of interest are those that explain ex ante, the first stage, the motivation of individual community members (collectively forming the agent in a PES contract arrangement) to become engaged in a PES-like contract in the first instance, which has a direct impact on conditionality (improving or maintaining ES provision), and ex post, the second stage, the risk that individual ES providers commit hidden activities causing a breach of contract when other LUC alternatives become available. The main objective is to identify variables which influence the decision of landowners towards conservation programs such as PES in the peri-urban context of Mexico City. This chapter elaborates on the application of a choice experiment in order to analyze the ES seller's preferences on attributes in PES-like contracts that reduce the probability of adverse selection and moral hazard. The outcome contributes to a better understanding of community members' perceptions in order to align mitigation policies with preferences, which helps to conserve natural resources and improve the welfare of local actors and global society.

Objective The specific research objective is to elicit ES sellers' (providers') response to different PES contract profiles in order to explore how adverse selection and moral hazard of ES sellers (providers) can be avoided so as to guarantee the permanence of forest carbon stocks. Using a choice-based experimental set-up employing Conjoint Analysis helps to better understand the role of ES sellers' (providers') preference in land-use decisions, and how this might affect collective decision-making in the context of common property regimes in Mexico.

Question The research question is: How do PES contract attributes influence the decision of the ES seller (provider) ex ante? How can PES contracts be designed to ensure ES sellers' (providers') compliance when conditions such as land-use alternatives change over time, while still assuring the permanence of forest carbon stocks desired by the ES buyer (user)?

Hypothesis The research hypothesis is that the stated preferences for land-use alternatives reflect the inner conflict of a contracted agent (the community) who relies on collective decision-making. A voluntary PES contract has to balance strict commitment ex ante with flexibility ex post in order to successfully address the problem of individual ES sellers' (providers') adverse selection and moral hazard. It is assumed that ex ante most community members of a common property regime prefer a market-based approach compared to a command-and-control approach for forest conservation. But ex post the agent (the community) has difficulties to keep the agreed conditionality upright once LUC alternatives offer higher rents to individuals (community members).

8.1.2. Method selection

Although the main contract attributes of ensuring the permanence of forest carbon stocks are known theoretically (see Section 2.4) and have been specified for the case of Mexico in the previous chapter (see Chapter 7), the response of landowners (e.g., members of a common property regime) to any particular incentive scheme is not clear. Given these circumstances, the use of experiments is promising in order to better understand the behavioral basis for the evaluation of environmental assets (Todd et al., 2009). Thus, a case study was conducted where field experiments were applied based on choice modeling, also called CA (see Section 5.3), for eliciting community members' land-use choices under alternative contract scenarios in the periphery of Mexico City. CA has relatively recently been applied to analyze environmental problems where preferences are directly stated by involved stakeholders (Bateman et al., 2002). This case study is interested to analyze how individual (potential) ES providers grouped in a common property regime (ES seller) state their preference over alternative contract scenarios. The CA is investigating the reasons for a respondent's choice of a certain "service or good" (e.g., environmental contract) based on its attributes, not only taking into account the payment (price). This approach enables the investigation to discover if and which attributes of a contract are most valued by those (potential ES providers) who have to decide whether to accept or reject an offered contract (Green et al., 2001). Furthermore, this approach helps to identify if or if not specific contract attributes are hampering or supporting the avoidance of ES sellers' hidden information (adverse selection) and hidden action (moral hazard) in a context where stated preferences of the individual may influence collective land-use behavior or cause a breach of contract. It is expected that the implicit valorization of the individual elements making up the contract can be determined. This implicit valorization or utility can be used to estimate acceptance of different "environmental contract" designs among potential ES providers grouped in a common property regime as ES seller. The emphasis of the experiments is on the integration of attributes related to permanence in contract design, where econometric analysis reveals respective preferences and takes also into account socio-economic characteristics of the respondents.

8.2. The experimental process

The experimental process used analyzes two groups of variables and their influence on asymmetric information problems regarding potential ES sellers (providers) who are collectively contracted in the case of Mexican common property regimes. The first set represents socio-economic characteristics of surveyed ES sellers which are referred to as case-specific variables in the following. The second group includes the attributes of choice alternatives such as environmental contract details which are referred to as alternative-specific variables in the remainder of this section. The choice modeling approach mainly involves two stages. In the first step, data are collected through a choice experiment implemented during a workshop, and second, summarized data serve as input for a CA which allows the construction of econometric models. The results from the previous two chapters have been the main guide and input for the design of the questionnaire, while the CA has been used to process the data and construct models that help to answer the research question. Incorporation of the previous results is straightforward. The details of the survey and modeling approach are explained in the remainder of this section.

8.2.1. Survey

The choice experiment involved two actors for eliciting preferences regarding controlled sets of alternatives: researchers (administration) and community members (respondents). The task of the administration has been the design, coordination and application of the experiment to a group of selected community members from two communities in the MRW during two workshops.

The sample instrument

The theory of CA was used to construct a controlled set of alternative scenarios affecting the natural capital of a common property regime. These sets have been submitted to existing ES sellers (two communities) in order to analyze stated preferences regarding hypothetical environmental contract scenarios. It is expected that the implicit valorization of the individual elements making up the profile alternatives can be determined. These implicit valorizations (utilities) can be used to estimate acceptance of different contract designs among potential ES sellers. Emphasis of the experimental design is on the integration of alternative-specific variables which affect permanence and reveal problems of asymmetric information. After formulating the preliminary version, the experimental format was subject to a two-stage process of revision and adjustments. First, professors and students familiar with the study site and technique provided comments regarding the content and wording of the format. After adjustments were made, the instrument was pre-tested in the laboratory with a group of undergraduate biology students. The feedback from the pre-test was used to further refine the experimental design and obtain the final version for application. An example of the questionnaire (Spanish version) is included in Appendix H and divided into the following sections: A. Introduction; B. General socio-economic questions; C. Choice set first round; and D. Choice set second round.

The first two sections of the questionnaire are self-explanatory. Section A. contains information for the respondent and is used by the researcher for administrative purposes. Section B. is comprised of several socio-economic questions that are similar to those used in Chapter 6.

Their inclusion was guided by two criteria: (i) the assumed likelihood to play a major role in the studied context, and (ii) the limitation in terms of time and experimental format making it important to ask only simple and less sensitive questions. The answer to these 12 questions are used in the econometric analysis as explanatory independent (case-specific) variables in order to better understand the stated preferences of alternative scenarios.

The design of sections C. (first round) and D. (second round) was more challenging, since they actually represent the main part of the two-stage experiment with a controlled set of profiles. Each profile alternative is differentiated by four alternative-specific variables. The first variable varies in each round by three land-use options that respectively provide a different good or service, which implies a particular duration and annual revenue per hectare. The second variable [RESSAN] corresponds to assigning responsibility for an avoidable reversal of forest cover. This variable is a dichotomous variable indicating if the community is collectively responsible and has to face the sanction of exclusion from future program benefits and repayment of obtained program benefits when loss is detected. The third variable [INSPEC] varies by three levels and indicates the risk of inspection by the governmental institution in charge of controlling the intact forest cover. The variable may take 1, 10 or 20 percent of random selection for control from all common property regimes, approximately 27,214 *ejidos* and 1,797 agrarian communities according to RAN (2011). The last variable [CORRUPT] indicates whether or not corruption is present in the government institution in charge of controlling the state of the natural capital and monitor avoidable forest cover loss respectively. This variable is a dichotomous variable indicating if the government institution enforces announced penalties in the case of non-compliance or if infringement can be "bargained" otherwise[1].

In summary, there are two alternative-specific variables with two levels (2^2=4) and two alternative-specific variables with three levels (3^2=9), which means that a total of (2x2x3x3) 36 combinations are possible. Since "complete factorial design" was rather impractical for the encountered circumstances in the study area, a "fractional factorial design" was adopted. Fractional profile sets reduce the number of alternatives from all possible combinations. This research uses the orthogonal main-effect plan for asymmetrical factorial experiments as first proposed by Addelman (1962a,b). Plan 2 (Addelman, 1962a) indicates that a full profile of 36 combinations can be reduced to nine (see Figure 8.1). In order to further easing the task for respondents, the experiment was set up in a way that the individual had to compare only three alternatives with each other at once and state a preference. For that purpose, the combination of three alternatives was randomized for each respondent. Furthermore, respondents had to repeat the "choice task" only three times in order to limited the time of the total experiment and, thus, avoid the loss of interest (boredom).

The purpose of the two-stage experimental set-up is to reveal if a PES scheme in the context

[1] It was left to the respondent's interpretation how detected infringment is "bargained". This was done because this research project had no detailed knowledge about procedures in practice due to its delicate character.

$2^2 \times 3^2 = 36$ combinations			
Alternative-specific variable	**Level**	**1st Round**	**2nd Round**
A. Option	**0**	**SC**	**PES-REDD**
	1	**PSAH**	**AGRI**
	2	**PES-REDD**	**URBAN**
B. Responsibility & Sanction	0	No	No
	1	Yes	Yes
C. Inspection	**0**	**Low**	**Low**
	1	**Medium**	**Medium**
	2	**High**	**High**
D. Corruption	0	No	No
	1	Yes	Yes

Plan	Combinations	Combination of variable levels
2	9	3^4, 2^4

	3^4				2^4			
Number	1	2	3	4	1	2	3	4
1	0	0	0	0	0	0	0	0
2	0	1	1	2	0	1	1	0
3	0	2	2	1	0	0	0	1
4	1	0	1	1	1	0	1	1
5	1	1	2	0	1	1	0	0
6	1	2	0	2	1	0	0	0
7	2	0	2	2	0	0	0	0
8	2	1	0	1	0	1	0	1
9	2	2	1	0	0	0	1	0
Columns	√	√					√	√

9 profiles of fractional factorial design					
Profile	**A. Option**		**B. Responsibility & Sanction**	**C. Inspection**	**D. Corruption**
1	**0 = SC**	**0 = PES-REDD**	0 = No	**0 = low**	0 = No
2	**0 = SC**	**0 = PES-REDD**	1 = Yes	**1 = medium**	0 = No
3	**0 = SC**	**0 = PES-REDD**	0 = No	**2 = high**	1 = Yes
4	**1 = PSAH**	**1 = AGRI**	1 = Yes	**1 = medium**	1 = Yes
5	**1 = PSAH**	**1 = AGRI**	0 = No	**2 = high**	0 = No
6	**1 = PSAH**	**1 = AGRI**	0 = No	**0 = low**	0 = No
7	**2 = PES-REDD**	**2 = URBAN**	0 = No	**2 = high**	0 = No
8	**2 = PES-REDD**	**2 = URBAN**	0 = No	**0 = low**	1 = Yes
9	**2 = PES-REDD**	**2 = URBAN**	1 = Yes	**1 = medium**	0 = No

Figure 8.1.: Orthogonal Main Effect Plan

of Mexican common property regimes is likely to face both adverse selection (ex ante - in first round) and moral hazard (ex post - in second round). Each round was introduced by a brief description of a scenario explaining the status quo and the presence of two alternatives.

In the first round (Section C.), respondents were confronted with a situation where the status quo for the protection of the forest on the common property is Soil Conservation (SC)[2]. The Federal Government is offering the next year two alternative environmental programs for the conservation of the forest cover based on two different concepts: Alternative 1 - PSAH[3], and Alternative 2 - PES-REDD[4]. The rationale behind comparing these three alternatives is that the actual status quo of the communities' natural capital is the SC when the current valid

[2]SC conserves the ecological part of the Federal District but does not imply an annual payment and has an open-ended duration (see Section 3.2.2). It was decided to provide a discrete indication of duration with 100 years in order to comply with the profile design.

[3]PSAH represents the official specification of the current national PSAH program for the provision of hydrological services with the lowest annual payment level of 382 MXN/ha and a contract duration of five years (see Section 3.3).

[4]PES-REDD draws on the specifications identified in Chapter 7 for the avoidance of CO_2 emissions. The annual amount of 855 MXN/ha is derived from Delphi Question 10 (20 USD/tCO_2) and the duration of 40 years corresponds to the group answer for Delphi Question 3. The assumptions for the input variables of the payment level calculation are (i) Deforestation rate: 1.00 % baseline (averaged from Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005; Sheinbaum Pardo, 2011), 0.33 % for the first five years of PES-REDD (conservative assumption about limited efficiency), and 0.00 % after the 5^{th} year of PES-REDD; (ii) Average carbon stock: 389.91 tCO_2-e/ha in forests of the area of study (averaged from Ávila Akerberg, 2009), and 0.00 tCO_2-e/ha after conversion; (iii) Average ERs: 3.07 tCO_2-e/ha/year; (iv) Payment level: 61.34 USD/ha/year converted to MXN with an average conversion rate of 13.941 for the year 2011/12.

PSAH contract expires the next year after its five-year duration. The idea is to investigate the attractiveness of environmental contracts and determine who is actually selecting them. For example, if PES alternatives are selected by respondents who do not have access to a land parcel (inscribed in RAN and/or worked or cultivated) this would indicate adverse selection, which may have significant implications for collective decision-making.

For the second round, respondents were presented with a scenario where the status quo is the community's participation in a federal PES-REDD[5] program in order to protect forests in order to mitigate GCC. It was assumed that the General Assembly signed this contract after the PSAH expired. Two land-use alternatives existed on the contracted commons: Alternative 1 - Agriculture [AGRI][6], and Alternative 2 - Urbanization [URBAN][7]. The idea of this comparison was to investigate how robust a decision was in favor of PES-REDD or how attractive moral hazard was. It is important to note that during the experiment it was not explicitly mentioned that land-use conversion for agriculture or settlements was actually illegal on the commons. The reason behind this was twofold: first, the intention was not to introduce a bias of "yeah-saying", and second, although legislation prohibits land-use conversion in the studied area for these concepts, despite this regulation LUC has occurred in the past due to these drivers. Hence, if a non-PES alternative is selected it would be interesting to see, for example, if the hidden action would be executed by respondents with or without access to a land parcel (inscribed in RAN and/or worked or cultivated).

The sample survey

The sample survey is a quantitative approach used for the collection of data to be processed and analyzed statistically, as is necessary for econometric analysis. The sample survey is characterized by a sampling design which corresponds to the specific conditions of the object (or subject) of study and the limitations of the research such as time constrictions, budget constraints and geographic outreach. The intention was to obtain representative information on the population of interest without collecting data from all individuals. The sample design refers mainly to the identification of the sample population (sample frame), sample unit (observation unit), sample intensity (sample size), and selection process of the sample unit.

The sample population of a survey is the sum of all individual units which have the possibility

[5] The specifications are the same as for Round 1.

[6] AGRI reflects the average agricultural production of the latest available statistics with a total value of 12,055 MXN/ha in the Delegation Magdalena Atlitic (SIAP, 2010), which usually implies a cyclic cultivation of one year.

[7] URBAN represents the option to sell ground for the construction of dwellings. The annual amount of 15,675 MXN/ha is derived from key informants in the communities and the duration of 50 years corresponds to a period approximately equal to the time span (18 to 68 years) an average person may be capabale to work a land property. The assumptions for the input variables of the payment level calculation are (i) Land value: 75 MXN/m^2 is the lowest price for terrain in the area of study; and (ii) Interest rate: 4.50 % (Banco de México, 2012). The payment level, therefore, represents an annuity over 50 years.

to be selected for a sample. The population of interest for this study was selected from communities located in the periphery of Mexico City. The agrarian community of Magdalena Atlitic and the *ejido* of San Nicolás Totolapan, both located in southwestern Mexico City (see Section 3.2), were selected for this study.

The observation unit for this research project was the individual formally or informally related to the community (respondent). Formal community members are considered those registered in RAN, while informal community members are typically relatives of a formal community member. Given the workshop format, it was not possible to assure that respondents be selected from different households. For this reason, it was not feasible to have an equal number of male and female respondents, as explained in more detail below.

The sampling intensity assures a "representative" crosscut of all potential subgroups present in the population of interest. The sample size may depend on two sampling criteria: (i) budget and time constraints, or (ii) statistical representation. While the first approach is quite random, it actually was the principal sampling criterium in this study. In consequence, the percentage of units sampled was automatically determined by the participation of community members in two workshops, thus, limiting the statistical power of the results obtained. It was projected to include at least 60 observations since past experience from workshops in that community revealed an average participation of 30 people.

The mode of selecting individual sample units concludes the survey design. In general, the observation unit can be selected from the population through different selection processes roughly divided into random and non-random sampling techniques (Bateman et al., 2002). Most studies intend to guarantee random selection in order to obtain statistically sound results. Given the format of the workshop, this research had to adapt and employ a non-random sampling approach. This is valid when the selected sample is representative of the sub-population under study (Smith, 1983). It is assumed that this is the case of this study, because decisions on community issues are made by regular participants in the General Assemblies and are probably influenced by an intra-household exchange of opinions. Therefore, a "convenience non-random sampling" is applied, defined by Kelley et al. (2003) as the "sample made up by the easiest subjects to recruit". One workshop in each community was organized in coordination with the presidents of the communities. The authorities of the communities were in charge of informing the community and scheduling the date and place. This process made it complicated to comply with the intention of obtaining a predetermined sampling intensity with equally male-female participation.

The idea of the workshop was first presented to the authorities of the communities in February, 2012 with final approval for its implementation given in June, 2012. The workshops were held on July 5^{th} and 7^{th}, 2012. In the agrarian community of Magdalena Atlitic 53 people participated, of which 16 respondents were female. In the *ejido* of San Nicolás Totolapan 13 individuals formed part of the experiment, of which only one respondent was female. The workshop goers who accepted to participate in the experiment were given a brief explanation regarding the purpose of the survey prior to its start. In the first part, two presentations were held about the fundaments of the current PSAH and a hypothetical PES-REDD in order to guarantee that respondents were able to make an informed judgment during the experiments. After questions from the presentations were clarified, the experiment itself started. It was emphasized ex ante that respondent's participation was completely voluntary, that responses were treated anonymously and that questions they felt uncomfortable with did not have to be answered. The intention was to organize the respondents into groups of 3-4 individuals with one survey assistant, so that the assistants were able to solve doubts and provide detailed and personalized information to the respondents. The research director guided the respondents through the questionnaire with a video projector and explained each alternative, while the assistants oversaw that answers were captured correctly. The experimental session lasted between one and a half to two hours.

8.2.2. The Model

The foundation of economic valorization with stated preference techniques is provided by Bateman et al. (2002) and the construction of econometric models is guided by the work of Long (1997) and Long and Freese (2006). Following their proceeding of CA and choice modeling respectively (see Section 5.3), the applied econometric analysis is based on three different regression models as proposed in other studies of ecosystem change valuation (e.g., Farber and Griner, 2000; Revollo Fernández, 2006; Roe et al., 1996). These models are used to revel potential ES providers' stated preferences regarding different land-use alternatives offered during the experiment. It was assumed that the decision-making of the community member was a function of utility provided by each of the n submitted alternatives. These n alternatives have similar alternative-specific variables but distinct levels which represent different states of well-being or utility U to the community member. For example, if three alternatives are offered as in Round 1 of the experiment with respective payment levels of 855 MXN (855), 382 MXN (382), or 0 MXN (0), then rationale behavior suggests $U_{855} > U_{382}$, $U_{855} > U_0$, and $U_{855} > U_{382}$, U_0. For this reason, the community member selects the alternative that offers the greatest utility compared to the others.

This research is interested in identifying the alternative-specific and case-specific variables of the respondent which are most influential for the decision of a potential ES seller (provider) in a peri-urban context of common property. The data obtained from choice experiments are analyzed in three distinct ways using econometric analysis.

(i) Logistic regression - which focuses on comparing each of the two alternatives with the status quo. Hence, the dependent variable takes the values of 1 if a change in the status quo is desired and 0 otherwise. One means that the respondent prefers the alternative 1 and 2 respectively. In the first round, the alternatives are (1) PSAH and (2) PES-REDD, and in the second round, (1) Agriculture and (2) Urbanization. Zero is in the first round SC and in the second PES-REDD.

(ii) Rank-ordered logistic regression - which focuses on the absolute ranking of the submitted alternatives. This task consists of ordering the three options presented to the respondent from the highest (1) to the lowest (3) preference. The order from 1 to 3 is then a function of the qualifications assigned by the subject according to her/his preferences.

(iii) Tobit regression - which focuses on the relative valuation of the submitted alternatives. This focus uses the qualifications indicated by the respondent for the three options presented. The respondent has to assign a unique value of 1 to 10 for each option without repetition. The assigned number depends on the preferences of the individual. Later, qualifications are normalized to zero, which is the value assigned to the status quo so that other qualifications may range between -9 and 9.

Hypothesis for the dependent variable

The decision to participate voluntarily in an environmental program, a typical feature in a PES scheme, reveals information about the ES seller's preferences. Such an approach requires that the ES buyer collect additional information on the "information rents" the ES seller holds in order to avoid inefficiencies arising from asymmetric information (Ferraro, 2008). For example, the Mexican PES scheme is deficient in identifying enrolled forest areas with actually zero opportunity costs (Muñoz Piña et al., 2008), thus, causing inefficiencies in the allocation of public funds and raising additionality concerns (Engel et al., 2008). Furthermore, it is possible in the Mexican context of common property regimes that a community collectively selects PES participation, although a small group of community members (characterized as natural capital dependent) is against the contract agreement. This may imply two things: first, the community adversely selected program participation ex ante since the majority is not actually driving depletion and degradation of natural capital, and second, the minority of natural resource dependent community members has a strong incentive of hidden action ex post. Therefore, the hypothesis is that PES program participation is not always voluntary as indicated out by accepted definitions of PES, i.e. Wunder (2005). It is argued that common property regimes, such as those found in rural-urban compacts, may adversely select PES participation through majority decisions, which may lead to hidden action ex post. Common practices observed in the study area that would qualify for moral hazard are illegal LUC and land sales (see Section 3.2), motivated by a set of factors such as (Ogonowski et al., 2009): a lack of adequate supervision of notaries in the public sector, which frequently recognizes illegal land transactions; illegally-forced land transactions through threat of violence; fragility in the process of verification of land ownership; and political-electoral interests that provide an incentive with the promise of future land regulations, which is often favored by the support from government officials.

Hypotheses for two categories of independent variables

The information collected in choice experiments was used to define a set of variables to allow determine whether or not a respondent (formal or informal community member) states a preference for integrating the commons into a PES program. Of particular interest is the implication of conditionality in ES provision which is jeopardized if individuals select program participation that does not actively improve or maintain the desired land use, or if individuals who are responsible for avoidable reversals of forest carbon stocks become involved. In order to detect these information problems, this study analyzed two types of variables: case-specific and alternative-specific.

Case-specific variables Case-specific variables relate to socio-economic characteristics of respondents that are tested for explanatory relationships towards the dependent variable. In interdisciplinary research and specifically in environmental valorization studies, it is important to consider various socio-economic characteristics of respondents in order to explain stated preferences (e.g., Bateman et al., 2002). Therefore, the models presented in the result section also incorporate a limited number of case-specific variables related to the socio-economic characteristics of the respondent. This study obtained a number of variables from the application of the questionnaire (see Appendix H in section B) but was generally confronted with the constraints resulting from the experimental design. Therefore, not all variables could be employed that indicated a significant level of relationship in Chapter 6. Selected variables are used in order to explore correlations that indicate their suitability for the distinct econometric models. The hypotheses for case-specific variables are included in Table 8.1.

Alternative-specific variables Alternative-specific variables relate to three specific contract attributes that are hypothesized to influence stated preferences regarding presented alternatives: (i) responsibility and sanctions [RESSAN]; (ii) inspection [INSPEC]; and (iii) corruption [CORRUPT].

The responsibility for and sanction of avoidable reversals [RESSAN] is a critical issue for permanence but probably causes confusion within the communities in terms of equity perception. It is part of an environmental contract, such as is the case of PES, that ES sellers (providers) have to comply with their contract in order to obtain compensation in the form of direct payments or other non-monetary benefits. This conditionality implies that detected non-compliance requires some sort of penalty. The catalog typically includes loss of future benefits (temporary or permanent), repayment (completely or partially), and/or loss of access to other related programs (temporary or permanent) (see Section 2.4). Wunder et al. (2008) argues that it is likely that the threat of more severe sanctions could reduce monitoring costs due to an induced higher compliance rate, although some sanctions may be unfeasible to enforce for political and practical reasons. Consequently, all alternatives presented to respondents are related to the issue of responsibility for avoidable reversals of forest cover and associated ESs. The variable is dichotomous where 1 indicates that the community is held responsible for detected avoidable forest cover loss with the consequence of exclusion and repayment of obtained benefits, and 0 otherwise (see Appendix H). It is hypothesized that assigned responsibility with a threat of sanction decreases the probability of accepting a PES contract in the first round, but increases compliance with the same in the second round (see Table 8.1).

As stated above, it is probable that interdependency between the former alternative-specific variable and inspections [INSPEC] be observed. The challenge of environmental policies designed to protect natural resources is to identify the level of monitoring effort required in order to achieve an effective and efficient compliance. Contract compliance is closely related to the program's ability to actually MRV ES delivery and ES sellers' risk-aversion. Site visits, remote sensing or a combination of both are often found in practice to MRV conditionality of ES provision (Wunder et al., 2008). Continued funding, capability and capacity is required. Accordingly, it has been observed that monitoring imperfections usually lead to higher levels of incentive payments for ensuring compliance (Choe and Fraser, 1998), especially where ES sellers provide different levels of ES quality (Ferraro, 2008; Moxey et al., 1999). The problem is that resources are oftern scarce, so that other alternatives need to be sought out, for example internal MRV approaches building on social capital (Asquith et al., 2008; Neitzel, 2007), in order to achieve certain levels of compliance at reduced administrative costs. The determination of optimal monitoring intensity is typically subject to the interaction between MRV costs and landowners' strategic behavior such as risk-aversion (Ozanne et al., 2001). In this experiment the inspection variable turns to the issue of how the level of control may affect individual decision-making. While risk is, in theory, symmetrical, theories of risk aversion have consistently demonstrated that individuals' perception of risk may not be symmetrical (Marshall and Kelly, 2010). Accordingly, all of the alternatives presented to respondents elaborate on the issue of risk behavior when the community is faced with different levels of control. The variable is continuous at three levels and indicates if the community has a 1, 10 or 20 percent probability to be the subject of an inspection related to forest cover monitoring (see Appendix H). It is hypothesized that an increase of risk regarding inspection decreases the probability of accepting a PES contract in the first round, but increases the compliance with the same in the second round (see Table 8.1).

Trust in institutional arrangements, and the role of corruption [CORRUPT] in particular, has already been pointed out in previous chapters. In parallel with the former two alternative-specific variables (RESSAN and INSPEC), it is also necessary to demonstrate to actual and potential ES sellers (providers) the programs' ability to enforce announced penalties in the case of non-compliance (Wunder et al., 2008). Law enforcement, therefore, becomes a critical issue for considerations of conditionality as it effectively punishes any LUC that represents a breach of existing agreements. Authors such as FERN (2003) and Wunder and Albán (2008) argue that existing ill-enforced legislation can be reinforced through policy instruments such as PES, which provide an additional incentive to follow the law. However, risk aversion might also depend on equity perceptions, that is, the strategic behavior of others has led to higher individual payoffs in the past. A gradual learning effect from observed "successful" illegal activities might influence individual reasoning. For example, if a community member decided not to deforest in the past, but others deforested, s/he received a lower "individual" payoff. As a consequence, s/he might be more willing to accept the risk of being detected by the authority in the future in order to obtain a higher "individual" payoff, if s/he knows that infringement can be bargained. This might lead to a modification of the "prisoner's dilemma" assumption towards an "assurance" problem (Runge, 1981), where (individual) community members are uncertain about other community members' choices (strategic behavior). That means that the setting moves from strict independent strategies to interdependent strategies. Understanding social capital may help to evaluate how strong endogenous institutions are in terms of imposing and enforcing rules that otherwise would have to be implemented more "costly and less effective" from outside a PES-REDD contract. Accordingly, all alternatives presented to respondents elaborate on the issue of corruption present in governmental institutions that monitor avoidable forest cover loss. The variable is dichotomous where 1 indicates that corruption-like procedures are found in the government, and 0 otherwise (see Appendix H). It is hypothesized that corruption involved in natural resource management practices increases the probability of accepting a PES contract in the first round, but decreases compliance with the same in the second round (see Table 8.1).

8.3. CA results

The application of choice experiments provides input to further explore the dynamics of socio-economic conditions (case-specific variables) in the communities and alternative-specific variables that explain why a community member accepts a PES program and resists any land-use alternative that represents a moral hazard. In-depth analysis is needed to come up with meaningful explanations and interpretations of the data. Data collection builds on the CA method presented in Section 5.3, mainly inspired by Bateman et al. (2002). Data processing mainly follows the guidance of econometric regression analysis provided by Long (1997) and Long and Freese (2006). Standard statistical procedures are selected for that purpose using STATA (Version 9.1) as the main processing software. Survey data are processed in three main subsequent steps. In the first step collected data are analyzed by employing descriptive statistics. Secondly, correlations are investigated revealing their relationship to the dependent variable for the three model approaches: Logit, rank-ordered Logit and Tobit. After sufficient

Table 8.1.: Case-specific and alternative-specific variables - hypotheses

Case-specific	**Hypotheses**
COMEJI	*Ejidatarios* compared to *comuneros* are more likely to prefer a PES contract even if confronted with other land-use alternatives.
ASSEMBLY	A greater degree of assembly attendance implies a preference for PES contracts even if confronted with other land-use alternatives.
RAN	A formal access and land-use right implies a denial of PES contracts and a greater acceptance of other land-use alternatives.
SEX	Female compared to male respondents are more likely to prefer a PES contract even if confronted with other land-use alternatives.
MARITAL	A household led by a couple is more interested in a PES contract and may have a negative attitude towards other land-use alternatives.
AGE	The older the respondent the greater the preference for a PES contract but not if financially more attractive land-use alternatives are offered.
EDU	A greater degree of formal education implies a preference for PES contracts even if confronted with other land-use alternatives.
LABOR	A stable employment implies a preference for PES contracts, even if confronted with other land-use alternatives.
INCOME	A reliable source of income sufficient for the household suggests a preference for PES contracts even if confronted with other land-use alternatives.
FAMSIZE	A greater availability of work force causes less preference for PES contracts and higher acceptance of other land-use alternatives.
PARCEL	A sufficiently large parcel cultivated by the respondent's household causes less preference for PES and higher acceptance for other land-use alternatives.
PSAH	A recognized participation in a PES program increases the acceptance of PES contracts and decreases the preference for other land-use alternatives.
Alternative-specific	**Hypotheses**
RESSAN	The assigned responsibility for the community and threat of sanctions for non-compliance reduces the attractiveness of PES contracts ex ante but causes less preference for LUC alternatives ex post.
INSPEC	Greater levels of control reduce the attractiveness of PES contracts ex ante, but cause less preference for LUC alternatives ex post.
CORRUPT	The presence of corruption increases the preference for PES contracts ex ante and likely increases the preference for LUC alternatives although they represent moral hazard.

information about correlations has been gathered, the third step deals with the construction of three econometric model types in order to explain stated preferences in the experiments. The intention is to use these models to reveal if PES contracts are susceptible to adverse selection and moral hazard at the individual community member level with implications for the common property regimes located in the periphery of Mexico City.

8.3.1. Descriptive data

In this study, the objective of descriptive data analysis is to summarize meaningful data sets in a way that they can be used for the development of econometric models. Hence, descriptive data analysis is an intermediate step towards their development. Descriptive statistics describe the main features of the quantitative data set collected through the format applied in the experiment (see Appendix H). The analysis summarizes this data set into two subsequent steps: (i) summary statistics, and (ii) analysis of differences.

Summary statistics

Summary statistics are purely descriptive and indicate the observations obtained for the different variables. The results are displayed in two different tables: first, indicating the statistics for the explanatory case-specific variables of respondents, and second, showing the stated preferences for presented profile sets in two rounds.

Table 8.2 presents the descriptive statistics of case-specific variables obtained from 13 questions (see Appendix H). The table shows the number of observations, mean, standard deviation and range for each variable. The outcome demonstrates that almost 80 percent (*ejido* 19.7 %) of observations [COMEJI] stem from the agrarian community. Across respondents, the participation in the General Assembly has been less than half with 5.2 visits out of an assumed 12 assemblies per year [ASSEMBLY]. In total 66 respondents participated and 46 lived in a relationship [MARITAL25]. Respondents were mainly men with 74.2 percent [SEX1], between 16 and 77 years old with an average age of 49 [AGE1]. The education level of respondents was on average secondary schooling [EDU1] and only slightly lower for the spouse [EDU2]. About 67 percent of the respondents indicated that they have regular work (independent or employed) [LABOR1W]. Most stated that their household income ranges between MXN 3,401 to 5,100 [INCOME], and since the average family size is 4.5 [FAMISZE] this figure reduces the average income per household member significantly to an average of MXN 1,244 per month [INCOPERS]. Almost 86 percent of the respondents indicated that they or a household member holds a formal land-use right and is inscribed in the RAN [RAN123]. About 60 percent indicated that they have immediate access to a land parcel [PARCEL] and about 53 percent stated that they work or cultivate that land parcel [WORKCULT]. The average parcel size is about 0.3 hectares [PARSIZE] and 0.07 hectares per household member [PARPERS]. Only about 26 percent of the respondents recognized the community's PSAH participation.

Table 8.3 presents the frequencies of stated preferences for the sets of profiles submitted in two rounds (see Appendix H). The frequencies are a multiple of the number of observations because three sets were presented to each respondent (e.g., 66 respondents x 3 sets = 198). The table shows on the left side the frequency of answers obtained from the first round and on the right side the results from the second round. The first row indicates the stated preferences of offered alternatives compared to the status quo, and in the subsequent three rows reveals the distribution of preferences in a ranked order (rank 1 the lowest preference to rank 3 the highest preference). It can be derived from these results that the preferences in the first round were more clear-cut than in the second round. In the first round, both PES contract offers were more attractive than the status quo. Accordingly, the rank order shows that Soil Conservation (status quo) had the lowest and the PES-REDD (Alternative 2) the highest preference. However, the second round revealed that the preference for Agriculture (Alternative 1) was slightly higher than for a PES-REDD contract (status quo), but for Urbanization

Table 8.2.: Summary of statistics - case-specific variables

Variable	Explanation	N	Mean	Std. dev.	Min.	Max.
COMEJI	Community type: agrarian community [0] or ejido [1]	66	0.197	0.398	0	1
ASSEMBLY	Attendance in the general assembly per year	66	5.258	4.204	0	12
RAN1*	Respondent is registered in RAN	66	0.515	0.500	0	1
RAN2*	Spouse of the respondent is in RAN	66	0.091	0.288	0	1
RAN3*	Household member of the respondent is in RAN	66	0.258	0.438	0	1
RAN4*	Other than a household member is in RAN	66	0.136	0.343	0	1
RAN12*	Respondent or spouse is registered in RAN	66	0.606	0.489	0	1
RAN123*	Household member is registered in RAN	66	0.864	0.343	0	1
SEX1	Sex of the respondent: male [0] or female [1]	66	0.258	0.438	0	1
SEX2	Sex of the respondent's spouse: male [0] or female [1]	46	0.761	0.427	0	1
MARITAL25*	Respondent is married or common law marriage	66	0.682	0.466	0	1
AGE1	Age of the respondent	66	49.182	15.566	16	77
AGE2	Age of the respondent's spouse	46	52.261	11.979	24	79
EDU1	Education of the respondent	66	3.227	1.537	1	7
EDU1SEC*	Respondent with secondary or higher education	66	0.591	0.492	0	1
EDU2	Education of the respondent's spouse	46	2.848	1.235	1	6
EDU2SEC*	Respondent's spouse with secondary or higher education	46	0.543	0.499	0	1
EDU12SEC*	Respondent and/or spouse with secondary or higher education	66	0.682	0.466	0	1
LABOR1W*	Regular work of the respondent	66	0.667	0.472	0	1
LABOR2W*	Regular work of the respondent's spouse	46	0.457	0.499	0	1
LABOR12W*	Regular work of the respondent and/or spouse	66	0.712	0.453	0	1
INCOME	Monthly income range available to the household	66	3.303	1.979	1	7
INCOMXN	Monthly income per household (MXN)	66	4,765.152	3,363.579	850	11,050
INCOPERS	Monthly income per household member (MXN)	66	1,244.606	1,066.711	106	4,675
FAMSIZE	Family size of the household	66	4.546	1.778	1	10
PARCEL*	Individual land property in RAN	66	0.606	0.489	0	1
WORKCULT*	Work or cultivate a land parcel	66	0.530	0.499	0	1
PARSIZE	Size of worked/cultivated land (m2)	66	2,992.197	5,164.436	0	20,000
PARPERS	Size of worked/cultivated land per household member (m2)	66	713.288	1,213.556	0	4,000
PSAH*	Recognized participation in PSAH	66	0.258	0.438	0	1

*Dichotomous variable with [0]=No and [1]=Yes

(Alternative 2) the superiority of the status quo is ambiguous.

Chi-square and T-test

The analysis of differences in terms of case-specific variables improves the understanding of stated preferences regarding offered profile sets. This information provides this research study with a background for the interpretation of quantitative findings. Differences between groups are tested using both the Chi-square test in combination with cross-tabulations and the T-test of differences between means. Since the interest of this project is to detect the probability of changes in the status quo in the two rounds, the data set is analyzed as a function of two groups: the first round - SC versus PSAH (see Table 8.4) and Soil Conservation [SC] versus PSA-REDD (see Table 8.5), and the second round - PSA-REDD versus Agriculture [AGRI] (see Table 8.6) and PSA-REDD versus Urbanization [URBAN] (see Table 8.7). The decision of which test to apply depends on the data scale used to measure the variable.

Nominal and ordinal variables are analyzed through the Chi-square test. Descriptive analysis of the relationship between two variables involves cross-tabulation tables in order to identify patterns of responses that differ by the stated preference for an alternative and the Chi-square test is ued to test whether differences in responses between sample groups are significant at ≤ 0.05 (or ≤ 0.10). In contrast, interval and ratio-scaled variables are analyzed through the

Table 8.3.: Frequency table - stated preferences

Round 1					Round 2				
Number of respondents			66		Number of respondents			65	
SC vs. PSAH			25.76% : 74.24%		PES-REDD vs. AGRI			43.08% : 56.92%	
SC vs. PES-REDD			28.28% : 71.72%		PES-REDD vs. URBAN			54.87% : 45.13%	
Rank 1					Rank 1				
Alternative	No.	Frequency	%	Cum. %	Alternative	No.	Frequency	%	Cum. %
SC	1	128	64.64	64.64	PES-REDD	1	66	33.85	33.85
PSAH	2	23	11.61	76.25	AGRI	2	43	22.05	55.90
PES-REDD	3	47	23.75	100.00	URBAN	3	86	44.10	100.00
	Total	198	100.00			Total	195	100.00	
Rank 2					Rank 2				
Alternative	No.	Frequency	%	Cum. %	Alternative	No.	Frequency	%	Cum. %
SC	1	33	16.67	16.67	PES-REDD	1	67	34.36	34.36
PSAH	2	128	64.64	81.31	AGRI	2	88	45.13	79.49
PES-REDD	3	37	18.69	100.00	URBAN	3	40	20.51	100.00
	Total	198	100.00			Total	195	100.00	
Rank 3					Rank 3				
Alternative	No.	Frequency	%	Cum. %	Alternative	No.	Frequency	%	Cum. %
SC	1	37	18.69	18.69	PES-REDD	1	62	31.79	31.79
PSAH	2	47	23.74	42.43	AGRI	2	64	32.82	64.61
PES-REDD	3	114	57.57	100.00	URBAN	3	69	35.39	100.00
	Total	198	100.00			Total	195	100.00	

Independent Samples T-test. This test is used to determine the difference of means between two sample groups, to reveal whether the variables are independent of one another or not and if significant differences are found in the samples, they are interpreted as representative for the total population. The group means are considered different at a significance level of ≤ 0.05 (or ≤ 0.10). The variables to test for significant differences between groups are exposed in the following section where only significant relationships are listed[8].

Round 1: SC versus PSAH Statistical analysis of the nominal and ordinal case-specific variables shows for stated preferences in the case of SC [0] versus PSAH [1] that "Education of the respondent" [EDU1], "Respondent's spouse with secondary or higher education" [EDU2SEC], "Regular work of the respondent" [LABOR1W], "Monthly income range available to the household" [INCOME], "Individual land property in RAN" [PARCEL] and "Work or cultivate a land parcel" [WORKCULT] demonstrate significant differences at ≤ 0.05 and ≤ 0.10 (EDU1 is slightly higher) between the groups; except for "Community type: agrarian community [0] or ejido [1]" [COMEJI] (see Table 8.4). The cross-tabulation indicates for COMEJI that respondents from both agrarian community and *ejido* tend to prefer PSAH over SC so that the type of common property regime alone does not explain differences in choice. The variable EDU1 indicates that most respondents who denote a preference for SC had rela-

[8] An exception is the variable COMEJI, which is included in order to elaborate on differences in choices at the "cluster level".

tively lower levels of education - mainly primary and secondary, while respondents preferring PSAH show a more even distribution of education levels. The variable EDU2SEC reveals a distribution where the spouse opting for SC reports having studied secondary school or higher education, whereas for the alternative PSAH, the distribution is balanced. The distribution of the variable LABOR1W suggests, that in relative terms, three-fourths of the respondents that tend to favor SC have a regular job (independent or employed) while it is two-thirds for PSAH. Income distribution [INCOME] reflects that respondents favoring SC tend to have lower incomes than those favoring PSAH. The variable PARCEL shows that most respondents who prefer SC tend to have access to a parcel of land while this tendency is less pronounced for PSAH, which becomes even clearer for the variable WORKCULT where more respondents preferring PSAH actually do not work nor cultivate a plot on the common property.

Interval and ratio-scaled case-specific variables with significant differences are shown in Table 8.4. Statistics indicate that "Attendance in the General Assembly per year" [ASSEMBLY], "Age of the respondent's spouse" [AGE2] and "Monthly income per household member (MXN)" [INCOPERS] explain differences between both groups (SC versus PSAH) at a significance level of ≤ 0.05. The statistics for these variables indicate that respondents who prefer the status quo [SC] tend to attend the General Assembly [ASSEMBLY] more frequently, respondents spouses tend to be younger on average [AGE2], and the monthly income available per month for each household member seems to be lower [INCOPERS].

Round 1: SC versus PES-REDD Statistical analysis of the nominal and ordinal variables reveal for the stated preferences in the case of SC [0] versus PES-REDD [1] that "Sex of the respondent's spouse: male [0] or female [1]" [SEX2], "Respondent is married or in a free union" [MARITAL25], "Respondent's spouse with secondary or higher education" [EDU2SEC] and "Work or cultivate a land parcel" [WORKCULT] show significant differences (at ≤ 0.05 and ≤ 0.10) between the two groups; except for "Community type: agrarian community [0] or ejido [1]" [COMEJI] (see Table 8.5). The variable COMEJI suggests that respondents from both agrarian community and *ejido* tend to prefer PES-REDD over SC so that the type of common property regime alone does not explain differences in choice. The cross-tabulation indicates that most respondents with a female spouse prefer SC, compared to the group of PES-REDD where the percentage of respondents with a male spouse is greater. The variable MARITAL25 shows that respondents favoring the status quo are equally distributed among singles and those in a relationship, while for those preferring PES-REDD more respondents had a spouse. The education of the respondent's spouse [EDU2SEC] tends to be equal or higher to secondary for those preferring the status quo [SC], compared to PES-REDD where the level of education is indifferent. The variable WORKCULT reveals that more respondents who favor the status quo are working or cultivating a land parcel, while in the group of those favoring a PES-REDD, respondents tend not to work nor cultivate a parcel of land.

Table 8.4.: SC versus PSAH - 1 Round: Chi-square and T-test

Variable	Chi-square	Answer	SC	%	PSAH	%	Total	%
COMEJI	0.227	Community	38	74.5	121	82.3	159	80.3
		Ejido	13	25.5	26	17.7	39	19.7
		Total	*51*	*100.0*	*147*	*100.0*	*198*	*100.0*
EDU1	0.109	Non	3	5.9	9	6.1	12	6.1
		Primary	22	43.1	47	32.0	69	34.8
		Secondary	17	33.3	37	25.2	54	27.3
		Preparatory	2	3.9	19	12.9	21	10.6
		Technical	0	0.0	12	8.2	12	6.1
		Graduate	7	13.7	20	13.6	27	13.6
		Postgraduate	0	0.0	3	3.0	3	1.5
		Total	*51*	*100.0*	*147*	*100.0*	*198*	*100.0*
EDU2SEC	0.062	$<$ Secondary	10	31.3	53	50.0	63	45.7
		$\geq$ Secondary	22	68.8	53	50.0	75	54.3
		Total	*32*	*100.0*	*106*	*100.0*	*138*	*100.0*
LABOR1W	0.085	non-Work	12	23.5	54	36.7	66	33.3
		Work	39	76.5	93	63.3	132	66.7
		Total	*51*	*100.0*	*147*	*100.0*	*198*	*100.0*
INCOME	0.086	1	11	21.6	28	19.0	39	19.7
		2	21	41.2	30	20.4	51	25.8
		3	8	15.7	31	21.1	39	19.7
		4	2	3.9	10	6.8	12	6.1
		5	2	3.9	7	4.8	9	4.5
		6	4	7.8	29	19.7	33	16.7
		7	3	5.9	12	8.2	15	7.6
		Total	*51*	*100.0*	*147*	*100.0*	*198*	*100.0*
PARCEL	0.090	No	15	29.4	63	42.9	78	39.4
		Yes	36	70.6	84	57.1	120	60.6
		Total	*51*	*100.0*	*147*	*100.0*	*198*	*100.0*
WORKCULT	0.000	No	12	23.5	81	55.1	93	47.0
		Yes	39	76.5	66	44.9	105	53.0
		Total	*51*	*100.0*	*147*	*100.0*	*198*	*100.0*
Variable	**T-test**	**Group**	**N**	**Mean**		**Std. deviation**		**Std. error mean**
ASSEMBLY	0.000	SC	51	7.20		4.25		0.59
		PSAH	147	4.59		3.99		0.33
AGE2	0.005	SC	32	47.03		12.04		2.13
		PSAH	106	53.84		11.60		1.13
INCOPERS	0.043	SC	51	984.61		842.77		118.01
		PSAH	147	1,334.81		1,124.94		92.78

Interval and ratio-scaled variables with significant differences are shown in Table 8.5. The statistics suggest that "Attendance in the General Assembly per year" [ASSEMBLY] and "Size of worked/cultivated land (m2)" [PARSIZE] explain differences between both groups (SC versus PES-REDD) at a significance level of $\leq$ 0.05 (or $\leq$ 0.10). The statistics for ASSEMBLY indicate that respondents stating their preference for SC (status quo), attend the General Assembly more frequently. The variable PARSIZE shows that the group preferring PES-REDD actually tend to have greater sizes of land.

Table 8.5.: SC versus PES-REDD - 1 Round: Chi-square and T-test

Variable	Chi-square	Answer	SC	%	REDD	%	Total	%
COMEJI	0.683	Community	46	82.1	113	79.6	159	80.3
		Ejido	10	17.9	29	20.4	39	19.7
		Total	*56*	*100.0*	*142*	*100.0*	*198*	*100.0*
SEX2	0.056	Male	4	11.8	29	27.9	33	23.9
		Female	30	88.2	75	72.1	105	76.1
		Total	*34*	*100.0*	*104*	*100.0*	*138*	*100.0*
MARITAL25	0.079	Single	23	41.1	40	28.2	63	31.8
		Couple	33	58.9	102	71.8	135	68.2
		Total	*56*	*100.0*	*142*	*100.0*	*198*	*100.0*
EDU2SEC	0.073	$<$ Secondary	11	32.4	52	50.0	63	45.7
		$\geq$ Secondary	23	67.6	52	50.0	75	54.3
		Total	*34*	*100.0*	*104*	*100.0*	*138*	*100.0*
WORKCULT	0.046	No	20	35.7	73	51.4	93	47.0
		Yes	36	64.3	69	48.6	105	53.0
		Total	*56*	*100.0*	*142*	*100.0*	*198*	*100.0*
Variable	**T-test**	**Group**	**N**	**Mean**		**Std. deviation**		**Std. error mean**
ASSEMBLY	0.000	SC	56	7.16		4.29		0.57
		PES-REDD	142	4.51		3.95		0.33
PARSIZE	0.074	SC	56	1,947.70		3,613.47		482.87
		PES-REDD	142	3,404.11		5,629.65		472.43

Round 2: PES-REDD versus AGRI Statistical analysis of the nominal and ordinal explanatory variables shows for stated preferences in the case of PES-REDD [0] versus AGRI [1] that "Community type: agrarian community [0] or ejido [1]" [COMEJI], "Respondent is registered in the RAN" [RAN1], "Respondent is married or in a free union" [MARITAL25], "Education of the respondent" [EDU1], "Regular work of the respondent" [LABOR1W], "Regular work of the respondent's spouse" [LABOR2W], "Regular work of the respondent and/or spouse" [LABOR12W], "Monthly income range available to the household" [INCOME], "Individual land property in RAN" [PARCEL] and "Work or cultivate a land parcel" [WORKCULT] demonstrated significant differences (at ≤ 0.05 and ≤ 0.10) between the groups (see Table 8.6). The cross-tabulation indicates for COMEJI that respondents belonging to an agrarian community tend to be equally divided between PES-REDD and AGRI, while *ejidatarios* demonstrate a week tendency for selecting AGRI. The variable RAN1 shows that respondents registered in the RAN tend to be the majority in the group of those favoring PES-REDD, while for those preferring AGRI the relationship is inverse. Three-fourths of the respondents in the group of PES-REDD are not single [MARITAL25], compared to two-thirds in the group of AGRI. The education level of the respondents [EDU1] denotes a tendency that stating a preference for PES-REDD (status) implies higher education levels than for those favoring the alternative (AGRI). For the three variables related to the labor status, the patterns are quite similar, except for LABOR2W. Respondents who indicated a preference for PES-REDD are more likely to have regular work (independent or employed). This trend is also reflected for the group of

those respondents preferring agricultural land-use but is actually less significant and for the variable LABOR2W even reversed (more spouses tend to have no regular work). The variable for INCOME demonstrates that those respondents preferring AGRI tend to have a lower range of monthly income available to the household. Two variables directly related to land-use indicate a significant difference between both groups. In the group of respondents favoring a PES-REDD, two-thirds tend to have a direct access to a land parcel [PARCEL] and slightly less also work and cultivate it [WORKCULT]. While in the group of respondents in favor of an agricultural alternative direct access [PARCEL] suggests indifference (only slightly higher for those with access) and working or cultivating land [WORKCULT] denotes only a slightly higher preference for those that actually do not.

Interval and ratio-scaled explanatory variables with significant differences are shown in Table 8.6. The statistics indicate that "Attendance in the General Assembly per year" [ASSEMBLY], "Monthly income per household member (MXN)" [INCOPERS] and "Size of worked/cultivated land (m2)" [PARSIZE] explain significant differences between both groups (PES-REDD versus AGRI) at a significance level of ≤ 0.05 (or ≤ 0.10). The statistics for ASSEMBLY reveal that respondents preferring PES-REDD (status quo) attend the General Assembly more frequently than those opting for AGRI. Furthermore, respondents who indicated their preference for PES-REDD have on average a higher income per household member available [INCOPERS] but have access to smaller land property [PARSIZE].

Round 2: PES-REDD versus URBAN Statistical analysis of the nominal and ordinal variables denotes for the stated preferences in the case of PES-REDD [0] versus URBAN [1] that "Sex of the respondent: male [0] or female [1]" [SEX1], "Sex of the respondent's spouse: male [0] or female [1]" [SEX2], "Respondent is married or in a common law marriage" [MARITAL25], "Education of the respondent" [EDU1], "Respondent with secondary or higher education" [EDU1SEC], "Education of the respondent's spouse" [EDU2], "Respondent's spouse with secondary or higher education" [EDU2SEC], "Respondent and/or spouse with secondary or higher education" [EDU12SEC] and "Work or cultivate a land parcel" [WORKCULT] demonstrated significant differences (at ≤ 0.05 and ≤ 0.10) between the two groups; except for "Community type: agrarian community [0] or ejido [1]" [COMEJI] (see Table 8.7). The cross-tabulation shows for COMEJI that respondents from both agrarian community and *ejido* are equally divided between PES-REDD and URBAN so that the variable alone does not explain differences in choice. The variables SEX1 and SEX2 indicate, respectively, that the status quo [PES-REDD] and infrastructure alternatives [URBAN] are equally preferred among male respondents, while female respondents preferred PES-REDD. The variable MARITAL25 further suggests that a respondent with a spouse is not necessarily attracted by one of the two alternatives, while singles opt for PES-REDD. There are five variables referring to the education level of the respondent and her/his spouse that highlight a significant difference between the two

Table 8.6.: PES-REDD versus AGRI - 2 Round: Chi-square and T-test

Variable	Chi-square	Answer	REDD	%	AGRI	%	Total	%
COMEJI	0.083	Community	72	85.7	84	75.7	156	80.0
		Ejido	12	14.3	27	24.3	39	20.0
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*
RAN1	0.066	No	35	41.7	61	55.0	96	49.2
		Yes	49	58.3	50	45.0	99	50.8
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*
MARITAL25	0.058	Single	21	25.0	42	37.8	63	32.3
		Couple	63	75.0	69	62.2	132	67.7
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*
EDU1	0.061	Non	7	8.3	5	4.5	12	6.2
		Primary	23	27.4	43	38.7	66	33.8
		Secondary	28	33.3	26	23.4	54	27.7
		Preparatory	9	10.7	12	10.8	21	10.8
		Technical	2	2.4	10	9.0	12	6.2
		Graduate	12	14.3	15	13.5	27	13.8
		Postgraduate	3	3.6	0	0.0	3	1.5
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*
LABOR1W	0.023	non-Work	21	25.0	45	40.5	66	33.8
		Work	63	75.0	66	59.5	129	66.2
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*
LABOR2W	0.037	non-Work	29	46.0	46	63.9	75	55.6
		Work	34	54.0	26	36.1	60	44.4
		Total	*63*	*100.0*	*72*	*100.0*	*135*	*100.0*
LABOR12W	0.016	non-Work	17	20.2	40	36.0	57	29.2
		Work	67	79.8	71	64.0	138	70.8
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*
INCOME	0.011	1	8	9.5	31	27.9	39	20.0
		2	19	22.6	29	26.1	48	24.6
		3	20	23.8	19	17.1	39	20.0
		4	6	7.1	6	5.4	12	6.2
		5	5	6.0	4	3.6	9	4.6
		6	21	25.0	12	10.8	33	16.9
		7	5	6.0	10	9.0	15	7.7
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*
PARCEL	0.051	No	27	32.1	51	45.9	78	40.0
		Yes	57	67.9	60	54.1	117	60.0
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*
WORKCULT	0.020	No	32	38.1	61	55.0	93	47.7
		Yes	52	61.9	50	45.0	102	52.3
		Total	*84*	*100.0*	*111*	*100.0*	*195*	*100.0*

Variable	T-test	Group	N	Mean	Std. deviation	Std. error mean
ASSEMBLY	0.018	PES-REDD	84	6.15	3.59	0.39
		AGRI	111	4.72	4.51	0.43
INCOPERS	0.007	PES-REDD	84	1,480.63	1,188.43	129.67
		AGRI	111	1,065.17	950.77	90.24
PARSIZE	0.100	PES-REDD	84	2,256.44	4,149.57	452.76
		AGRI	111	3,494.72	5,844.41	554.73

groups. The pattern observed is that generally higher levels of education ($\geq$ secondary) relate to a preference for PES-REDD, while in the group of less educated URBAN is more selected. Finally, the variable WORKCULT demonstrates that those working or cultivating land parcels indicate their desire to participate in a PES-REDD scheme, while those respondents who do not obtain benefits from active cultivation do prefer an alternative such as urbanization.

The only interval explanatory variable found with significant differences is displayed in Table 8.7. The statistics suggest that "Attendance in the General Assembly per year" [ASSEMBLY] explains significant differences (≤ 0.05) between both groups. The tendency for ASSEMBLY indicates that respondents prefer PES-REDD in particular if they are attending the General Assembly more frequently.

8.3.2. Correlation analysis

The purpose of constructing an econometric model is to identify a composite of variables that jointly explain why a respondent selects a certain alternative that is characterized by a set of alternative-specific variables. Accordingly, the set of quantitative data is mined for interrelationships that indicate their suitability for a regression model. The intermediate step of analysis is a filtration of variables by calculating coefficients of linear correlation among variables and selecting those variables which have plausible and statistically significant coefficients. It is assumed that the combination of variables, proving the most instrumental for explaining stated preferences in the survey area, differs in ways that are somewhat predictable. Therefore, the strongest individual variables that distinguish between presented profile sets are selected. The statistical procedure of filtering variables follows a two-step approach: first, linear correlation coefficients are calculated, and second, variables are selected based on plausible correlation and significance testing. The linear correlation coefficient procedure is the primary means of filtering in order to determine which variables best appear to capture relative differences among respondents in the studied context.

Pearson's Linear Correlation Coefficient is a statistical procedure used to measure the degree of association between two variables and denotes the direction of the relationship. The results from the second step of the filtering process are shown in Table 8.8 in order to provide a plausible data set to fit the three econometric regression models: (i) Logit - comparing options; (ii) rank-ordered Logit - ordering options; and (iii) Tobit - evaluating options. Due to the reduced sample size (N=66), variables up to a significance level of $p \leq 0.10$ were included and case-specific variables which revealed rather modest (to low) correlation coefficients were also included.

Table 8.8 displays Pearson's Correlation Coefficients $[r]$ for the case-specific variables which relate to different dependent variables used to construct the econometric regression models. These variables represent the outcome of this intermediate filtering process and are used for fitting the regression models. Positive correlation coefficients indicate that the independent case-specific variable favors an alternative compared to the status quo, while a negative value reduces the probability for changing the status quo. The left column of the table indicates the

Table 8.7.: PES-REDD versus URBAN - 2 Round: Chi-square and T-test

Variable	Chi-square	Answer	REDD	%	URBAN	%	Total	%
COMEJI	0.886	Community	86	80.4	70	79.5	156	80.0
		Ejido	21	19.6	18	20.5	39	20.0
		Total	*107*	*100.0*	*88*	*100.0*	*195*	*100.0*
SEX1	0.049	Male	73	68.2	71	80.7	144	73.8
		Female	34	31.8	17	19.3	51	26.2
		Total	*107*	*100.0*	*88*	*100.0*	*195*	*100.0*
SEX2	0.050	Male	22	31.4	11	16.9	33	24.4
		Female	48	68.6	54	83.1	102	75.6
		Total	*70*	*100.0*	*65*	*100.0*	*135*	*100.0*
MARITAL25	0.095	Single	40	37.4	23	26.1	63	32.3
		Couple	67	62.6	65	73.9	132	67.7
		Total	*107*	*100.0*	*88*	*100.0*	*195*	*100.0*
EDU1	0.022	Non	5	4.7	7	8.0	12	6.2
		Primary	32	29.9	34	38.6	66	33.8
		Secondary	37	34.6	17	19.3	54	27.7
		Preparatory	7	6.5	14	15.9	21	10.8
		Technical	5	4.7	7	8.0	12	6.2
		Graduate	18	16.8	9	10.2	27	13.8
		Postgraduate	3	2.8	0	0.0	3	1.5
		Total	*107*	*100.0*	*88*	*100.0*	*195*	*100.0*
EDU1SEC	0.088	$<$ Secondary	37	34.6	41	46.6	78	40.0
		$\geq$ Secondary	70	65.4	47	53.4	117	60.0
		Total	*107*	*100.0*	*88*	*100.0*	*195*	*100.0*
EDU2	0.011	Non	1	1.4	8	12.3	9	6.7
		Primary	24	34.3	27	41.5	51	37.8
		Secondary	28	40.0	17	26.2	45	33.3
		Preparatory	10	14.3	2	3.1	12	8.9
		Technical	4	5.7	8	12.3	12	8.9
		Graduate	3	4.3	3	4.6	6	4.4
		Postgraduate	0	0.0	0	0.0	0	0.0
		Total	*70*	*100.0*	*65*	*100.0*	*135*	*100.0*
EDU2SEC	0.034	$<$ Secondary	25	35.7	35	53.8	60	44.4
		$\geq$ Secondary	45	64.3	30	46.2	75	55.6
		Total	*70*	*100.0*	*65*	*100.0*	*135*	*100.0*
EDU12SEC	0.031	$<$ Secondary	26	24.3	34	38.6	60	30.8
		$\geq$ Secondary	81	75.7	54	61.4	135	69.2
		Total	*107*	*100.0*	*88*	*100.0*	*195*	*100.0*
WORKCULT	0.043	No	44	41.1	49	55.7	93	47.7
		Yes	63	58.9	39	44.3	102	52.3
		Total	*107*	*100.0*	*88*	*100.0*	*195*	*100.0*
Variable	**T-test**	**Group**	**N**	**Mean**		**Std. deviation**		**Std. error mean**
ASSEMBLY	0.002	REDD	107	6.17		4.00		0.39
		URBAN	88	4.33		4.22		0.45

significant values of the first round and the right side shows the results for the second round.

- The first section indicates the outcome for the dichotomous dependent variable of comparisons that takes a value of zero (0) for the status quo (round 1: SC and round 2 PES-REDD) and one (1) if Alternative 1 (round 1: PSAH and round 2: AGRI) or Alternative 2 (round 1: PES-REDD and round 2: URBAN) is selected.

- The middle part denotes the output for the dependent variable of ordered options that takes values of 1, 2 or 3 (1 = low, 2 = middle, 3 = high) for Alternative 1 (or Alternative 2) indicating a change of the status quo if ranked high.
- The bottom section shows the relation for the dependent variable of evaluating alternative options with the qualifications -9 to 9 appointed to Alternative 1 (or Alternative 2) indicating a change of the status quo if positive.

8.3.3. Econometric model results

The independent variables used for further analysis have been obtained from the previous section through correlation analysis between the dependent variable (stated preference) and associated independent (case-specific) variables. In this section, the resulting set of potential independent variables is further screened through econometric analysis in order to lose the least amount of information and identify those variables with the greatest potential for statistical interpretation. In the rest of this section, the results from three types of econometric regression models are presemted: (i) Logit; (ii) rank-ordered Logit; and (iii) Tobit. This analysis included the responses of 66 respondents (65 in the second round) for the construction of the econometric models. There is no evidence of multicollinearity in any model since the Variance Inflation Factor (VIF) in all cases falls below 10. Equally, the Breusch-Pagan/Cook-Weisberg test for heteroscedasticity suggests that the null hypothesis of constant variance is accepted, which implies that no problem of heteroscedasticity exists in the presented models[9].

Logit models

Logistic regression, also called a Logit model, is used to model a dichotomous outcome variable (dependent variable). The four Logit models presented here consider the following dependent variables: first round, SC [0] versus PSAH [1] and SC [0] versus PSA-REDD [1], and second round, PSA-REDD [0] versus AGRI [1] and PSA-REDD [0] versus URBAN [1]. In the Logit model the log odds of the outcome is modeled as a linear combination of the predictor variables (independent variables). Because the respondents were confronted with three profile sets per round, the Logit model has 198 (195) observations.

Round 1: SC versus PSAH The resulting Logit model determined the variables that explain why a respondent in the study area associated with a common property regime prefers to change the status quo [SC] and selects PSAH. The dependent variable in the model is labeled $PSAH$

[9]There is only one exception: the first Tobit model for SC versus PES programs. The case-specific variables ASSEMBLY and LABOR12W would have to be excluded in order to accept constant variance. However, since their exclusion does not affect the magnitude and signs of the other coefficients significantly, and in other models these variables explained stated preferences, they were kept in the representation below.

Table 8.8.: Correlation coefficients

Round 1	Indicator	r	p	n	Round 2	Indicator	r	p	n
SC [0] vs. PSAH [1]					PES-REDD [0] vs. AGRI [1]				
1	ASSEMBLY	-0.272	0.000	198	1	COMEJI	0.124	0.084	195
2	AGE2	0.240	0.005	138	2	ASSEMBLY	-0.170	0.018	195
3	EDU1	0.125	0.080	198	3	RAN1	-0.132	0.067	195
4	EDU2	-0.137	0.108	138	4	MARITAL25	-0.136	0.058	195
5	EDU2SEC	-0.159	0.063	138	5	LABOR1W	-0.163	0.023	195
6	LABOR1W	-0.123	0.087	198	6	LABOR2W	-0.179	0.038	135
7	INCOME	0.166	0.019	198	7	LABOR12W	-0.172	0.016	195
8	INCOPERS	0.144	0.043	198	8	INCOME	-0.192	0.007	195
9	PARCEL	-0.120	0.091	198	9	INCOPERS	-0.192	0.007	195
10	WORKCULT	-0.277	0.000	198	10	PARCEL	-0.140	0.052	195
					11	WORKCULT	-0.167	0.020	195
					12	PARSIZE	0.118	0.100	195
SC [0] vs. PES-REDD [1]					PES-REDD [0] vs. URBAN [1]				
1	ASSEMBLY	-0.285	0.000	198	1	ASSEMBLY	-0.219	0.002	195
2	SEX2	-0.163	0.056	138	2	SEX1	-0.141	0.049	195
3	MARITAL25	0.125	0.080	198	3	SEX2	0.169	0.051	135
4	EDU2SEC	-0.153	0.074	138	4	MARITAL25	0.120	0.096	195
5	WORKCULT	-0.142	0.047	198	5	EDU1SEC	-0.122	0.089	195
6	PARSIZE	0.127	0.074	198	6	EDU2SEC	-0.182	0.034	135
					7	EDU12SEC	-0.155	0.031	195
					8	WORKCULT	-0.145	0.043	195
Alternative 1	PSAH [1,3]				Alternative 1	AGRI [1,3]			
1	COMEJI	-0.125	0.080	198	1	COMEJI	0.171	0.017	195
2	RAN3	-0.123	0.085	198	2	SEX1	-0.151	0.035	195
3	RAN12	0.150	0.035	198	3	MARITAL25	-0.198	0.006	195
4	AGE2	0.240	0.005	138	4	LABOR2W	-0.214	0.013	135
5	EDU2	-0.151	0.077	138	5	PARSIZE	0.180	0.012	195
6	LABOR12W	-0.136	0.056	198	6	PARPERS	0.151	0.036	195
7	WORKCULT	-0.152	0.033	198					
Alternative 2	PES-REDD [1,3]				Alternative 2	URBAN [1,3]			
1	ASSEMBLY	-0.284	0.000	198	1	ASSEMBLY	-0.227	0.001	195
2	SEX1	0.121	0.090	198	2	MARITAL25	0.155	0.031	195
3	SEX2	-0.185	0.030	138	3	AGE2	0.169	0.050	135
4	EDU2SEC	-0.139	0.104	138	4	EDU1	-0.150	0.037	195
5	WORKCULT	-0.115	0.106	198	5	EDU1SEC	-0.139	0.052	195
					6	EDU2SEC	-0.148	0.086	135
					7	EDU12SEC	-0.178	0.013	195
					8	LABOR1W	-0.119	0.097	195
					9	WORKCULT	-0.152	0.034	195
Alternative 1	PSAH [-9,9]				Alternative 1	AGRI [-9,9]			
1	ASSEMBLY	-0.127	0.076	198	1	ASSEMBLY	-0.124	0.048	195
2	RAN12	0.115	0.106	198	2	SEX1	-0.229	0.001	195
3	AGE2	0.265	0.002	138	3	SEX2	0.208	0.015	135
4	EDU2	-0.163	0.057	138	4	LABOR2W	-0.146	0.092	135
5	LABOR1W	-0.182	0.010	198	5	INCOME	-0.126	0.080	195
6	LABOR12W	-0.149	0.037	198	6	INCOPERS	-0.122	0.088	195
7	WORKCULT	-0.186	0.009	198	7	FAMSIZE	-0.132	0.066	195
					8	WORKCULT	-0.142	0.048	195
					9	PARSIZE	0.115	0.110	195
Alternative 2	REDD [-9,9]				Alternative 2	URBAN [-9,9]			
1	ASSEMBLY	-0.257	0.000	198	1	ASSEMBLY	-0.290	0.000	195
2	SEX2	-0.157	0.065	138	2	EDU12SEC	-0.128	0.075	195
3	MARITAL25	0.194	0.006	198	3	WORKCULT	-0.216	0.002	195
4	WORKCULT	-0.138	0.053	198	4	PSAH	-0.120	0.095	195

r: correlation coefficient; p: level of significance; n: observations from N=198

and takes the value of one (1) if the set of independent variables indicate a stated preference for PSAH, and zero (0) if the status quo was selected. The Logit model for the dependent variable is estimated by the following expression:

$$PSAH = x_0 + x_1 * ASSEMBLY + x_2 * INCOPERS + x_3 * WORKCULT \\ + x_4 * RESSAN + x_5 * INSPEC + x_6 * CORRUPT + \epsilon_i \tag{8.1}$$

The results of the estimations derived from the econometric model are shown in Table 8.9. The variables jointly explain the dependent variable at a significance level of ≤ 0.05. The summary statistics obtained from the model reveal that out of 198 observations, 74 percent of the subjects indicated their preference to participate in PSAH. Likewise, all the coefficients of the independent variables with their marginal effects are statistically significant at ≤ 0.05, except INSPEC (> 0.10). The six independent variables of the econometric model helped to explain why a respondent with access to common property prefers the PES program.

Table 8.9.: Round 1: SC versus PSAH - Logit

Log likelihood	-91.205048					Number of obs.		198
Marginal effects after Logit						LR chi2(6)		43.51
y =	Pr(PSAH)					Prob > chi2		0.0000
=	0.7996798					Pseudo R2		0.1926
Variable	**dy/dx**	**%****	**Std. Error**	**z**	**P>|z|**	[95% $C.I.$]		**X**
ASSEMBLY	-0.0289805	-16.5	0.0072	-4.03	0.000	-0.04309	-0.014871	5.25758
INCOPERS	0.0000854	0.1	0.00003	2.71	0.007	0.000024	0.000147	1,244.61
WORKCULT*	-0.2245817	-76.2	0.05831	-3.85	0.000	-0.338861	-0.110302	0.530303
RESSAN*	-0.2147725	-70.7	0.08515	-2.52	0.012	-0.381658	-0.047887	0.368687
INSPEC	-0.0095698	-5.8	0.03877	-0.25	0.805	-0.085551	0.066412	0.984848
CORRUPT*	0.1447325	173.0	0.06372	2.27	0.023	0.01984	0.269625	0.323232

(*) dy/dx is for discrete change of the dummy variable from 0 to 1
(**) % is for percentage change in odds for unit increase in X

The three case-specific independent variables referring to socio-economic characteristics of the respondent have mixed signs. For interpretation, the percentage change in odds is used, which implies that all other variables are held constant. The variable ASSEMBLY is negatively related with the dependent variable. For each additional attendance in the General Assembly, the odds of selecting PSAH decrease by 16.5 percent. On average, the respondents stated that they attended five General Assembly meetings in the last year. The model denotes for the variable INCOPERS that a unit increase in available income per household member, the odds of selecting the PES program increases by 0.1 percent. Observations show that a household member has on average an available budget of MXN 1,245 per month. Finally, the variable WORKCULT has a negative sign, which suggests that working or cultivating a land parcel decreases the odds by 76.2 percent that a respondent will select the PES program. About 53 percent of the respondents confirmed that they work or cultivate a land parcel within shared common property.

The three alternative-specific independent variables referring to profile attributes have mixed signs as well, although INSPEC is not significant. The variables RESSAN and INSPEC are both negatively related to the dependent variable, while CORRUPT shows a positive influence. The percentage change in odds for RESSAN reveals that assigning the responsibility for avoidable reversals to the community decreases the odds of selecting the PSAH contract by 70.7 percent. A similar tendency holds true for the variable INSPEC where an increase in government control provokes that the odds of stating a preference for PSAH decreases by 5.8 percent. Corruption [CORRUPT] in the government institutions administrating the alternatives affect the odds of selecting the PSAH contract, increasing it by 173 percent.

Round 1: SC versus PES-REDD The resulting Logit model determined the variables which explain why a respondent in the study area associated with a common property regime prefers selecting a PES-REDD scheme, which implies a change of the status quo [SC]. The dependent variable in the model is labeled $PES - REDD$ and takes the value of one (1) if the set of independent variables indicate a stated preference for PES-REDD participation, and zero (0) if the respondent desired the status quo. The Logit model for the dependent variable is estimated by the following expression:

$$\begin{aligned} PES - REDD = x_0 + x_1 * ASSEMBLY + x_2 * WORKCULT + x_3 * PARSIZE \\ + x_4 * RESSAN + x_5 * INSPEC + x_6 * CORRUPT + \epsilon_i \end{aligned} \tag{8.2}$$

The results of the estimates derived from the econometric model appear in Table 8.10. The variables jointly explain the dependent variable at a significance level of ≤ 0.05. The summary statistics obtained from the model reveal that out of 198 observations, 72 percent of the subjects indicated their preference to participate in a PES-REDD contract. Likewise, all the coefficients of the independent case-specific variables with their marginal effects are statistically significant at ≤ 0.05, except for the alternative-specific variables RESSAN, INSPEC and CORRUPT (all > 0.10). The six independent variables of the econometric model contribute to an understanding why a community member with access to the common property prefers participation in the PES program.

The three independent case-specific variables referring to socio-economic characteristics of the respondent have mixed signs. The variable ASSEMBLY is negatively related with the dependent variable. On average, the respondents stated that they attended five General Assembly meetings in the last year. For each additional attendance in the General Assembly, the odds of selecting PES-REDD decrease by 13.8 percent, holding all other variables constant. The variable WORKCULT also has a negative sign and descriptive statistics denote that 53 percent work or cultivate a land parcel. This indicates that for those working or cultivating a land parcel, the odds of selecting the PES program decrease by 70.3 percent. The variable PARSIZE denotes a positive relation with the dependent variable. For an additional unit of

Table 8.10.: Round 1: SC versus PES-REDD - Logit

Log likelihood	-102.30526						Number of obs.	198
Marginal effects after Logit							LR chi2(6)	31.25
y =	Pr(REDD)						Prob > chi2	0.0000
=	0.75429037						Pseudo R2	0.1325
Variable	**dy/dx**	**%****	**Std. Error**	**z**	**P>|z|**	[95% $C.I.$]		**X**
ASSEMBLY	-0.0274679	-13.8	0.00761	-3.61	0.000	-0.042387	-0.012548	5.25758
WORKCULT*	-0.2195304	-70.3	0.06822	-3.22	0.001	-0.353237	-0.085824	0.530303
PARSIZE	0.0000261	0.0	0.00001	2.95	0.003	0.000008	0.000043	2,992.2
RESSAN*	-0.0931266	-38.3	0.08741	-1.07	0.287	-0.264445	0.078191	0.333333
INSPEC	-0.0342502	-16.9	0.0428	-0.80	0.424	-0.118141	0.049641	1.0303
CORRUPT*	-0.0970189	-39.6	0.09208	-1.05	0.292	-0.277491	0.083453	0.343434

(*) dy/dx is for discrete change of the dummy variable from 0 to 1
(**) % is for percentage change in odds for unit increase in X

land available to the respondent, the likelihood of choosing the PES program increases only marginal in relation to the square meter measurement of land. However, the observations show that a respondent has on average access to 0.3 hectares.

The three independent alternative-specific variables referring to the profile attributes all have negative signs, but do not demonstrate significance. The variable RESSAN reveals that for assigning responsibility for avoidable reversals to the community, the likelihood of selecting the PES-REDD contract decreases by 38.3 percent. A similar tendency holds true for the variable INSPEC where an increase of inspections by government institutions decreases the probability of choosing the PES program by 16.9 percent. Equally, for the presence of corruption [CORRUPT] in the government institutions administrating the alternatives, the odds of selecting the PES-REDD contract decreased by 39.6 percent.

Round 2: PES-REDD versus AGRI The resulting Logit model of comparing PES-REDD versus AGRI determined the variables that explain why a respondent in the study area associated with a common property regime prefers to deviate from a PES-REDD contract (status quo) and selects an agricultural land-use alternative [AGRI]. The dependent variable in the model is labeled $AGRI$ and takes the value of one (1) if the set of independent variables indicates a stated preference for an agricultural land-use alternative, and zero (0) if s/he desires the status quo. The Logit model for the dependent variable is estimated by the following expression:

$$\begin{aligned}AGRI = x_0 + x_1 * ASSEMBLY + x_2 * MARITAL25 + x_3 * LABOR12W \\ +x_4 * INCOME + x_5 * WORKCULT + x_6 * PARSIZE \\ +x_7 * RESSAN + x_8 * INSPEC + x_9 * CORRUPT + \epsilon_i\end{aligned} \tag{8.3}$$

The results of the estimates derived from the econometric model are shown in Table 8.11. The variables jointly explain the dependent variable at a significance level of ≤ 0.05. The summary statistics obtained from the model reveal that out of 195 observations, 57 percent of the subjects indicated a preference for agricultural land-use [AGRI]. Likewise, all the coefficients of the independent variables with their marginal effects are statistically significant at ≤ 0.05, except for RESSAN (> 0.10) and CORRUPT (≤ 0.10). The nine independent variables of the econometric model denote why a respondent with access to common property is likely to deviate from the PES-REDD contract.

Table 8.11.: Round 2: PES-REDD versus AGRI - Logit

Log likelihood	-107.99495						Number of obs.	195
Marginal effects after Logit							LR chi2(6)	50.59
y =	Pr(AGRI)						Prob > chi2	0.0000
=	0.59585307						Pseudo R2	0.1898
Variable	**dy/dx**	**%****	**Std. Error**	**z**	**P>|z|**	[95%$C.I.$]		**X**
ASSEMBLY	-0.0239679	-9.5	0.01026	-2.34	0.020	-0.044086	-0.00385	5.33846
MARITAL25*	-0.2487658	-66.8	0.08056	-3.09	0.002	-0.406662	-0.09087	0.676923
LABOR12W*	-0.2192035	-62.1	0.08531	-2.57	0.010	-0.386405	-0.052002	0.707692
INCOME	-0.0711081	-25.6	0.02148	-3.31	0.001	-0.113208	-0.029008	3.32308
WORKCULT*	-0.2344742	-63.1	0.0939	-2.50	0.013	-0.418524	-0.050425	0.523077
PARSIZE	0.0000334	0.0	0.00001	3.27	0.001	0.000013	0.000053	2,961.31
RESSAN*	-0.0040633	-1.7	0.09291	-0.04	0.965	-0.186164	0.178037	0.292308
INSPEC	0.1542499	89.8	0.05424	2.84	0.004	0.047932	0.260568	1.12308
CORRUPT*	-0.1707772	-50.3	0.09887	-1.73	0.084	-0.364557	0.023003	0.292308

(*) dy/dx is for discrete change of the dummy variable from 0 to 1
(**) % is for percentage change in odds for unit increase in X

The six independent case-specific variables referring to socio-economic characteristics of the respondent have negative signs, except for PARSIZE. The coefficient of ASSSEMBLY suggests that for each additional attendance in the General Assembly, the odds of selecting an agricultural land-use alternative [AGRI] decreases by 9.5 percent, holding all other variables constant. On average, respondents stated that they attended five General Assembly meetings in the last year. The weight of the coefficient for MARITAL25 indicates that for a respondent with a spouse, the likelihood of selecting AGRI decreases by 66.8 percent. The observations show that 68 percent of the respondents are in a relationship. The LABOR12W variable reveals that nearly 71 percent of the respondents (or their spouses) have regular work. The respective coefficient denotes for at least one of the couple having regular work, the odds of selecting AGRI decreases by 62.1 percent. Accordingly, the coefficient of the variable INCOME shows that for a one unit increase in the income level, the odds of choosing the AGRI alternative decreases by 25.6 percent. The observations show that a household has on average an available budget range between MXN 3,401 to 5,100 per month. The variable WORKCULT indicates for those working or cultivating a land parcel, the odds of selecting AGRI decreases by 63.1 percent. About 52 percent of the respondents confirmed that they work or cultivate a land parcel within the common property. However, the effect of the variable PARSIZE is contrary, indicating that for an additional unit of land property available to the respondent, the odds of stating a preference for AGRI increased but only marginally (0.0 percent). This is because the unit of the measurement is in square meters. On average, respondents indicated that they individually have access to 0.3 hectares.

The three independent alternative-specific variables referring to profile attributes have mixed signs, RESSAN was the only non-significant coefficient. The variable RESSAN revealed that for assigning the responsibility of avoidable forest cover loss to the community, the likelihood of selecting an agricultural alternative [AGRI] decreased by 1.7 percent. On the other hand, if government institution control efforts [INSPEC] increase, the odds of choosing AGRI also increased by 89.8 percent. The last alternative-specific variable CORRUPT reported a coefficient that suggested that for corruption in government institutions administrating the alternatives, the odds of opting to AGRI decreased by 50.3 percent.

Round 2: PES-REDD versus URBAN The resulting Logit model determined the variables that explained why a respondent in the study area associated with a common property regime prefers to deviate from a PES-REDD contract (status quo) celebrated through the General Assembly and select urbanization [URBAN] of the property of land. The dependent variable in the model is labeled $URBAN$ and takes the value of one (1) if the set of independent variables indicates a stated preference for URBAN, and zero (0) if the respondent prefers the status quo. The Logit model for the dependent variable is estimated by the following expression:

$$\begin{aligned} URBAN = x_0 + x_1 * ASSEMBLY + x_2 * SEX1 + x_3 * EDU12SEC + x_4 * WORKCULT \\ + x_5 * RESSAN + x_6 * INSPEC + x_7 * CORRUPT + \epsilon_i \end{aligned} \tag{8.4}$$

The results of the estimates derived from the econometric model are shown in Table 8.12. The variables jointly explain the dependent variable at a significance level of ≤ 0.05. Summary statistics obtained from the model reveal that out of 195 observations, 45 percent of the subjects indicated a preference for urbanization. Likewise, all the coefficients of the independent variables with their marginal effects are statistically significant at ≤ 0.05, except for the variables WORKCULT (≤ 0.10), RESSAN (slightly higher than ≤ 0.10), INSPEC (> 0.10) and CORRUPT (> 0.10). The seven independent variables of the econometric model indicate why a community member with access to the common property of a community is likely to prefer a change of the status quo [PES-REDD].

All four independent case-specific variables referring to the socio-economic characteristics of the respondent have negative signs. The coefficient of the variable ASSEMBLY suggested that for additional attendance in the General Assembly, the odds of selecting urbanization decreased by 11.7 percent, holding all other variables constant. On average, the respondents

Table 8.12.: Round 2: PES-REDD versus URBAN - Logit

Log likelihood	-120.70683						Number of obs.	195
Marginal effects after Logit							LR chi2(7)	27.06
y =	Pr(URBAN)						Prob > chi2	0.0003
=	0.44195463						Pseudo R2	0.1008
Variable	**dy/dx**	**%****	**Std. Error**	**z**	**P>|z|**	[95% *C.I.*]		**X**
ASSEMBLY	-0.0307698	-11.7	0.00958	-3.21	0.001	-0.04955	-0.01199	5.33846
SEX1*	-0.1709333	-51.3	0.08427	-2.03	0.043	-0.336103	-0.005763	0.261538
EDU12SEC*	-0.2221304	-59.5	0.0831	-2.67	0.008	-0.385012	-0.059248	0.692308
WORKCULT*	-0.1380319	-43.0	0.07616	-1.81	0.070	-0.287295	0.011231	0.523077
RESSAN*	0.1534237	85.9	0.09552	1.61	0.108	-0.03379	0.340638	0.282051
INSPEC	-0.0237994	-9.2	0.04522	-0.53	0.599	-0.112437	0.064838	0.969231
CORRUPT*	0.0781875	37.2	0.09011	0.87	0.386	-0.098418	0.254793	0.369231

(*) dy/dx is for discrete change of the dummy variable from 0 to 1
(**) % is for percentage change in odds for unit increase in X

stated that they attended five general assemblies in the last year. The weight of the coefficient for SEX1 for female respondents denoting the likelihood of preference for URBAN decreased by 51.3 percent. The statistics show that 26 percent of the respondents were female. The variable EDU12SEC revealed that 69 percent of the respondents and/or their spouses have minimum secondary education. The coefficient for a respondent (and/or her/his spouse) with minimum secondary education shows the odds of selecting URBAN decreased by 59.5 percent. For respondents working or cultivating [WORKCULT] a land parcel, the odds of choosing AGRI instead of the status quo decreased by 43 percent. About 52 percent of the respondents confirmed that they work or cultivate a land parcel within the common property.

The three independent alternative-specific variables referring to profile attributes have mixed signs. Only RESSAN is significant at 0.10 (and actually slightly higher). The variable RESSAN revealed the odds of selecting URBAN increase by 85.9 percent for assigning the responsibility for avoidable forest cover loss to the community. In contrast, if higher control effort by the governmental institution [INSPEC] occured, the odds of preferring URBAN decrease by 9.2 percent. And for corruption in government institutions administering the alternatives [CORRUPT], the likelihood of opting for urbanization increased by 37.2 percent.

Rank-ordered Logit models

Rank-ordered logistic regression, also called a rank-ordered Logit model or multinomial Logit, was used to model a categorical variable (dependent variable) that takes value of 1, 2 or 3 (from most to least preferred) as a function of the suggested qualifications indicated by respondents. Hence, the respondent is confronted with all three alternatives and the two rank-ordered Logit models presented here consider the following groups that have been ranked: in first round, SC (status quo), PSAH (Alternative 1) and PES-REDD (Alternative 2), and in second round, PES-

REDD (status quo), AGRI (Alternative 1) and URBAN (Alternative 2). In the rank-ordered Logit model, the outcome was modeled as a linear combination of the predictor variables (independent variables). Because the respondents were confronted with three profile sets per round the rank-ordered Logit has 594 (585) observations.

Round 1: SC versus PSAH and PES-REDD The resulting rank-ordered Logit model determined which variables explained why a respondent in the study area associated with a common property regime ranked two alternative profiles [PSAH and PES-REDD] ahead of or behind the status quo [SC]. The dependent variable in the model is labeled PES_R and takes the value of one (1) if the set of independent variables indicates a low stated preference, two (2) if there is medium stated preference, and three (3) if there is high stated preference. The rank-ordered Logit model for the dependent variable is estimated by the following expression:

$$\begin{aligned} PES_R = x_0 + x_1 * ASSEMBLY + x_2 * MARITAL25 + x_3 * INCOPERS \\ + x_4 * WORKCULT + x_5 * PARSIZE \\ + x_6 * RESSAN + x_7 * INSPEC + x_8 * CORRUPT + \epsilon_i \end{aligned} \tag{8.5}$$

The results of the estimates derived from the econometric model are shown in Table 8.13. The variables jointly explain the dependent variable at a significance level of ≤ 0.05. Likewise, all the coefficients of the independent variables are statistically significant at ≤ 0.10, except for RESSAN (> 0.10). The eight independent variables of the econometric model denote which variables influence a community member to rank the two alternatives ahead of or behind the status quo [SC]. The results also show that if RESSAN, INSPEC, and CORRUPT were equal, respondents would be more likely to select PSAH than SC and they would be even more likely to opt for PES-REDD rather than SC.

The five independent case-specific variables referring to socio-economic characteristics of the respondent have mixed signs. The coefficients of the variable ASSEMBLY show negative signs. This suggests that additional attendance of the General Assembly decreases the odds of ranking PSAH ahead of SC by 10.3 percent, and of ranking PES-REDD ahead of SC by 18.8 percent, holding all other variables constant. Overall, the higher a respondent's attendance in the General Assembly, the more the status quo was valued relative to the other alternatives. The coefficients of the variable MARITAL25 report positive signs. This impliee that a household led by a couple increases the odds of ranking PSAH ahead of SC by 78.1 percent and of ranking PES-REDD ahead of SC by 99.9 percent. Overall, a household with a household head and spouse denotes a lower appreciation for the status quo relative to the other alternatives. Equally, the variable INCOPERS has a positive impact on changing the status quo. A monetary unit increase of the budget available per household member increases the odds of ranking PSAH ahead of SC and of ranking PES-REDD ahead of SC. Overall, this effect is marginal

Table 8.13.: Round 1: SC versus PSAH and PES-REDD - rank-ordered Logit

Number of groups	198				Number of obs.		594
Obs. per group:	max=	3			Log likelihood		-278.1015
	avg=	3.00			LR chi2(15)		153.33
	max=	3			Prob > chi2		0.0000

Variable	**Coef.**	%**	**Std. Error**	**z**	**P>|z|**	[95%*C.I.*]	
PSAHxASSEMBLY	-0.1083252	-10.3	0.0382269	-2.83	0.005	-0.1832485	-0.0334019
PSAHxMARITAL25*	0.5772484	78.1	0.3446144	1.68	0.094	-0.0981835	1.25268
PSAHxINCOPERS	0.0003073	0.0	0.0001582	1.94	0.052	-0.0000275	0.0006173
PSAHxWORKCULT*	-1.355155	-74.2	0.3746981	-3.62	0.000	-2.089549	-0.62076
PSAHxPARSIZE	0.000065	0.0	0.0000393	1.65	0.098	-0.000012	0.0001419
PSAH	1.422843	314.9	0.4499207	3.16	0.002	0.5410142	2.304671
REDDxASSEMBLY	-0.2078517	-18.8	0.0409868	-5.07	0.000	-0.2881843	-0.1275192
REDDxMARITAL25*	0.6928566	99.9	0.3720617	1.86	0.063	-0.0363709	1.422084
REDDxINCOPERS	0.000402	0.0	0.0001728	2.33	0.020	0.0000634	0.0007406
REDDxWORKCULT*	-1.723916	-82.2	0.4024968	-4.28	0.000	-2.512795	-0.9350364
REDDxPARSIZE	0.0001319	0.0	0.0000435	3.03	0.002	0.0000466	0.002173
REDD	2.100284	716.8	0.4927548	4.26	0.000	1.134502	3.066065
RESSAN*	2.100284	20.4	0.1714377	1.08	0.279	-0.1504198	0.5216035
INSPEC	0.19537	21.6	0.0958992	2.04	0.042	0.0074111	0.3833289
CORRUPT*	-0.492724	-38.9	0.1629194	-3.02	0.002	-0.8120401	-0.1734079

(*) discrete change of the dummy variable from 0 to 1
(**) % is for percentage change in odds for unit increase in X

since the unit increase refers to one Mexican Peso, but the higher the available budget per household member, the lower the respondent judges the status quo relative to other alternatives. Yet, the WORKCULT variables show negative signs. This reveals that a respondent working or cultivating a land parcel decreases the likelihood of ranking PSAH ahead of SC by 74.2 percent and of ranking PES-REDD ahead of SC by 82.2 percent. Overall, working or cultivating land on the common property denotes a higher appreciation for the status quo relative to other alternatives. However, the variable PARSIZE has a positive impact on changing the status quo. A unit increase in the size of the land parcel available to a household increases the odds of ranking PSAH ahead of SC and of ranking PES-REDD ahead of SC. Overall, the effect is marginal since the unit increase refers to one square meter, but the greater the available land parcel per household, the lower respondents evaluate the status quo relative to other alternatives.

The three independent alternative-specific variables referring to profile attributes have mixed signs and RESSAN was not significant. The interpretation for the alternative-specific variables RESSAN, INSPEC and CORRUPT is different from previous interpretation of odds. Each odds ratio is the multiplicative effect of a unit change in that independent variable on the odds of any given environmental policy (SC, PSAH or PES-REDD). Therefore, the variable RESSAN reveals, all else being equal, that assigning the responsibility of avoidable forest cover loss to the community for a given environmental policy (SC, PSAH or PES-REDD respectively) increases the likelihood of selecting this policy by 20.4 percent. Equally, if additional control effort by the government institution [INSPEC] exists, the probability of stating a preference for a given environmental policy increases by 21.6 percent. On the contrary, if the government institution administering a given environmental policy is corrupt [CORRUPT], this decreases the odds of preferring that policy by 38.9 percent, holding the values for the other policy alternatives constant.[10]

Round 2: PES-REDD versus AGRI and URBAN The resulting rank-ordered Logit model determined the variables that explain why a respondent associated with a common property regime ranks two alternative profiles [AGRI and URBAN] ahead of or behind the status quo [PES-REDD]. The dependent variable in the model is labeled LUC_R and takes the value of one (1) if the set of independent variables indicates a low stated preference, two (2) if there is a medium stated preference, and three (3) if there is a high stated preference. The rank-ordered Logit model for the dependent variable is estimated by the following expression:

$$\begin{aligned} LUC_R = x_0 + x_1 * ASSEMBLY + x_2 * INCOPERS + x_3 * WORKCULT \\ + x_4 * RESSAN + x_5 * INSPEC + x_6 * CORRUPT + \epsilon_i \end{aligned} \tag{8.6}$$

The results of the estimates derived from the econometric model are reported in Table 8.14. The variables jointly explain the dependent variable at a significance level of ≤ 0.05. Likewise, all the coefficients of the independent variables are statistically significant at ≤ 0.10, except for INCOPERS (slightly higher than ≤ 0.10 in one case) and all alternative-specific variables (only RESSAN is slightly higher than ≤ 0.10). The six independent variables of the econometric model suggest which variables influence a community member to rank the two alternatives ahead of or behind the status quo [PES-REDD]. Furthermore, the results show that if RESSAN, INSPEC, and CORRUPT were equal, respondents would be more likely to select AGRI than PES-REDD and they would be even more likely to opt for URBAN than PES-REDD.

All three independent case-specific variables referring to the socio-economic characteristics of the respondent show negative signs. The coefficients of the variable ASSEMBLY suggest that an additional attendance of the General Assembly decreases the odds of ranking AGRI ahead of PES-REDD by 5.8 percent and of ranking URBAN ahead of PES-REDD by 12.3 percent, when all other variables are constant. Overall, the higher a respondent's attendance in the General Assembly, the more valued the status quo relative to other alternatives. Equally, INCOPERS variables report that a monetary unit increase of the budget available per household member

[10] In general, if it is assumed that the effect of alternative-specific variables might differ depending on which alternatives are examined, then it would require the specification of interactions between the alternative-specific variables and the alternatives (Long and Freese, 2006). However, since a main-effects plan has been applied in order to poll information, this is not feasible (Addelman, 1962a,b; Bateman et al., 2002).

Table 8.14.: Round 2: PES-REDD versus AGRI and URBAN - rank-ordered Logit

Number of groups	195				Number of obs.		585
Obs. per group:	max=	3			Log likelihood		-329.7249
	avg=	3.00			LR chi2(11)		39.34
	max=	3			Prob > chi2		0.0000
Variable	**Coef.**	%**	**Std. Error**	**z**	**P>$\|z\|$**	[95%$C.I.$]	
AGRIxASSEMBLY	-0.059233	-5.8	0.0322038	-1.84	0.066	-0.1223513	0.038853
AGRIxINCOPERS	-0.0001863	-0.0	0.0001244	-1.50	0.134	-0.0004302	0.0000575
AGRIxWORKCULT*	-0.5218208	-40.7	0.2693643	-1.94	0.053	-1.049765	0.0061236
AGRI	1.002686	172.6	0.2981789	3.36	0.001	0.418266	1.587106
URBANxASSEMBLY	-0.1314591	-12.3	0.034496	-3.81	0.000	-0.19907	-0.0638482
URBANxINCOPERS	-0.0003657	-0.0	0.0001433	-2.55	0.011	-0.0006465	-0.0000848
URBANxWORKCULT*	-0.7882342	-54.5	0.2865452	-2.75	0.006	-1.349852	-0.226616
URBAN	1.391153	301.9	0.3306425	4.21	0.000	0.7431055	2.0392
RESSAN*	-0.2446335	-21.7	0.1605915	-1.52	0.128	-0.5593872	0.0701201
INSPEC	0.0554698	5.7	0.0806852	0.69	0.492	-0.1026703	0.21361
CORRUPT*	-0.0553123	-5.4	0.1446713	-0.38	0.702	-0.3388629	0.2282383

(*) discrete change of the dummy variable from 0 to 1
(**) % is for percentage change in odds for unit increase in X

decreased the odds of ranking AGRI or URBAN ahead of PES-REDD. Overall, the effect is marginal since the unit increase refers to one Mexican Peso, but the higher the available budget per household member, the stronger the value of the status quo relative to the other alternatives. Finally, WORKCULT variables reveal that a respondent working or cultivating a land parcel decreased the likelihood of ranking AGRI ahead of PES-REDD by 40.7 percent and of ranking URBAN ahead of PES-REDD by 54.5 percent. Overall, working or cultivating a parcel on the common property denotes a higher appreciation for the status quo relative to other alternatives.

The three independent alternative-specific variables referring to the profile attributes have mixed signs, but are not significant (only RESSAN is slightly above ≤ 0.10). For alternative-specific variables RESSAN, INSPEC and CORRUPT, each odds ratio is the multiplicative effect of a unit change in that independent variable on the odds of any given land-use alternative (PES-REDD, AGRI or URBAN). The variable RESSAN shows, all else being equal, that assigning the responsibility of avoidable forest cover loss to the community for a given land-use alternative (PES-REDD, AGRI or URBAN) decreased the odds of selecting that alternative by 21.7 percent. In contrast, for additional control effort by government institutions [INSPEC], the probability of stating a preference for a given land-use alternative increased by 5.7 percent. On the other hand, if the government institution administering the implementation of a given land-use alternative is corrupt [CORRUPT], this decreases the odds of preferring that land-use alternative by 5.4 percent, if the values for other alternatives remain constant.[11]

[11] As stated in the previous rank-ordered Logit model, the inability of specifying interactions between alternative-specific variables and the alternatives holds true.

Tobit models

The Tobit model, also called a censored regression model, is designed to estimate linear relationships between variables (independent variables) when there is either (or both) left-censoring or right-censoring in the dependent variable. It is also known as censoring from below and above respectively. If censoring takes place from above and below, the Tobit regression is called a two-limit Tobit. The values of the dependent variable are a function of the qualification given by the respondents to the profile sets of three alternatives ranging from 1 to 10. As the Tobit model is used to analyze the preference to change of the status quo in the respective round, the obtained qualifications for the alternatives are converted assuming that the status quo is zero. Therefore, the dependent variable may take values between -9 and 9, where central values indicate indifference between a change and the status quo. Since the respondents were confronted with three profile sets per round the Tobit has 396 (390) observations.

Round 1: SC versus PSAH and PES-REDD The resulting Tobit model determined which variables explain why a respondent in the study area associated with a common property regime prefers to change the status quo and accept a PES contract. The dependent variable in the model is labeled PES_T and takes a positive value (+), if the set of independent variables indicate a stated preference for PES contracts. It shows a negative value (-), if the respondent shows a preference for the status quo [SC]. The Tobit model for the dependent variable is estimated by the following expression:

$$\begin{aligned} PES_T = x_0 + x_1 * ASSEMBLY + x_2 * MARITIAL25 + x_3 * LABOR1W + x_4 * WORKCULT \\ + x_5 * RESSAN + x_6 * INSPEC + x_7 * CORRUPT + \epsilon_i \end{aligned} \tag{8.7}$$

The results of the estimates derived from the econometric model are shown in Table 8.15. The variables jointly explain the dependent variable at a significance level of ≤ 0.05. Likewise, all the coefficients of the independent variables with their marginal effects are statistically significant at ≤ 0.05, except for three alternative-specific variables (> 0.10). The seven independent variables of the econometric model denote why a community member with access to the common property is likely to accept or reject a change of the status quo [SC].

The four independent case-specific variables referring to the socio-economic characteristics of the respondent have mixed signs. ASSEMBLY, LABOR12W and WORKCULT show negative signs, and MARITAL25 reports a positive sign. The coefficient of the variable ASSEMBLY indicates that an increase in assistance of the General Assembly reduced the likelihood of accepting a government PES program, when all other variables remain constant. If the respondent is not single [MARITIAL25], the probability of selecting a PES program increased. The variable LABOR1W denotes the odds of selecting a PES contract decreased for a respondent with regular work. Equally, for those working or cultivating a land parcel [WORKCULT], the

Table 8.15.: Round 1: SC versus PSAH and PES-REDD - Tobit

Log likelihood	-1044.7968					Number of obs.		396
Marginal effects after Tobit						LR chi2(7)		44.37
y =	Fitted values					Prob > chi2		0.0000
=	1.9712343					Pseudo R2		0.0208
Variable	**dy/dx**	**Std. Error**	**z**	**P>|z|**	[95% $C.I.$]			**X**
ASSEMBLY	-0.1972178	0.04502	-4.38	0.000	-0.285455	-0.108981		5.25758
MARITAL25*	1.530029	0.40272	3.80	0.000	0.740714	2.31934		0.681818
LABOR12W*	-0.906103	0.44948	-2.02	0.044	-1.78708	-0.02513		0.712121
WORKCULT*	-0.9702793	0.3946	-2.46	0.014	-1.74368	-0.196881		0.530303
RESSAN*	-0.4091682	0.40897	-1.00	0.317	-1.21073	0.39239		0.333333
INSPEC	0.2704698	0.25383	1.07	0.287	-0.227033	0.767973		0.949495
CORRUPT*	-0.4488271	0.44557	-1.01	0.314	-1.32213	0.424472		0.366162

(*) dy/dx is for discrete change of the dummy variable from 0 to 1

likelihood of accepting PES program participation decreased.

The three independent alternative-specific variables referring to profile attributes have mixed signs, but without exhibiting tested significance. The variable RESSAN reveals that when assigning the responsibility of avoidable forest cover loss to the community, the likelihood of selecting a PES contract decreases. On the other hand, when government institution control effort [INSPEC] increases, the odds of selecting a PES program increased. On the contrary, if corruption in the governmental institution administrating the PES alternatives existed [CORRUPT], the probability of choosing a PES contract decreased.

Round 2: PES-REDD versus AGRI and URBAN The resulting Tobit model determined the variables explaining why a respondent in the study area associated with a common property regime prefers to change the status quo [PES-REDD] and accept a LUC alternative that probably degrades and depletes the natural forest resource. The dependent variable in the model is labeled LUC_T and takes a positive value (+), if the set of independent variables indicates a stated preference for LUC, and acquire a negative value (-), if the respondent desires the status quo [PSA-REDD]. The Tobit model is estimated by the following expression:

$$\begin{aligned} LUC_T = x_0 + x_1 * ASSEMBLY + x_2 * SEX1 + x_3 * LABOR12W + x_4 * INCOPERS \\ + x_5 * FAMSIZE + x_6 * WORKCULT + x_7 * PARSIZE + x_8 * PSAH \\ + x_9 * RESSAN + x_{10} * INSPEC + x_{11} * CORRUPT + \epsilon_i \end{aligned} \tag{8.8}$$

The results of the estimates derived from the econometric model are shown in Table 8.16. The variables jointly explain the dependent variable at a significance level of ≤ 0.05. Likewise, all the coefficients of the independent variables with their marginal effects are statistically significant at $\leq$ 0.05, except for the three alternative-specific variables (> 0.10). The 11 independent variables of the econometric model suggest why a respondent with access to common property is likely to accept or reject a change of the status quo [PES-REDD].

Table 8.16.: Round 2: PES-REDD versus AGRI and URBAN - Tobit

Log likelihood	-1043.924				Number of obs.		390
Marginal effects after Tobit					LR chi2(11)		62.59
y =	Fitted values				Prob > chi2		0.0000
=	0.06472084				Pseudo R2		0.0291
Variable	**dy/dx**	**Std. Error**	**z**	**P>$\lvert z \rvert$**	[95%$C.I.$]		**X**
ASSEMBLY	-0.1936856	0.04647	-4.17	0.000	-0.284773	-0.102598	5.33846
SEX1*	-1.350436	0.44184	-3.06	0.002	-2.21643	-0.484437	0.261538
LABOR12W*	-1.00356	0.45883	-2.19	0.029	-1.90286	-0.104263	0.707692
INCOPERS	-0.0005975	0.00021	-2.90	0.004	-0.001001	-0.000194	1244.14
FAMSIZE	-0.3995993	0.12555	-3.18	0.001	-0.645665	-0.153533	4.58462
WORKCULT*	-1.140515	0.49074	-2.32	0.020	-2.10235	-0.178678	0.523077
PARSIZE	0.0001017	0.00005	2.14	0.032	0.000008	0.000195	2961.31
PSAH*	-1.127214	0.48992	-2.30	0.021	-2.08744	-0.166993	0.246154
RESSAN*	-0.1823769	0.42486	-0.43	0.668	-1.01508	0.650328	0.307692
INSPEC	-0.0193026	0.26189	-0.07	0.941	-0.532598	0.493993	1.06154
CORRUPT*	0.210077	0.48291	0.44	0.664	-0.736408	1.15656	0.328205

(*) dy/dx is for discrete change of the dummy variable from 0 to 1

All eight independent case-specific variables referring to socio-economic characteristics of the respondent have negative signs, except for the variable PARSIZE. The coefficient of ASSEMBLY indicated when assistance in the General Assembly increases, the probability of selecting LUC alternatives decreased, holding all other variables constant. For a female [SEX1] respondent the coefficient denotes the odds of selecting LUC decreased. The variable LABOR12W suggests that for a respondent (and/or her/his spouse) having regular work, the likelihood decreased for selecting for LUC. The coefficient of the variable INCOPERS denotes the odds of stating a preference for LUC decreasd with an increase in the monthly income per household member. In the case of an increase in additional household members [FAMSIZE], the likelihood of choosing LUC decreased. For respondents who work or cultivate a land parcel [WORKCULT], the probability decreased for selecting LUC. On the contrary, for having an additional unit of land [PARSIZE], the odds of selecting a LUC alternative increased. Finally, the coefficient of PSAH suggests that for those who previous to the experiment already recognized their participation in the national PES program, the likelihood of LUC decreased.

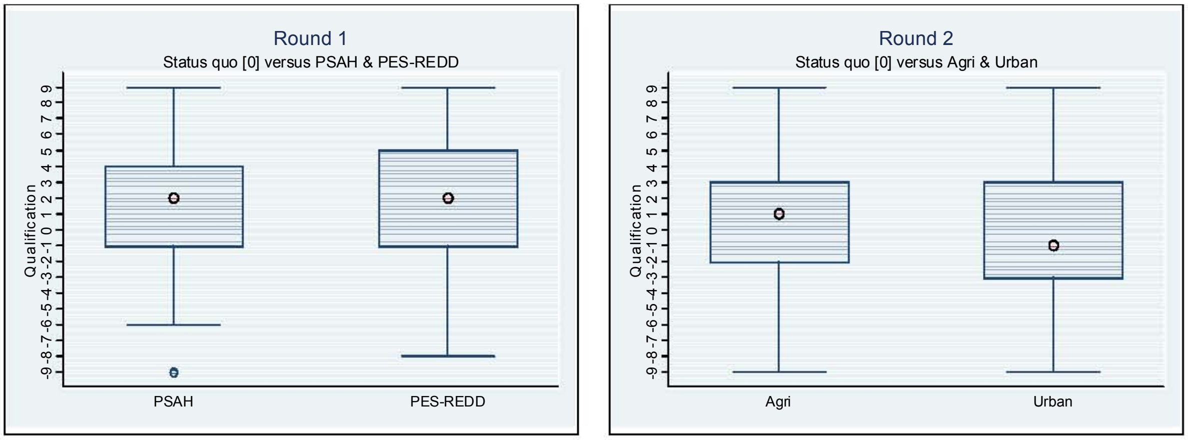
The three independent alternative-specific variables referring to profile attributes have mixed signs, but none reflect levels of significance. The variable RESSAN reveals for allocating the responsibility of avoidable forest cover loss to the community, the likelihood of selecting LUC decreased. Equally, if control effort by government institution [INSPEC] increased, the odds of stating a preference for LUC decreased. In the presence of corruption in the government institution administering the alternatives [CORRUPT], the probability of choosing a LUC alternative increased.

8.4. Discussion

The results of the two-stage experiment reveal that a PES scheme in the context of Mexican common property regimes is likely to face both adverse selection (ex ante - in first round) and moral hazard (ex post - in second round). Although it is a joint decision of individual ES providers grouped in a collective (ES seller), results indicate that a decision on any agreed land-use alternative will not be unanimously selected (see Figure 8.2)[12]. The results confirm the outcome of Chapter 6, revealing that the heterogeneity of livelihood asset endowment (internal factors) and surrounding conditions (external factors) are likely to provoke different selection strategies regarding presented alternatives. In the first round, the sampled group (N=66) preferred a change of the status quo [SC], meaning that respondents tended to qualify both offered PES contracts higher (see Figure 8.2(a)). While in the second round, the sampled group (N=65) did not necessarily prefer a change of the status quo [PES-REDD], suggesting that respondents tended to qualify an agricultural alternative higher and the expansion of urbanization lower (see Figure 8.2(b)). However, the median values of the second round in particular are close to the status quo. This indicates that the selection of urbanization (URBAN is ranked ahead of PES-REDD, if converting the qualifications to ranks; see Table 8.3 and 8.14) is not unrealistic and both alternatives would represent moral hazard (contract breach with the status quo). This outcome demonstrates that those case-specific and alternative-specific variables that are able to reduce problems of adverse selection and moral hazard have to be identified in order to guarantee the permanence of forest carbon stocks. Analyzing case-specific (explanatory socio-economic) and alternative-specific (contract attributes: responsibility and sanction, control and corruption) variables within two recipient communities in the periphery of Mexico City helps to alleviate problems of asymmetric information in environmental contract design. The econometric models revealed that twelve case-specific variables and three alternative-specific variables influence asymmetric information, highlighting their relevance for guaranteeing ES seller's conditionality of ES provision.

The discussion and interpretation of the results derived from the three econometric model approaches is the subject of this section. The outcome of the two rounds is dealt with separately and the implications of adverse selection and moral hazard are discussed for (i) case-specific variables, and (ii) alternative-specific variables.

[12]The Figure shows four vertical box plots, where the y axis is numerical (qualifications: normalized to zero, which is the value assigned to the status quo), and the x axis is categorical (alternatives: choice options other than the status quo). The point in the box represents the median, while the lower and upper sides represent the 25^{th} and 75^{th} percentiles. The ends of the whiskers show the 5^{th} and 95^{th} percentile. Values beyond the whiskers are marked as a dot.



(a) (b)

Figure 8.2.: Median of stated preferences: (a) Before and (b) After agreement to PES contracts

Round 1 - Adverse selection (ex ante)

The results from the first round indicate that a change of the status quo [SC] is preferred and community members of two communities in the periphery of Mexico City are likely to select a PES contract such as PSAH or PES-REDD (see Figure 8.2(a)). During a feedback session in the agrarian community held on August 30^{th}, 2012, community members were presented the resulting ranking of preferences. Their reaction showed little surprise. They explained the change of the status quo due to the necessity of obtaining compensation for conserving the forest. They argued that SC alone, without direct benefits, is not sufficient to guarantee the continuous provision of any ES.

In order to explain the underlying reasons for these stated preferences, three regression approaches (Logit, rank-ordered Logit and Tobit) were used. They identified case-specific and alternative-specific variables likely to influence the choice of alternatives on the individual level (see Table 8.17), which may allow detection if adverse selection were to occur. The results demonstrate that the case-specific variables ASSEMBLY and WORKCULT were of particular importance as they entered all models at a significant level ($\leq$0.05). Furthermore, the explanatory variables MARITAL25 (Rank-ordered, Tobit), INCOPERS (Logit 1, Rank-ordered) and PARSIZE (Logit 2, Rank-ordered) entered twice, while LABOR12W was represented once (Tobit). As alternative-specific variables were of particular interest, all three (RESSAN, INSPEC and CORRUPT) were integrated. However, they demonstrated some significance ($\leq$0.05) in only two models (Logit 1, Rank-ordered).

Case-specific Case-specific variables elaborate on the socio-economic characteristics of the respondents that influence the selection of a specific alternative. As revealed, six variables are of relevance to explain stated preferences and their implications on adverse selection of

Table 8.17.: Round 1: Summary of econometric models

Regress. model	Logit 1		Logit 2		Rank-ordered				Tobit	
	SC vs PSAH		SC vs PES-REDD		SC vs PSAH		SC vs REDD		SC vs PES	
	±	p	±	p	±	p	±	p	±	p
Case-specific										
ASSEMBLY	–	***	–	***	–	***	–	***	–	***
MARITAL25°	n/a	n/a	n/a	n/a	+	*	+	*	+	***
LABOR12W°	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	–	**
INCOPERS	+	***	n/a	n/a	+	*	+	**	n/a	n/a
WORKCULT°	–	***	–	***	–	***	–	***	–	**
PARSIZE	n/a	n/a	+	***	+	*	+	***	n/a	n/a
Alternative-specific						±	p			
RESSAN°	–	**	–			+			–	
INSPEC	–		–			+	**		+	
CORRUPT°	+	**	–			–	***		–	

* $p \leq 0.10$; ** $p \leq 0.05$; *** $p \leq 0.01$
° discrete change of the dummy variable from 0 to 1

PES participation. In the process of "fitting" the final models, seven categories were excluded from the total set of 30 collected variables (see Table 8.2). This is because they were unable to significantly explain differences in decision-making within these models, namely, COMEJI, RAN, SEX, AGE, EDU, FAMSIZE, and PSAH. Accordingly, the formulated hypotheses for these excluded variables cannot be accepted (see Table 8.1).

The variable ASSEMBLY shows a strong impact. It is similar to other referenced variables that are supposed to influence participation on a PES program at a community level. They include the capacity to self-organize (Echeverría, 2010), communal leadership (Echeverría, 2010), form of governance and processes of decision-making (Tognetti et al., 2004), access and diffusion of information (Adesina and Chianu, 2002; Adesina et al., 2000; Arnold, 1992; Hosier, 1989; Hyman, 1983; Thacher et al., 1996; Zbinden and Lee, 2005), and trust in institutional agreements (Tognetti et al., 2004). Specifically for the Mexican scenario, Kosoy et al. (2008) reveal that processes and management at the community level (e.g., rules of forest management, collective conservation values, consensus on the use of PES income, the small size of the community) are of importance. In the studied cases, the General Assembly represents the highest decision body and is the formal and regular channel of information dissemination, as for example, the participation in the PES program. Interestingly, it was observed that attendance in assemblies decreased the probability that a community member would select a change of the status quo, in other words that the respondent was against a PES-like contract. This trend was unexpected, because in the assemblies all community-related issues (economic, social and cultural) are discussed and collective decision-making is made. It is the regular means of communication that exists among "all" community members in the community. Perhaps the active involvement of community members via attendance, in this case, depreciates "new" governmental programs. It seems that things sobered up regarding governmental programs (as indicated, for example, during the feedback session) designed for conserving the natural capital of the common property more actively - also through incentive payments.

A second variable strongly reflected in the models was WORKCULT, which is also linked to PARSIZE. These variables relate to the critical issue of opportunity costs for conservation in peri-urban areas. The literature suggests that program appropriation is influenced by land size or managed area (Ayuk, 1997; Caveness and Kurtz, 1993; Chambers and Foster, 1983; Nagubadi et al., 1996; Nowak, 1987; Thacher et al., 1996; Zbinden and Lee, 2005), land characteristics (Adesina and Chianu, 2002; Claassen et al., 2008; Mortensen et al., 1988; Zbinden and Lee, 2005), and processes and management at the community member level (e.g., contribution to the household income, strengthening and diversification of productive activities, ensuring access to research and projects) (Kosoy et al., 2008). The econometric analysis found that if the community member worked or cultivated common land property, s/he was less likely to select a PES-like contract, which is consistent with the formulated hypothesis. For risks of adverse selection this means that those not able to directly influence ES provision with active land management are more likely to opt for PES programs. This may suggest that working a land parcel implies greater opportunity costs relative to the PES offer. The theory states that the economic amount paid for ES must be greater than or at least equal to the opportunity costs of not using the natural resource (Bergen et al., 2002; Claassen et al., 2008; Engel et al., 2008; Ferraro, 2008; Ibarra Gené, 2007). Other authors interpret the PES offer as a risk factor in the decision-making process of the landholder, arguing that s/he may fear a "cold" expropriation (Dobbs and Pretty, 2008) and the program, thus, undermines usual (cultural) activity. Similarly, Kosoy et al. (2008) point out that the economic incentive of PES is not always the strongest motivation for participation. It seems that preserving traditions, such as cultivating and maintaining their heritage, are stronger incentives. The mindset, especially of older community members, is deeply rooted in the ability to work and cultivate the land. Once this is restricted, there is a lower level of perceived ownership. In the Mexican culture "the land belongs to the tiller" and justifies landownership, which has been particularly important since the 1910 Revolution. Therefore, it is likely that stopping to work the land to support conservation purposes conflicts with the rationale of justifying landownership. The traditional form of working and cultivating the land is commonly at odds with the conservation objectives of PES programs, and it is likely that many people who which to preserve this tradition either for consumption or as a lucrative source of income are not interested in conservation programs. Thus, the reason for preference to cultivate, in certain cases, goes beyond a pure monetary opportunity cost consideration. Interestingly, in one Logit and the rank-ordered Logit the variable PARSIZE suggests that greater parcel sizes per household increases the probability of selecting a PES contract such as PES-REDD. This is surprising and seems to go against the interpretation of the WORKCULT variable. One possible explanation might be that households with smaller parcel sizes fear more restrictions as they depend more on the land.

The ability to generate income is a key feature for a sustainable livelihood, but may also relate to the likelihood of PES program selection. Variables such as primary occupation (farm or non-farm) (Claassen et al., 2008), monetary income and indebtedness (Thacher et al., 1996; Wunder, 2008; Zbinden and Lee, 2005) together with processes and management at the community member level (e.g., contribution to the household income, strengthening and diversification of productive activities, ensuring access to research and projects) (Kosoy et al., 2008) play an active role. Accordingly, the econometric models identified three variables which facilitate interpretation. First, MARITAL25 denoted in the rank-ordered Logit and the Tobit that non-single households are more likely to change the status quo and choose a PES-like contract. This outcome was expected. The reason might be two-fold. First, couples are more likely to have children, so that the desire of conserving the community's natural heritage is reinforced through PES programs. And second, a couple tends to be economically better-off and is able to share responsibilities so that it relies on a more diversified set of income alternatives, which implies that program restrictions for land use doesn't affect them as much as a single-parent household. The latter implication seems to be confirmed by the second variable INCOPERS. Logit 1 and rank-ordered Logit show that a higher level of liquid financial resources available to each household member influences a respondent to more likely select PES participation. That may imply that community members only become actively involved in a PES program when either they do not earn relatively high income from the activities a conservation program intends to restrict (Claassen et al., 2008; Engel et al., 2008; Ferraro, 2008) or they do not obtain any income at all from these activities. If the latter assumption holds true, the opportunity costs are zero and a payment, in addition to being inefficient (as in the first case), will also be ineffective. On the other hand, these results indicate that lower income groups are less interested in PES participation, which contrasts with the additional side-objective of the program to alleviate poverty. Presumably, a community member with a higher income perceives the payment only as an additional income that is insignificant (and/or as an opportunity to diversify and complement personal income portfolios), while community members of lower income ranks perceive it as a threat to their income and subsistence activities which are based on resource extraction. The third variable LABOR12W may suggest that this is a valid assumption. Although it was initially not expected, the variable had a negative impact on PES contract selection. This may be due to the fact that during the experiments it turned out that several respondents indicating an independent economic activity were actually referring to farming activities.

Alternative-specific The experimental design was set up in order to analyze three alternative-specific variables that are critical for principal-agent (government-community) relation. The intention was to see how the collective reacts to these alternative-specific variables of the submitted alternatives ex ante and if this may influence the permanence of ES provision from common properties. These alternative-specific variables relate to attributes of environmental policy enforcement and have been mentioned by the literature in order to explain the appropriation of environmental programs. Associated variables are processes and management at the program level (e.g., simple rules, flexibility in processes, effective communication at different levels and access to information) (Kosoy et al., 2008) together with trust in institutional agreements (Tognetti et al., 2004). Overall, the results show that these variables did not reflect significant levels in all models. This may suggest four caveats: first, the scales used for the dependent variables in the models influence model results; second, the sample size needs to be increased significantly in order to obtain more significant values; third, these variables are actually not the most influential on stated preference (adverse selection); and fourth, the exercise was too abstract for most of the respondents so that considerable noise influenced the results.

The variable RESSAN only entered the first Logit model with a significant coefficient, suggesting that the likelihood of choosing to participate in the PSAH program decreases if the responsibility of avoidable forest cover loss is assigned to the community. Equally, the second Logit model for a PES-REDD alternative and the Tobit model reflect the same trend. Indeed, respondents seemed to dislike the concept of collective liability for avoidable reversals of forest. The internal distrust reported by Ramos (2008) and comments from the feedback session confirm that respondents actually perceive a real threat from the moral hazard of individuals. This may suggest that in the communities studied, community members are aware of the problem but would still adversely select program participation if responsibility of avoidable reversals were not assigned to the community as a whole. In contrast, the inclusion of this rather strict alternative-specific variable may foster the selection of those common property regimes that actually don't perceive such a risk and have effective means of enforcing PES activities internally. Due to the insignificant value of the coefficient in the rank-ordered Logit, it is assumed that it has no greater explanatory power for interpretation. However, for the sake of completeness, the positive coefficient in the rank-ordered Logit suggests that assigning responsibility to the community in a given environmental policy (SC, PSAH and PES-REDD) increases the likelihood of selecting this policy, holding the values for the other alternatives constant.

The variable INSPEC indicated a significant and positive relation only in the rank-ordered Logit, although this trend was confirmed in the Tobit model. In contrast to the formulated hypothesis, the rank-ordered Logit suggests that increasing the level of governement control in a given environmental policy (SC, PSAH and PES-REDD) raises the likelihood of selecting this policy, when holding the values for the other alternatives constant. The positive implication is that higher levels of external control may avoid any intentional reversal. This was unexpected because government control may also be perceived as a command-and-control approach and may suffer from institutional distrust. Accordingly, although not significant, both Logit models comparing the status quo [SC] with PSAH and PES-REDD, respectively, have opposite implications so that caution should be taken. The equivocal result may be explained by the difference in jurisdiction. While in the case of PES alternatives the institution responsible for program administration would be CONAFOR, in the case of the status quo it is the Ministry of Environment-Commission of Natural Resources (SMA-CORENA, for its Spanish acronym). It may be that trust in a particular institution controlling a program affects respondents' perceived effectiveness of control.

The variable CORRUPT referrs to the external (principal: e.g., CONAFOR) institutional arrangement in the case of study. This arrangement likely involves monitoring of, for example, compliance with payment rules and participation requirements, and especially the payment of economic benefits. The variable CORRUPT was expected to have a positive implication for a change in the status quo. The underlying assumption was that higher PES payments (at least) equalize the presence of this variable. Interestingly, CORRUPT entered in two models at a significant level, but with opposite algebraic signs. In the first Logit model (SC versus PSAH), the presence of corruption increased the odds for selecting PSAH. Two reasons might explain this outcome specifically for this program: first, common property regimes already have a track-record with this program and experience was (at least) not worse than expected; and second, respondents expect corruption to be the BAU and an integrated feature of "doing business". In contrast, the rank-ordered Logit revealed that the presence of corruption under a given environmental policy (SC, PSAH and PES-REDD) decreases the likelihood of selecting this policy, holding the values for the other alternatives constant. That is, the degree of community members' perceived corruption regarding institutions handling environmental programs in a non-transparent manner or when not performing as expected, discourages active individual involvement. The underlying cause explaining the relationship could be the historically motivated distrust of rural-coined groups towards authorities of the government, which hampers the introduction and implementation of any environmental program, and presumably affects the performance of the PES program. In fact, Ramos (2008) has indicated that institutional trust of communities in the area of the study is rather low. Furthermore, community representation feels that the government is interested in the MRW for all the benefits it produces, especially the provision of water to Mexico City's sectors with higher socio-economic levels (Community's President, pers. comm., 2010). On the other hand, it might be that the alternative-specific variable has been treated as a highly emotional "yeah-saying" attribute. This may limit the overall reliability of the suggested negative implication, although the trend was also shown for PES-REDD selection (Logit 2) and PES programs in general (Tobit).

Round 2 - Moral hazard (ex post)

The results from the second round indicate that a change of the assumed status quo [PES-REDD] for next year is not necessarily preferred, although some community members in the two studied communities would also be likely to pursue activities (agriculture and urbanization) on the common property that is responsible for forest cover loss in the periphery of Mexico City (see Figure 8.2(b)). During a feedback session in the agrarian community held on August 30^{th}, 2012, community members were confronted with the resulting ranking of preferences. They acknowledged that, in fact, different positions exist internally. Mainly two partially opposing viewpoints were voiced. The first position actually reiterated the need to comply with a PES-like contract. It had been argued that "it is not good practice to change the land use as the water is not renewable and the trees need a lot of time for growth after planting". Advocates of this group acknowledged the importance of common property for providing water and oxygen. They further argued that the territory is not suitable for agriculture and were surprised that several community members stated such a preference, although they acknowledged that in neighboring communities the conditions are slightly better (e.g., *ejido* of San Nicolás Totolapan). Regarding the urbanization of common property they believe that forests are more important due to the ES provision. However, they think that urbanization may be required as well, but only in designated areas.

The second line of reasoning actually defended those that stated a preference for deviating from the hypothetical status quo of a PES-like contract. Although this group considers conservation and preservation important, their experience with government programs is characterized by mistrust since they perceive that program benefits do not reach everyone in the community. Hence, they would consider LUC alternatives in order to create more direct and individual benefits. The same community members feel that information is missing and government resources are divided into small pieces so that the overall benefit becomes zero, while they see forests continuously destroyed without anything really being done. They perceive part of the problem being that programs such as PES communicate only with community authorities.

At the end of the session, community members demanded that environmental program administrations provide better information and improve communication. They stated a preference for programs to focus on options allowing the extraction of forest products in order to obtain more direct benefits from their own natural capital, which would offer an additional incentive for conservation. This request underlines two issues. First, communities are not experimenting a strengthening of the community's internal organization as a side effect of PES participation as hypothesized by the literature (e.g., Rosa et al., 2004; Robertson and Wunder, 2005; Wunder and Albán, 2008). Second, the statements complied confirm that common property regimes raise issues of benefit-sharing structures among and within communities (e.g., Rojahn and Engel, 2005; cited in Engel et al., 2008).

In order to further explore underlying reasons for stated preferences at the individual level, the same three regression approaches (Logit, rank-ordered Logit and Tobit) like in Round 1 were used. They identified case-specific and alternative-specific variables which were likely to influence the choice of alternatives at the individual level (see Table 8.18), to help detect if moral hazard is likely to occur. This is of great interest because the decision to conserve a forest or change land use seems not to depend exclusively on the weight of monetary incentives. That is, relatively low PES payments could, in some cases, support the resistance of the pressure from the city, industry and market, and favor the conservation of land use (e.g., Murillo-Hernández, 2008). The results demonstrate that the case-specific variables ASSEMBLY and WORKCULT were again of particular importance as they entered all models at significant levels ($\leq$0.10). Furthermore, explanatory variables SEX1 (Logit 2, Tobit), LABOR12W (Logit 1, Tobit), INCOPERS (rank-ordered Logit, Tobit) and PARSIZE (Logit 1, Tobit) entered in models twice, while MARITAL25 (Logit 1), EDU12SEC (Logit 2), FAMSIZE (Tobit), INCOME (Logit 1) and PSAH (Tobit) were each represented only once. As alternative-specific variables were of particular interest for the second round alike, all three (RESSAN, INSPEC and CORRUPT) were integrated. However, they revealed some significance only in the two Logit models and rank-ordered Logit.

Table 8.18.: Round 2: Summary of econometric models

Regress. model	Logit 1		Logit 2		Rank-ordered				Tobit	
	PES vs AGRI		PES vs URBAN		PES vs AGRI		PES vs URBAN		PES vs LUC	
	±	p	±	p	±	p	±	p	±	p
Case-specific										
ASSEMBLY	−	**	−	***	−	*	−	***	−	***
SEX1°	n/a	n/a	−	**	n/a	n/a	n/a	n/a	−	***
MARITAL25°	−	***	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
EDU12SEC°	n/a	n/a	−	***	n/a	n/a	n/a	n/a	n/a	n/a
LABOR12W°	−	***	n/a	n/a	n/a	n/a	n/a	n/a	−	**
FAMSIZE	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−	***
INCOME	−	***	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
INCOPERS	n/a	n/a	n/a	n/a	−	(*)	−	**	−	***
WORKCULT°	−	**	−	*	−	*	−	***	−	**
PARSIZE	+	***	n/a	n/a	n/a	n/a	n/a	n/a	+	**
PSAH°	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	−	**
Alternative-specific						±	p			
RESSAN°	−		+	(*)		−	(*)		−	
INSPEC	+	***	−			+			−	
CORRUPT°	−	*	+			−			+	

(*) slightly above $p \leq 0.10$; * $p \leq 0.10$; ** $p \leq 0.05$; *** $p \leq 0.01$
° discrete change of the dummy variable from 0 to 1

Case-specific Case-specific variables elaborate on those socio-economic characteristics of respondents which influence the selection of a specific alternative. As stated above, 11 variables are of relevance for explaining the selection of alternatives and their implications on moral hazard in PES participation. They partially correspond to those identified in Round 1. While "fitting" the final models, three categories were excluded from the total set of 30 collected variables (see Table 8.2) since they were unable to explain differences in stated preferences at significant levels within the models, namely, COMEJI, RAN, and AGE. Therefore, the corresponding hypotheses cannot be accepted for these excluded variables (see Table 8.1).

The variable ASSEMBLY which showed a strong influence on stated preferences was reaffirmed in the second round. As in the first round, an increase in the attendance of assemblies decreased the probability that a community member would select a change of the status quo [PES-REDD], in other words respondents remained against a LUC alternative. Hence, frequent attendance in the General Assembly seems to favor compliance with a PES contract. This trend was actually expected, because in the assemblies all community-related (economic, social and cultural) issues are discussed and collective decision-making is carried out. It is an observable characteristic of social capital and cultural heritage. It is the regular means of communication among "all" community members in the community and symbolizes collective decision-making. In the same forum, PSAH-related issues of the past are also discussed such as collectively accepting the program. Accordingly, the negative coefficient of the variable PSAH indicates that the recognized participation effectively decreases the likelihood that moral hazard occurs, although the variable only entered in one model (Tobit).

The relevance of the variables WORKCULT and PARSIZE were confirmed in the second round as well. Equally, these variables reiterate the importance of opportunity costs for conservation in peri-urban areas. The econometric analysis found that if a community member works or cultivates land on common property, s/he is less likely to take hidden action, which is inconsistent with the formulated hypothesis. For risks of moral hazard, this means that those able to directly influence ES provision with active land management are more likely to comply with a PES-REDD program in the face of two LUC choices. On the other hand, for those currently without an assigned parcel, the status quo implies the forgone option value at considerably greater opportunity costs. Hence, for the first group it seems that PES payment supports the resistance of the pressure from urban sprawl and favors the conservation of land use (Murillo-Hernández, 2008). This partially contradicts other authors interpreting PES as a risk factor in a "farmer's" decision-making arguing that s/he may fear a masked expropriation (Dobbs and Pretty, 2008; Ogonowski et al., 2009; Robertson and Wunder, 2005). Accordingly the acceptance of and compliance with a PES contract may be interpreted as a risk-reducing strategy against other environmental policies which could become even more restrictive in the future (Skerratt, 1998). In addition, as Kosoy et al. (2008) point out, the economic incentive of PES is not always the strongest motivation for participation, since sometimes a higher appreciation for factors reinforcing heritage exists. It seems that those community members directly in touch with the communities' natural capital have a high interest in preserving their tradition of cultivating small patches on the commons. They are aware of urban pressure, so if they had a choice, they would rather stick to the PES program. On the other hand, in two models (Logit 1, Tobit) the variable PARSIZE suggests that greater parcel sizes per household increases the probability of selecting a LUC alternative - apparently agriculture. This was expected, but the variable seems to conflict with the interpretation of the WORKCULT variable, once again. An explanation might be that for households with greater parcel sizes the land value goes beyond subsistence and tradition. For them active land management means a lucrative income and they probably sense no immediate threat for ES provision by extending agricultural production.

The three variables MARITAL25, SEX1 and FAMSIZE were adopted in several models and reflect the social structure of a household, which apparently contributes to the avoidance of hidden action. For instance, the variable MARITAL25 denotes that a household led by a couple is more likely to demonstrate compliance with a PES-REDD contract when the land-use alternative is agriculture. This outcome is congruent with the formulated hypothesis. The explanation for this probably two-fold. First, couples tend to be economically better-off because they rely on a more diversified set of income alternatives, so that program restrictions on land use doesn't affect them as much as a single-parent household who may at least see the status quo as a renouncement from an option value. Second, couples are more likely to have children so that the attraction of conserving the community's natural heritage is reinforced through the PES program. This second explanation seems to be confirmed by the variable FAMSIZE which revealed relevance in the Tobit model. The negative coefficient of the variable indicates that larger households are less likely to commit hidden action (change the status quo). According to the interpretation of MARITAL25, protecting the cultural heritage, at least against the threat of urban expansion, for future generation is of concern. Although, this is inconsistent with the assumption initially made since it was expected that the availability of labor force to manage the commons more actively might have a positive impact on LUC (Ayuk, 1997; Neupane et al., 2002; Scherr, 1992). An additional explanation, supporting the interpretation of the encountered result of the previous two variables, is the gender of the respondent. The gender issue is of particular interest in policy design and development economics. It has been suggested that women are stewards of sustainable management and are more likely to positively influence land-use decisions such as program compliance. Accordingly, the variable SEX1 reveals that female respondents are less likely to favor a LUC alternative (Tobit) and in particular urbanization (Logit 2) of the commons, thus supporting the initial hypothesis.

The fourth block of independent variables with relevance for moral hazard consideration relates mainly to the economic well-being of the livelihood in the studied communities. The econometric analysis detected three associated categories, the same as those identified in the literature in the context of PES: education (Ayuk, 1997; Claassen et al., 2008; Echeverría, 2010; Nagubadi et al., 1996; Rahm and Huffman, 1984; Tognetti et al., 2004; Zbinden and Lee, 2005), occupation (Claassen et al., 2008; Kosoy et al., 2008) and income (Thacher et al., 1996; Wunder, 2008; Zbinden and Lee, 2005). Of these categories, four variables revealed significance for explaining stated preferences. The variables EDU12SEC, LABOR12W, INCOME and INCOPERS appeared in several models with higher levels respectively, decreasing the odds of PES-REDD non-compliance, which is keeping with the formulated hypotheses. The variable EDU12SEC revealed this relation in the second Logit model, suggesting that the level of higher education of the family head and/or spouse (at least secondary) leads to refraining from urbanization in particular. The impact of higher education may have three complementary explanations: first, it makes people effectively more aware of the illegal nature of urbanization on the commons; second, it facilitates environmental awareness of community members and their desire to preserve the land - they may be less driven by the payment but more driven because it provides the opportunity to conserve the land and inherit it to their descendants (e.g., Illukpitiya, 2005; Rico García-Amado et al., 2011; Teklewold and Köhlin, 2010); and third, it provides information about the respondent's ability to access alternative income sources effectively independent from the presented choice set. This reasoning is reinforced by the second variable. The variable LABOR12W which was also included in the first Logit (PES-REDD versus AGRI) and the Tobit. It suggests that those (heads of household and/or spouses) with regular work have income alternatives that are unaffected by land-use restrictions or at least they don't perceive the need to expand one of the land-use alternatives (AGRI and URBAN). However, it is worth noting that several respondents who reported an independent economic activity were actually "active land manager", thus casting doubt on the plausibility of the contribution to the Logit model. One explanation might be that those already pursuing agricultural activities have currently no intention of expanding this practice. On the contrary, this result suggests that those without regular work would rather like to derive direct benefits from LUC alternatives at the detriment of PES contract compliance, which contrasts with the additional side-objective of the program to alleviate poverty. This interpretation seems to be confirmed by the third and fourth variable referring to available household budget. The variable INCOME entered the first Logit model (PES-REDD versus AGRI) and the variable INCOPERS has been included in the rank-ordered Logit and Tobit. Both confirm that a higher level of liquid financial resources available to the household and individual household members indicates that a respondent is more likely to comply with the PES contract. Thus, the explanation might be that community members perceive the PES program (at least) as an opportunity to diversify and complement their income portfolios. Hence, community members may only become actively involved in a PES program when they do not receive a relatively high income from LUC alternatives (e.g., AGRI and URBAN) which the conservation program (e.g., PES-REDD) intends to restrict (Claassen et al., 2008; Engel et al., 2008; Ferraro, 2008), or they do not receive any income at all from these activities. In the latter case, opportunity costs are zero and a payment, in addition to being inefficient (as in the first case), will also be ineffective. On the other hand, these results indicate that lower income groups are less likely to comply with the PES contract. In a nutshell, community members with a higher income only perceive the payment as an additional income which is insignificant since they have no plans of engaging in any LUC activity, while community members of lower income ranks perceive LUC alternatives (at least) as a chance to improve their well-being.

Alternative-specific The experimental design incorporated three alternative-specific variables in particular which were expected to be critical for the principal-agent (government-community) relation in the context studied. The objective was to review these alternative-specific variables in a hypothetical scenario after a PES-REDD contract had been signed with the community in the General Assembly. Particular interest was placed analyzing if these alternative-specific variables influenced the permanence of ES provision from common properties. These variables relate to attributes of environmental policy enforcement in the framework of PES (Kosoy et al., 2008; Tognetti et al., 2004) and are considered to be of importance in order to guarantee compliance with environmental programs. Overall, the results show that these variables could not be included at a significant level in any model. The reasons for this outcome might be similar to those enumerated in the first round, drawing attention to problems of different scales, sample size, non-appropriate variables, and understanding.

The variable RESSAN has mixed implications in the two models, although in a strict sense its coefficient was not significant. In the rank-ordered Logit, the variable had a negative coefficient, which suggests that if responsibility for avoidable reversals of forest cover is assigned to the community in a given land-use alternative (PES-REDD, AGRI and URBAN), the less likely that alternative would be chosen, holding the values for the other alternatives constant. Equally, the first Logit (PES-REDD versus AGRI) and the Tobit (PES-REDD versus LUC) confirm a reducing effect of RESSAN on moral hazard, but at a non-significant level. Hence, the alternative-specific variable of collective liability seems to reinforce compliance, at least when comparing PES-REDD with expanding the agricultural frontier, which is consistent with the formulated hypothesis. In the second Logit model (PES-REDD versus URBAN) the effect was the opposite, but since the significance level is slightly above 0.10, its impact was not significant in a strict sense. Nonetheless, for the sake of completeness, the result suggests that most likely the economic direct and individual benefit from urbanization is not outweighed by the collective risk of RESSAN, which denotes moral hazard.

The variable INSPEC indicates a positive and significant relation only in the first Logit, and is similar to the observed trend in the rank-ordered Logit, but not significant. In contrast to the initial assumption, the Logit implies for an increase in control of compliance, the odds of selecting AGRI increases. Equally, the rank-ordered Logit suggests that increasing the level of government control in a given land-use alternative (PES-REDD, AGRI and URBAN) increases the odds of selecting this alternative, holding the values for the other alternatives constant. This was unexpected because more intense government control increases the probability of detecting the two LUC alternatives which constitute a contract breach (moral hazard). An explanation might be that AGRI specifically is considered by most respondents as an attractive alternative to increase direct benefits from the commons, but with a comparable low negative impact on the natural capital if controlled adequately. On the other hand, the application of INSPEC may suffer from institutional distrust or absence of threatened sanctions. Of relevance for the equivocal result may be that in the case of the PES alternative the institution responsible for program administration would probably be CONAFOR, while in the case of the LUC alternatives different institutions and policies apply. It is possible that trust and experience in the past with institutions handling environmental programs, agriculture and illegal urbanization could affect the respondents' perceived effectiveness of control and enforcement of sanction, which has been effectively low in the past (Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005). The opposite implications at non-significant levels hold true in the second Logit (PES-REDD versus URBAN) and Tobit (PES-REDD versus LUC) so that caution is warranted.

The variable CORRUPT directly relates to the external (principal: e.g., CONAFOR) institutional arrangement in the studied case. This structure most likely involves monitoring compliance with payment rules and participation requirements, and especially the payment of economic benefits. The variable CORRUPT was expected to have a positive implication for a change in the status quo [PES-REDD], implying moral hazard. The underlying assumption was that contract infringement may be bargained without actual consequences. Interestingly enough, CORRUPT has mixed signs but entered only the first Logit model (PES-REDD versus AGRI) with a negative sign at a low significance level. That is, the degree of perceived corruption regarding institutions handling payments from the program in a non-transparent manner or when not performing as expected, discouraged LUC in the form of agriculture. Similarly, the rank-ordered Logit revealed that the presence of corruption under a given land-use alternative (PES-REDD, AGRI and URBAN) decreases the odds of selecting this alternative, holding the values for the other alternatives constant. One underlying cause explaining the relationship could be the historically motivated distrust of rural-coined groups towards government authorities. Ramos (2008) has indicated that within communities in the area studied, institutional trust is rather low. It might also be that the alternative-specific variable was handled as a highly emotional "yeah-saying" attribute. This may limit the reliability of the suggested negative implication overall, even though answers were submitted anonymously. On the contrary, the second Logit model (PES-REDD versus URBAN) and Tobit registered on a non-significant level, corruption, indeed, could favor hidden action. In particular, urbanization (Logit 2) with its higher individual payoffs may have contributed to this tendency. The preliminary explanation is that some community members effectively traded-off the potential individual gain against moral hazard. It is possible that past experience with government authorities regulating illegal settlements ex post (Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005) is interpreted by some community members as the BAU and a way of "doing business".

9. Policy implications

The results of this research project point to the fact that PES-REDD, as an approach for aligning global benefits with local costs, is confronted with several design issues which warrant further consideration and should be improved upon for developing future strategies to guarantee the permanence of forest carbon stocks in Mexico. Elaborating on these aspects, this last chapter is dedicated to policy implications related to permanence issues in PES contracts. The first section of this chapter highlights the contribution of the conceptual framework (see Chapter 4) in regard to key analysis results. The second section focuses directly on the conclusions obtained from exploring the three main research questions (see Section 1.3). The third part provides policy recommendations which may aid in overcoming the problems of adverse selection and moral hazard of potential ES sellers (providers) who are organized in common property regimes.

9.1. Contribution of the conceptual framework

The starting point of this study was the interplay of the REDD mechanism (see Section 2.3 and 3.4) and the environmental policy instrument PES (see Section 2.2 and 3.3) in order to guarantee the permanence of forest carbon stocks (see Section 2.4) which presumably depends on those parties (see Section 3.1.3) that have an influence on the choice between land use and environmental contract (e.g., PES-REDD). Since PES and in particular REDD are still in an early stage of development, a lot has to be learned about the complex processes related to the provision of the public good "carbon" at the local level. Therefore, the conceptual framework of this research project used theoretical concepts for a more systematic analysis of environmental contracts. Hence, aspects were incorporated that draw the attention to possible obstacles in contractual arrangements itself and "surrounding" factors influencing the parties (the principal and the agent) of the contract. Here, the combination of the Contract Theory and the SLA in the analysis provided useful insights dealing with contract issues on the one hand and heterogeneous local conditions on the other hand. This conceptual framework allowed a deeper understanding for the parties of a contract, especially the agent (ES seller), in order to gain a better foundation for more profound conclusions. Furthermore, the conceptual framework represents a response to the demand in Natural Resource Economics of using interdisciplinary approaches in order to study interactions between economic and natural systems. It allowed explicitly analyzing the socio-economic motivation of the principal-agent relationship beyond a mere supply and demand agreement coordinated by a price.

The Contract Theory

The Contract Theory permitted discovering problems between ES buyers and ES sellers that arise from "non-complete" contracts. The results of this study, especially from Chapter 7 and the respective process, show the complexity of designing contracts. Despite the assistance of experts, answers to questions on the contract details remain ambiguous, such as the distinction and consequences of avoidable and unavoidable forest cover losses. This fact confirms two findings that are known from the Contract Theory: (i) "optimal" (or "complete") contracts are impossible to formulate, particularly when dealing with complex issues such as those discussed under this conceptual framework, and (ii) it is necessary to accept trade-offs between strict and flexible terms, such as the above mentioned distinction and different sanctioning of contingencies which do no longer ensure or at least lessen contract compliance.

Though the question arises, in both the Conceptual Framework and the Contract Theory in particular, which uncertainties exist in the selection and fulfillment of contracts by the contracting parties. This is done in this study especially with regard to the ES seller (the community with access to natural capital), although the conceptual framework includes the possibility that ES buyers (the government) can cause respective uncertainty as well. Here, the Contract Theory and the PES literature point to two common problems that may cause that payments to ES sellers are inefficient and contribute only marginally or not at all to the permanence of the ES provision at desired levels. The two problems are adverse selection and moral hazard. Both are crucial subject of the conceptual framework, as they play an important role in the choice and compliance with environmental contracts and thus the intended permanence of ESs, such as the increase and maintenance of forest carbon stocks.

The asymmetric information problem adverse selection and the probability of its occurrence were treated in conjunction with the current PSAH (see Chapter 6) and experimentally regarding PES-REDD (see Chapter 8). I.e. whether there is a possibility that the ES seller agrees to a contract, although s/he would have provided these ESs anyway without an additional payment. Starting from the idea that a contract is the subject of the interaction between an ES buyer (the government) and the ES seller (the community), the results of the respective chapters have essentially shown two things: (i) contracts concluded with a community (ES seller) doesn't preclude that all members of the community (potential ES providers) recognize their participation or rather vote for this alternative, and (ii) those community members who recognize their participation or rather state a preference for participation are not directly dependent on the management of common land that provides ESs. This outcome, derived from contract-theoretic considerations, suggests that adverse selection is a problem.

Similarly, this study analyzed especially through the application of experiments (see Chapter 8) the asymmetric information problem moral hazard in environmental contracts (e.g., PES-REDD). I.e. whether it exists the probability that the ES seller (community) carries out specific activities that constitute a breach of contract. Results of this chapter discover two main issues: (i) contracts concluded with a community (ES seller) are not supported by all members of the community (potential ES providers) during the contract period, and (ii) those community members that support environmental contracts are directly dependent on the management of common land which is providing ESs. This outcome indicates once again that information asymmetry exists; in this case moral hazard.

The insight of these results is mainly that the ES seller (the community) in the Mexican context is at odds internally (community members) regarding the selection and fulfillment of environmental contracts, but the ES buyer (the government) does not necessarily recognize this. Thus, it is possible to scrutinize whether the effort of the ES seller, here in the sense of inclusion of all community members, is sufficient to ensure the permanence of ES provision as stipulated in the environmental contract.

The Sustainable Livelihood Approach

While fundamental problems of asymmetric information in the principal-agent relationship between ES buyer and ES seller could be uncovered with the help of the Contract Theory, the SLA, complementing the conceptual framework, allowed analyzing the "surrounding" factors that explain the motivation and behavior of the parties. The incorporation of the SLA has been particularly useful in the Mexican context of study because the agent (ES seller) consists of single livelihoods (community members with their households). Thus, the SLA offers a deeper understanding for the underlying socio-economic issues favoring asymmetric information. The discovered divide within the community, acting as an ES seller, emerges as a complex issue and reveals that the studied communities are composed out of very heterogeneous livelihoods. Accordingly, the conceptual framework suggests that the factors surrounding a PES contract co-determine decisions of the individual community member (potential ES provider) whether a contract offered by an ES buyer is accepted or rejected, and fulfilled or broken.

The "external" factors within the SLA consist of two generic components: the vulnerability context and the policy and institutional framework. Both have been reviewed mainly in the Chapters 2 and 3 providing the foundation for ES buyers (ES users) action and influenced the discussion of the results in the Chapters 6, 7 and 8. Their integration offered a more detailed overview about the motivation and constraints of the ES buyer (ES user) in order to overcome problems of "natural resource management" in general and specifically in the context of Mexico. From the perspective of the ES buyer (ES user) this review has shown that the global (e.g., GCC) and local (e.g., water scarcity) vulnerability context is the reason for the development of policy programs, such as the country's *ProÁrbol*, and the creation of governmental institutions, such as the CONAFOR. This has deepened the understanding for the Mexican context and revealed that the government is acting as an ES buyer on behalf of the actual ES user, if "natural resource management problems" (e.g., water scarcity and GCC) are addressed inter alia with market-based mechanisms such as a PES program. The fact that in Mexico a government-financed PES structure is most likely connotes particular challenges of guaranteeing the permanence of ES provision. For example, this set-up is suffering from inefficiencies such as: (i) the main PES objective "ES provision" has not necessarily priority because side-objectives (e.g., targeting marginalized groups) are pursued, and (ii) budgetary constraints limit capacity and capability to select and monitor adequately ES sellers. These insights in turn explain why the ES buyer (the government) will have problems to avoid or reduce ES seller's adverse selection and/or moral hazard.

However, the more profound interest of this study is to analyze the socio-economic reasoning for the ES seller (the community) to engage in a contractual arrangement and reveal if problems of asymmetric information exist. The analysis of "internal" (from the perspective of the SLA) factors deepens the knowledge about the vulnerability context of the community (the ES seller) and the socio-economic motivation of a community member (potential ES provider) to recognize, or choose and comply with, a PES contract. In this regard, two main results have been obtained from the Chapters 6 and 8. First, the socio-economic situation of the ES seller (the community) is not featured by marginalization which is a proxy of the vulnerability context at the household level. This outcome suggests two additional issues: (i) the inclusion of CONAPO's marginalization index into the ES buyer's (the government) scoring system may be inefficient and provides a distorted picture, and (ii) more vulnerable livelihoods, which do not directly descend from the ES seller, push forward the urban frontier despite strict land-use regulations (see Section 3.2.2). Second, the socio-economic characteristics of a community member (potential ES provider) have a greater impact on the recognition, or rather choice and compliance, of environmental contracts than contract attributes themselves. Furthermore, this indicates two issues: (i) community members (livelihoods) within the community depend on different livelihood assets (capitals), and (ii) there are community members which are more or less likely to guarantee the permanence of ES provision depending on their endowment of livelihood capitals. These insights indicate that the ES seller (the community) probably shows, in particular at the community member (livelihood) level, signs of adverse selection and/or moral hazard in environmental contracts such as PES.

The main finding of these results is that an ES seller (the community) in the Mexican context is not a homogenous group of community members (livelihoods) and not all of them are necessarily active ES providers. The differentiated analysis of socio-economic characteristics (livelihood assets and their dimensions) of the community members allowed questioning the effort of the ES seller, here in the sense of actively involving those community members which are able to maintain or improve ES provision, in order to ensure the permanence of ES provision as stipulated in a PES contract.

9.2. Conclusions

This overview of conclusions is the result of the discussions stemming from Chapters 6, 7 and 8. Specific implications are pointed out separately for each research question elaborating on contract design issues relevant for guaranteeing the permanence of forest carbon stocks in the context of Mexico's common property regimes. The acceptance or rejection of previously formulated research hypotheses are included here.

Current PES practice

The first part of this study examined the current practice of the Mexican PSAH program, particularly assessing its appropriation at the household level. The application of a specially elaborated index assessment tool contrasted several livelihood dimensions (derived from the SLA) with recognized PES participation. The surveyed households are forming part of a common property regime collectively receiving PES benefits. The strong assumption here was that recognized participation highlights those community members who probably selected program participation in the General Assembly. In this context, the results and discussion in Chapter 6 suggested that the formulated research hypothesis was accepted for the cases studied. Accordingly, it was concluded that the objective of Mexico's national PES program and conditions to obtain incentive payments were misunderstood and insufficiently diffused among community members. The PES program is treated as a subsidy by communities and its use is adversely selected (in contract-theoretic terms) by some community members, resulting probably in no effective and efficient change in managing the natural resource base. Furthermore, the fact that PSAH is administered by the government means that budgetary constraints and equity concerns play an imminent role. Equity concerns are likely endanger the original idea of PES, tainting it with objectives which do not increase its effectiveness. The results of this research project are similar to other studies (Kosoy and Corbera, 2010; Lohmann, 2010; Norgaard, 2010) in that the PES concept described by Wunder (2005) reveals limitations when applied to the context of common property regimes. These refer to the problems of ES market-creation where underlying implications for social, political and biophysical relationships create conflicts among humans and ecosystems. Accordingly, the existence of diverse socio-ecological systems makes it impossible to identify a single institutional design which would work well in all circumstances (Corbera et al., 2009).

These conclusions proposed above are enriched by the following five points. First, the survey results of recognized participation confirmed that the PSAH program was not sufficiently disseminated among community members of the studied communities. Interest in participating actively in the PES program (Engel et al., 2008; Pagiola et al., 2005) was unincisive among households in the studied context. Although all community members were informed of the community's participation in the national PES scheme and benefited from it, in theory, not all community members of the peri-urban communities were truly aware of their participation. This implies that "complete" voluntary participation did not actually exist since a considerable number were not actively involved. The inquiry showed that only 61 percent (47 out of 77) recognized the community's involvement. This percentage probably somewhat overestimates the actual number, because interviews revealed that different environmental programs were confused. As projected for the choice-experiments, a more accurate figure would probably be about 26 percent (17 out of 66). The inability to provide detailed information about the program's objectives and rules was striking and has also been described by Caro Borrero (2012) and Perevochtchikova (2010) for the same peri-urban context. Furthermore, this observation coincides with results from field studies in the rural context (Angela Caro Borrero, Consultant contracted by the CONAFOR for the evaluation of Mexico's PES program, pers. comm., 2012; Muñoz Piña et al., 2008) and casts some further doubts about the current form of the PES program.

Second, PSAH in the studied context is facing the problem of limited additionality. Although, land enrollment in PES is voluntary, it theoretically represents just only one of the few options for the community to legally benefit from common property. This is because land use is already heavily restricted by the government. Therefore, the voluntary character of PES participation is actually flawed. PES, which is supposed to prevent forest degradation and loss, is granted to communities that effectively form part of the city's SC and are subject to other federal and state ANPs with a permanent ban on any type of land-use activity change; a condition which also applies to other reported cases in Mexico (Muñoz Piña et al., 2008). Consequently, the area should remain the same with or without a compensation payment. Hence, the current PES scheme acts more like a subsidy for those communities which suffer from historical government command-and-control regulations. Nonetheless, environmental law enforcement has been poor in the past so that illegal LUC driven by agriculture and urbanization is present in the area of study (Ávila Akerberg, 2004; Pérez Campuzano et al., 2011; PMRM, 2008; PMRE, 2008; Schteingart and Salazar, 2005), and is a phenomenon that corresponds to national trends (e.g., CONAFOR, 2010b). This circumstance may actually warrant some limited additionality if payments induce the control and subsequent reduction of illegal encroachment and settlements by the ES sellers (providers) as suggested by Asquith et al. (2008). However, caution needs to be applied for two reasons: first, the (illegal) opportunity costs in the peri-urban area of Mexico City are probably considerable higher than the national average so that the PES program may still be perceived as a subsidy and contributes only marginally to household income; and second, it is not clear if those recognizing PES participation are actually likely to provide higher levels of ES provision as will be discussed below.

Third, detected limited additionality raises concern as to whether PSAH (at least) guarantees conditionality in the studied communities. The main problem of addressing this concern is that payment does not depend on monitored and verified ES provision both in rural and peri-urban contexts (DOF, 2011). PSAH does not have a well-defined ES since linkage between land use and water quality (and/or quantity) is not entirely clear (Muñoz Piña et al., 2008). This is, actually, not new to PES schemes paying for hydrological services (e.g., Pagiola, 2008). Therefore, "land use" which is supposed to guarantee ES provision has been adopted. In the studied context, there is already strict preexisting protection with external control over natural resource extraction, such as agriculture and "zero" urban expansion. This still implies that the PES program is able to stimulate active involvement of community members, in particular those able to improve conditionality through their livelihood assets. Nonetheless, the division among community members recognizing PES participation indicates that conditionality might be a problem. Accordingly, the assessment of six indexes (human, natural, financial, physical, social and marginalization) suggests that people aware of their PES participation seem to have only a limited impact on ES provision. Hence, the low level of recognized participation, in combination with the results of the index assessment, suggests that the conditionality criterion of the "conventional" PES definition is not entirely met in this peri-urban context. Furthermore, this reveals that a real risk of individual and collective adverse selection exists, as supported by human, natural, physical and marginalization index assessments.

Fourth, Mexico's government-financed PES program includes several design flaws affecting program appropriation on-the-ground both in the rural and the studied peri-urban context. The ES buyer is the Mexican government while the actual ES user pays for the ES anonymously through a fixed water tax applied to the water bill (Muñoz Piña et al., 2008). This mechanism of collecting funds has been criticized by several authors (e.g., Pagiola, 2008; Wunder et al., 2008). The problem of this structure is that it does not create a feedback loop regarding the quality of ES provision between actual ES providers and users, and, therefore, is less likely to correct the alleged market failure. Instead, the program is likely to suffer from budgetary constraints. In effect, the durability and outreach of the program depends on political will and may undergo budgetary cuts or be cancelled entirely after the stipulated five-year contract currently in practice. Furthermore, this survey detected negative effects on-the-ground. CONAFOR's capacity is seriously limited financially as its budget is a fixed percentage of the total assigned fiscal budget. The problem, then, is that community members do not recognize the institution making the payment, even though the program has been operating in the communities since 2003. This is presumably the consequence of the minimal presence of CONAFOR due to budgetary restraints, which is exacerbated by the fact that the governance over the ecosystem's resource water is not well-defined in the study area since several institutions are involved on different administrative levels. This may suggest that the implementation of policy instruments and environmental management is inefficient. These issues actually make it difficult, as other authors confirm (Murillo-Hernández, 2008; Wunder et al., 2008), to distinguish the Mexican PES scheme from an ordinary subsidy program.

Fifth, a review of Mexico's national PES program has shown that the Federal Government has made attempts in the past to select certain ES sellers (providers) through a scoring system (DOF, 2011), with a propensity for participation depending mainly on the program's targeting through established eligibility criteria (Engel et al., 2008; Pagiola et al., 2005). The revised Rules of Operation indicate that the PES program has integrated aspects of poverty alleviation so that the effectiveness of ES delivery is likely be reduced since cost-efficiency of ES provision comes at the expense of an impact of general welfare of the communities (Wunder et al., 2008). This caveat has been studied using the Urban Marginalization Index for spatial targeting in the national PES program, showing results which strongly suggest that although the peri-urban area is marginalized, the studied communities *per se* are not. Hence, it seems that the expansion of the urban frontier is driven by other generally marginalized interest groups. These marginalized groups consist mainly of illegal settlements (most made up of non-community members) who, it can be assumed, have a negative impact on water provision. In brief, it can be concluded that including the targeting criterion of marginalization provides a distorted picture of the studied context.

Future PES-REDD contract design

The second part of this research study focused on "forecasting" a future PES-REDD regime in Mexico from a policy designers' perspective. More specifically, it identified contract attributes and attribute levels that tradeoff environmental integrity and contractual flexibility in order to guarantee the permanence of forest carbon stocks. The application of a Policy Delphi contrasted the opinions of experts on this subject matter. Four groups of experts consulted (private sector, academics, government and NGO) were supposed to give clear indications on appropriate key attributes for contract formulation. These experts took an ex ante perspective on contract design and elaborated on attribute levels which faced problems of adverse selection and moral hazard in order to safeguard the conditional payment of ES provision. Within this context, the results and discussion included in Chapter 7 determined that it is possible to accept the formulated research hypothesis, and with this determine that the resulting PES-REDD contract profile reflects the policy designers' desire to secure the permanence of ES. The effectiveness of a PES-REDD contract will partially depend on the program's ability to avoid ES sellers' adverse selection ex ante and moral hazard ex post - two asymmetric information problems described in the Contract Theory. Results show that adverse selection can be reduced with an appropriate definition of additionality, the stipulation of eligibility criteria for ES sellers, and the use of justified time frames. Moral hazard can be reduced with the adequate accounting of environmental benefits, adjustment of the payment structure for the ES and enforcement of contracts by adequate sanctions.

A summary of this can be complemented by three specific conclusions. First, the tradeoffs of strict versus flexible interpretation of permanence have troubled policy makers from the beginning of the GCC mitigation debate and have not been solved as market results suggest under CDM for forest carbon credits. A great concern for assuring environmental integrity has led to the adoption, both in the compliance market and Delphi analysis, of a carbon accounting methodology (stock-change method) which implicitly requires a relatively long liability for any premature loss of carbon given that it implies a credit-debit system. Results from the expert panel suggest that flexibility of shared responsibility is possible in two ways: first, by limiting the responsibility of the ES seller (provider) only to the agreed crediting period so that the ES buyer takes back the responsibility afterwards, and second, distinguishing during the crediting period between types of reversals, which if they occur, do not result in "tough" sanctions on the already presumably poor ES sellers (providers). Accordingly, the resulting PES-REDD contract profile included attribute levels to effectively guarantee the permanence of the created carbon benefits during and after a predefined contract period. The outcome clearly assigns responsibilities for any premature loss of forest carbon during a contracted period of 40 years in the case of avoidable reversals to the ES seller (provider), and in the case of unavoidable reversals to a third party. After 40 years, the liability of the credited amount goes back in full to the ES buyer (user). Although this is correct from an accounting perspective and safeguards the environmental integrity of the carbon regime, it is not clear if such an approach would perform significantly differently from current CDM practices in regard to A/R project activities. Thus, it can be concluded that stakeholders in policy design are highly concerned about assuring that any marketing REDD credits approach guarantee the permanence of forest carbon stocks. The experts were unable to come up with a concrete approach so that LULUCF projects avoid facing a discount for their impermanent character. Thus, it is questionable if a favored market approach has any appeal without any further policy intervention in the form of price floors, additional funding, premiums or quotas for forest carbon credits and is able to create a market price around USD 20 per tCO_2-e as suggested by the panel of experts.

Second, the issue of adverse selection by potential ES sellers (providers) is effectively addressed by the contract profile obtained from the Delphi process. The experts' opinion to include primarily avoided deforestation and degradation leaves little interpretation as to what is considered additional. It implies that forest carbon stocks actually decrease in the BAU scenario and that any active change of land-use management other than that scenario is likely to result in higher forest carbon stocks. Hence, sellers must change and/or improve their land-use behavior in order to provide verifiable carbon sequestration and/or emission avoidance greater than the agreed baseline. This may require that ES sellers (providers) effectively control land-use patterns within the agreed boundaries. This revealed condition implicitly allows for determining ex post regardless as to whether reversals are intentional or unintentional. Hence, in order to reduce adverse selection two key criteria for eligibility need to be adopted: the ability to effectively change forest carbon stock levels and to control land-use patterns. As this implies an actual threat of forest carbon loss now or in the future, potential ES sellers (providers) are continuously confronted with opportunity costs that probably offer immediate (often individual) short-term benefits. The experts recognized this problem and pointed out that long-term contracts must seem extremely unattractive to any potential ES provider, concluding that adopting time spans beyond 40 years increases the risk that potential ES sellers (providers) with a true ability to contribute positively to mitigation goals may restrain from voluntary participation, while those with a lower probability to contribute are more likely to adversely select their participation.

Third, the problem of any premature loss of credited forest carbon stocks which would implicitly reduce conditionality is reflected in the final contract profile as well. Independent of the cause of the reversal, experts selected the stock-change method which explicitly credits any increase and discounts any decrease of verified forest carbon stocks. This credit-debit system is immediate and simple, and safeguards the environmental integrity of the carbon regime. However, this accounting method implicitly raises issues of responsibility and liability for forest carbon stocks and for adequate incentives in order to guarantee commitment during the contracted period. Accordingly, the problem of moral hazard entered into the experts' arguments. They upheld the opinion that a contract needs to differentiate between causes of reversals. Specifically, an avoidable reversal is a phenomenon of moral hazard by the ES seller (provider) which is considered to be an intentional breach of contract if it occurs during the contracted period. This is because it is assumed that sellers (providers) have effective control over land-use patterns. Yet the experts also acknowledged that even if it is reasonable to make ES sellers (providers) responsible for any intentional reversal, they would select a "softer" form of sanction (retirement of credits) in order to reduce the risk of a regret formulation. Care must be taken in this case since a "soft" regulation may excuse moral hazard and reduce the level of commitment ex post. Despite this risk, retirement of carbon credits from, for example, a buffer pool at least safeguards the environmental integrity of the carbon regime as long as the accumulated amount of avoidable reversals does not exceed the total buffer pool. Furthermore, experts note that, in addition, moral hazard should be dealt with using incentives throughout the complete contract period. They argue that annual payments encourage, at best, an activity-reducing strategy such as REDD.

Choice of land-use alternatives

The third part of this study analyzed ES sellers' (providers') responses to PES contract profiles in order to explore how adverse selection and moral hazard, two concepts known from the Contract Theory, of ES sellers (providers) can be avoided (or at least reduced) so as to guarantee the permanence of forest carbon stocks. The application of a choice-based experimental set-up revealed ES sellers' (providers') preference in land-use decisions and how this might affect collective decision-making in the context of common property regimes. A strong assumption here is that community members' revealed preferences would be equal to their selection of program participation in the General Assembly ex ante and land-use choice ex post. In this context, the results and discussion of Chapter 8 indicated that it is possible to accept the formulated research hypothesis for the case studied. The revealed preferences for land-use alternatives reflect the inner conflict of a contracted agent (the community) who relies on collective decision-making. A voluntary PES contract must balance strict commitment ex ante with flexibility ex post in order to successfully address the problem of individual ES sellers' (providers') adverse selection and moral hazard. Ex ante most community members of a common property regime prefer a market-based approach over a command-and-control approach for forest conservation, but ex post the agent (the community) has difficulties to maintain agreed conditionality once LUC alternatives offer higher rents to individuals (community members).

The general reasoning proposed above can be complemented with three conclusions. First, the applied econometric analysis of the two-stage choice-experiment finds that stated preferences for submitted alternatives reflect a heterogeneity among community members of two peri-urban communities with access to common natural property. On the one hand, the results reveal a desire to obtain legal benefits (higher payoffs) through government programs which should ideally increase social cohesion. On the other hand, it suggests high external and internal pressure (higher payoffs from LUC) provoking hidden action and weakening of the social structure. Both case-specific variables and alternative-specific attributes influenced differences in stated preferences. The explanatory variables "General Assembly attendance" and "working or cultivating a parcel on the commons" were of particular relevance. However, alternative-specific attributes alone were not able to explain the probability of accepting a certain alternative in all cases. In fact, the three attributes (i) responsibility and sanction, (ii) control and (iii) corruption were partially irrelevant for the selection which suggests that further research is warranted.

Second, the results of the first round of the experiment show that environmental contracts such as PES have considerable appeal to community members in peri-urban communities. As expected, the higher economic incentive compared to the status quo actually demonstrated incentive compatibility. Although the payment level for the PES-REDD alternative was approximately double that offered by PSAH, it seems that this was not sufficient to fully offset the eightfold contract duration as suggested by the expert panel. The two PES concepts presented were almost equally preferred, but varied depending on the applied scale: comparing, ordering or ranking options. A strict commitment to higher PES contract durations probably limited their enthusiasm, although it could be argued that it provides more reliable (and legal) funding over time. This outcome confirms statements supported by the literature (e.g., Ogonowski et al., 2009), also specifically for Mexico's rural context (Bray, 2012), and the expert panel discussion, arguing that longer time frames reduce the sovereignty of communities and most likely increase their fear of expropriation. Therefore, it can be reasoned that shorter time frames as those currently earmarked for the national PES program have a greater appeal. The analyzed alternative-specific variables and their levels seemed to play a collectively minor role, even though the hypothetical character of the experimental design itself may have blurred individual judgment. Overall it is apparent that assigning responsibility for avoidable reversals to the collective with "hard" sanctions has the potential of reducing adverse selection. This is because the common property regime only participates if it presumes that it is able to collectively guarantee compliance. Nonetheless, the results from the experiments and feedback reveal that communities currently expect relatively low levels of collective enforcement, which explains why response to "collective liability" was negative. This outcome is backed by the literature (e.g., Ogonowski et al., 2009) and the discussion among the experts included in the Policy Delphi arguing that strict sanctions applied to the community as a whole are perceived as unfair. Flexible mechanisms for dealing with avoidable reversals are probably appreciated by ES sellers (providers), and PES payments may still turn out to be effective in the long-run if they stimulate internal organization. Accordingly, a higher level of external control is accepted by most community members in order to reinforce contractual obligations thereby avoiding any intentional reversal. The role of corruption is critical in this context, but ambiguous as revealed. Overall, corruption as a general rule, limits the effectiveness and efficiency of any environmental program. Community members expressed their dislike of corruption and regarded it as a factor which eroded the common property regime and negatively affected avoidance of intentional reversals.

Third, the results of the second round of the experiments demonstrated that PES-REDD contracts are likely to face the problem of complying with the agreed conditionality when LUC alternatives come into the picture offering higher rents to individuals in peri-urban communities. As expected, the higher economic incentive compared to the status quo actually incentivized hidden action. Higher per hectare rents and the prospect of receiving immediate and direct benefits compared to non-immediate and non-transparent benefit-sharing structures under a PES program seemed to be a driving force. These results suggest that considerably long time frames, such as 40 years, and relatively low annual payments are not sufficient to assure compliance at the individual level, which risks overall conditionality in cases where the ES seller is organized in a group. As pointed out, the three analyzed alternative-specific variables and their levels seemed to play a minor role collectively for reducing moral hazard. It should be noted that the hypothetical character of the experimental design may have influenced individual judgment, yet assigning responsibility for avoidable reversals to the community generally improves compliance ex post. The consequence for the detection of an avoidable reversal such as the reimbursement of all obtained benefits and exclusion from future benefits seems to be an effective measure to restrain LUC. It seems that the relatively high direct and immediate benefit may counter balance the consequences only in the case of urbanization.

Accordingly, the risk of control and detection of avoidable reversals reduces the likelihood of moral hazard and reinforces rules of natural resource management which provide more explicit benefits to individuals through sustainable resource extraction. Corruption may, consequently, favor moral hazard ex post, especially if this alternative provides higher individual payoffs, as has been observed in the past with illegal settlements eventually regularized by the government.

9.3. Recommendations

This last section focuses on policy recommendations for the design of a PES-REDD strategy which guarantees the permanence of forest carbon stocks in Mexico. Most of these recommendations probably improve Mexico's current PSA program as well. Aspects are emphasized that solve (or at least reduce) problems of asymmetric information in the application of PES contracts. The following six categories of suggestions refer to toeholds for avoiding ex ante the adverse selection and ex post the moral hazard of potential ES sellers (providers) organized in a common property regime. It is hoped that these recommendations help to improve the effectiveness, efficiency and equity of environmental programs such as PES.

Selecting and monitoring CONAFOR has continuously developed a scoring system to select potential ES sellers and select those who are able to provide the desired ES. This targeting approach was introduced because policy-makers perceived the need to increase effectiveness, efficiency and equity through a non-random selection of participants (Muñoz Piña et al., 2008). It is applied mainly at the community level, ignoring internal heterogeneity. This study's index assessment and econometric analysis reveal that common property regimes (agrarian communities and *ejidos*) as the most significant ES providers in Mexico face considerable internal diversity, at least in the studied peri-urban zone. This diversity is reflected by the distinct livelihood asset endowment of participating households. The different socio-economic characteristics of community members forming a common property regime limit the selection effect in its current form as applied in Mexico's PSA program. The outcome of this is that those community members recognizing their participation are less likely to improve ES provision over the contracted period. Therefore, it is recommended that additionality and conditionality be improved through the operationalization of an index assessment tool on a household level. This index tool would be able to identify ex ante community members able to maintain or improve natural resource management practices (avoiding adverse selection) and monitor ex post their active involvement to determine if there is a real impact on promoting sustainable livelihood (avoiding moral hazard). The index assessment would typically identify those community members who have valid access and resource extraction rights within the internal titling system of the common property regime and are likely to make use of them. This would permit monitoring and verification to assure that participants develop their land in terms of capital invested for a certain uninterrupted time span, and consequently distinguish between avoidable and unavoidable reversals.

Communication A limited awareness of PES program details surfaced from the survey and the feedback session (after the experiments) highlighting that future improvements must be made on membership-level communication rather than leadership-level communication so that the principal-agent relationship is improved. CONAFOR, the institution in charge of PES programs needs to maintain closer ties with the communities in order to convey and disseminate the rules of operation of current (PSAH) and/or any future (e.g., PES-REDD) programs. It should clarify, for example, where the financial support comes from, why it is provided and what must be done in return. Emphasis should be placed on those community members who have insufficient access to communication due to physical or cognitive limitations. Both the index assessment and the econometric analysis imply that lower levels of education limit the appropriation of environmental policies. This is important in order to ensure equal access to information throughout the targeted population. The PES administrator (CONAFOR) should explore a communication strategy which takes full advantage of existing channels of communication in the community and use these as a multiplier to transmit information and feedback about PES performance. A starting point could be the venue where common property regimes make their collective decisions on, for example, PES contract adoption. From the beginning, the CONAFOR should assure that prior informed "broad" consent is the fundament of PES contract acceptance and that the collective decision-making is (at least) based on a simple majority in absolute terms, i.e. considering all community members inscribed in the RAN. The General Assembly, legally anchored as the highest decision forum of an agrarian nucleus is a traditional and the only regular communication platform for all community members. The assembly may be used for providing the members of the communities with information and fostering discussion on the program's usefulness. Nontheless, results from the first round of the choice experiment indicate that employing the General Assembly won't run by itself, although results from the second round suggest a strengthening effect to resist LUC alternatives. Therefore, it depends if continuous and frequent "face-to-face" interaction with all community members in the General Assembly could bring additional credibility to the contractual PES arrangement. The success probably relies on the administrator's ability to overcome with these sessions perceived problems of community members related to institutional distrust, the far-reaching impression that corruption affects the principal-agent relationship and the opinion of week law enforcement.

Cultural heritage The cultural dimension of the cases studied is important, because it has a profound implication for the Mexican context. The origin of common property regimes in Mexico has its roots in the history of land distribution. During the Mexican Revolution (in

1910) agrarian groups fought for the right to access the land and manage it autonomously and collectively. Therefore, programs like PES may come into conflict with the Mexican culture that is deeply rooted in indigenous and agrarian land use. Nonetheless, the Mexican rural-coined society is overaging and new generations may lose interest in actively and sustainably managing the natural capital since their cultural heritage is under considerable pressure, specifically in the periphery of Mexico City. This is due to pressure of government regulations (top down) and urbanization (bottom up). Therefore, it is important to convey the idea that safeguarding the benefits of ES provision, such as water and carbon, has a value for future generations and third parties. Similarly, the perceived importance of forests which provide water and oxygen is an aspect that directly affects the well-being (health and economy) of community members at large. For example, the administration of the PSAH program should take advantage of these concerns and provide better information on the importance of the amount of water currently being used and water needed in the future, together with the positive implications of program participation. In fact, this entry point could be used to disseminate PES objectives, elaborate on activity diversification, invest in sustainable natural resource management, and draw attention to the possibility that a PES scheme may act as an insurance policy against unforeseen events while strengthening internal solidarity. Furthermore, emphasizing more direct sustainable natural resource utilization is likely to increase the immediate interest of the community and the program's recognition. For example, active SFM promoted by a PES-REDD scheme may allow active land management, provide remunerated employment in the forestry sector and benefit the climate (increase in carbon stocks) at the same time.

Diversification Communities are under considerable pressure to sustain their livelihood. The index assessment results revealed that households within the communities have different sources of assets which determine their income portfolio and opportunities to diversify. Similarly, the econometric analysis showed that LUC alternatives generating immediate individual benefits were attractive. Overall, this points to the fact that community members are interested in diversifying their opportunities in order to generate income, but may do so at the detriment of natural capital. Hence, increasing a community's appreciation for forests providing ESs (e.g., water and carbon) assures the preservation of natural resources. Therefore, the PES orientation of current practice (PSAH) should be reconsidered, especially in the cases studied, in order to allow access to other sources of income and/or promote sustainable management of natural resources. It might eventually improve current ES provision by allowing the community to pursue active natural resource management. The PES program has management activities to offer on the commons that offset the opportunity costs from livelihood activities which the program intends to restrict. Of particular concern are those community members in the community with lower levels of education who have fewer possibilities to diversify easily, but probably depend more on natural resource extraction. They need to be actively involved in the conservation concept, identifying activities that can be performed within the polygon without harming the program's objectives. The implication for policy design is that (i) program activities should not be promoted as a subsidy for those who do no receive income from the commons and (ii) alternatives for those still capable of working within the limits of the common property should be promoted. The Mexican government should refrain from policies of "do not touch" which have demonstrated harmful effects and work against the goal of conservation. Instead, policies should emphasize the sustainable management of forest ecosystems developing at least one axis of action that builds on SFM. PES could offer, in contrast to an ANP, a scheme of voluntary participation that embraces the ability to maintain a set of income sources coming from the area or forest in question and effectively reduce illegal activities.

Opportunity costs An analysis of the information collected from experts combined with experimental data, revealed that opportunity costs together with time scales are critical aspects and likely to influence the decision-making ex ante and ex post of individuals forming a common property regime. The choice-experiments demonstrated that changing circumstances, or more specifically the opportunity to select ex post "socially less desired" land-use alternatives, represent a risk to commit hidden action at the individual level so that moral hazard has to be considered ex ante. Employing the concept of opportunity costs for determining payment levels requires the capability and capacity to accurately measure relevant land-use alternatives differentiated by location and reflect possible changes over time. Therefore, the voluntary character of PES makes the negotiation process between ES sellers (providers) and ES buyers (users) a critical component for guaranteeing permanence. Especially when shorter time frames are selected, it allows the parties to adapt to changing circumstances. This is reasonable where deforestation and degradation drivers, especially if exogenous, increase pressure. For example, economic incentives for LUC may increase as a direct or indirect response to offered conservation incentives since the scarcity of (forest) areas provokes competition. Therefore, it is recommended that the payment structure of the PES scheme be adjusted to different levels of opportunity costs in terms of legal activities that cause deforestation and degradation in different locations of the country. In addition, the cases studied document that the opportunity costs of illegal activities should also be considered, if the institutional arrangements were not yet able to enforce environmental regulations, for example, in the case of avoiding illegal settlements. Furthermore, it is suggested to consider the possibility of combining ESs (compare with Section 2.2.2), such as bundling or layering water and carbon benefits, in order to increase the payable amount per hectare and compete economically with LUC alternatives.

Law enforcement A review of the literature, specifically for the area of study (e.g., Pérez Campuzano et al., 2011; Schteingart and Salazar, 2005), and the results and conclusions from this research project draw attention to the problem of enforcing environmental policies such as

PSAH and PES-REDD, and identifying contract rules which support them. As the outcome suggests, a gap in law enforcement exists on two levels, that of government institutions and that of community. Therefore, it is recommended that action be improved on both levels simultaneously. At the government level, urban and environmental policies need to be streamlined in order to effectively address deforestation and forest degradation drivers. Federal and state institutions have to avoid overlaps in jurisdiction, which confuses ES sellers (providers) and inhibits government action. Forestry programs should focus on transparency, equality and sustainable resource extraction. Drivers of forest stock loss and land conflicts must be analyzed and solutions need to be designed carefully between stakeholders in conjunction with institutions in order to reach a consensus for prioritizing coordinated action. This implies that government institutions provide ES sellers (providers) with effective incentives (the "carrot") to battle potential conflicts with external parties (e.g., illegal dwellers) threatening natural resources, effectively enforcing natural resource use rights, and increasing the ability to self-enforce property rights. On the other hand, law enforcement must be guaranteed internally on the community level as well. In brief, it is recommended that opportunities be further explored to not abandon completely the application of sanctions (the "stick"). Given the current circumstances of weak internal enforcement, a collective liability clause and effective (non-corrupt) external controls could reinforce self-enforcement and strengthen the social capital which showed considerable signs of erosion in the cases studied.

Bibliography

Acosta, S. L., 2001. Las tierras comunales de la Magdalena Contreras, una naturalez socializada. Tesis de Licenciatura en Geografía, Facultad de Filosofía y Letras, Universidad Nacional Autónoma de México (UNAM), México.

Addelman, S., February 1962a. Orthogonal Main-Effect Plans for Asymmetrical Factorial Experiments. Technometrics 4 (1), 21–46.
URL http://www.jstor.org/stable/1266170

Addelman, S., February 1962b. Symmetrical and Asymmetrical Fractional Factorial Plans. Technometrics 4 (1), 47–58.
URL http://www.jstor.org/stable/1266171

Adesina, A., Chianu, J., 2002. Determinants of farmers' adoption and adaptation of alley farming technology in Nigeria. Agroforestry Systems 55 (2), 99–112.
URL http://dx.doi.org/10.1023/A:1020556132073

Adesina, A. A., Mbila, D., Nkamleu, G. B., Endamana, D., 2000. Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. Agriculture, Ecosystems & Environment 80 (3), 255–265.
URL http://www.sciencedirect.com/science/article/pii/S0167880900001523

Akerlof, G. A., August 1970. The Market for "Lemons": Quality Uncertainty and the Market Mechanism. The Quarterly Journal of Economics 84 (3), 488–500.
URL http://www.jstor.org/stable/1879431

Alatorre Frenk, G., 2000. La construcción de una cultura gerencial democrática en las empresas forestales comunitarias. Premio Estudios Agrarios 1998. Casa Juan Pablos S.A. - Procuraduría Agraria, México.

Albrecht, A., Kandji, S. T., 2003. Carbon sequestration in tropical agroforestry systems. Agriculture, Ecosystems & Environment 99 (1-3), 15–27.
URL http://www.sciencedirect.com/science/article/pii/S0167880903001385

Alix-García, J. M., Shapiro, E. N., Sims, K. R. E., February 2010. The environmental effectiveness of payments for ecosystem services in Mexico: Preliminary lessons for REDD. Draft Paper - Land Tenure Center Brief 11, Department of Agriculture and Applied Economic, University of Wisconsin, Madison, retrieved February 18th, 2012.
URL http://www.aae.wisc.edu/events/papers/DevEcon/2010/alix-garcia.05.06.pdf

Álvarez, K., 2000. Geografía de la educación ambiental: algunas propuestas de trabajo en el bosque de los dinamos, área de conservación ecológica de la Delegación Magdalena Contreras. Tesis de Licenciatura en Geografía, Facultad de Filosofía y Letras, Universidad Nacional Autónoma de México (UNAM), México, pp.127.

Angelsen, A., Kaimowitz, D., 2001. Agricultural Technologies and Tropical Deforestation. CABI Publishing and Center for International Forest Research (CIFOR).
URL http://www.cifor.org/publications/pdf_files/Books/BAngelsen0101E0.pdf

Arnold, J. E. M., 1992. Policy issues related to the role of trees in rural income and welfare security. In: Gregersen, H., Oram, P., Spears, J. (Eds.), Priorities for forestry and agroforestry policy research: Report of an international workshop. International Food Policy Research Institute, Washington DC, Ch. 2, pp. 15–31.
URL http://www.ifpri.cgiar.org/sites/default/files/publications/oc24.pdf

Asquith, N., Wunder, S., 2009. Pagos por servicios hídricos: las conversaciones de Bellagio. Fundación Natura Bolivia, Santa Cruz de la Sierra, Bolivia.
URL http:/www.cifor.org/nc/id/online-library/browse/view-publication/publication/2785.html

Asquith, N. M., Vargas, M. T., Wunder, S., 2008. Selling two environmental services: In-kind payments for bird habitat and watershed protection in Los Negros, Bolivia. Ecological Economics 65 (4), 675–684.
URL http://www.sciencedirect.com/science/article/pii/S0921800907006076

Astigarraga, E., 2004. El Método Delphi. Working Paper, Facultad de CC.EE. y Empresariales, Universidad de Deusto, San Sebastian, retrieved June 4th, 2010.
URL http://www.echalemojo.com/uploadsarchivos/metodo_delphi.pdf

Aukland, L., Moura-Costa, P., October 2002. Review of methodologies relating to the issue of permanence for LULUCF projects. Cooperative Agreement between Winrock International and the EPA - Product 11, Winrock International, Arlington, VA, retrieved, September 1st, 2011.
URL http://www.winrock.org/ecosystems/files/Product%2011%20Permanence%20methodology.pdf

Ávila Akerberg, V., 2002. La vegetación en la cuenca alta del río Magdalena: un enfoque florístico, fitosociológico y estructural. Tesis de Licenciatura en Biología, Facultad de Filosofía y Letras, Universidad Nacional Autónoma de México (UNAM), México.

Ávila Akerberg, V., 2004. Autenticidad de los bosques en la cuenca alta del río magdalena. Tesis de Maestría en Ciencias Biológicas, Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), México.

Ávila Akerberg, V., 2009. Forest quality in the southwest of Mexico City - assessment towards ecological restoration of ecosystem services. Ph.D. thesis, Albert-Ludwigs-Universität Freiburg, Germany.

Ávila Akerberg, V., González-Hidalgo, B., Nava-López, M., Almeida-Leñero, L., 2008. Refugio de fitodiversidad en la ciudad de México, el caso de la cuenca del río Magdalena. Journal of Botanical Research Institute of Texas 2 (1), 605–619.
URL http://www2.brit.org/fileadmin/Publications/JBotResInstTexas_2_1/56_Avila-Akerberg_et_al-Fitodiversidad_en_la_cuenca_del_rio_Magdalena_Mexico_D.F.pdf

Ayuk, E. T., 1997. Adoption of agroforestry technology: The case of live hedges in the central plateau of Burkina Faso. Agricultural Systems 54 (2), 189–206.
URL http://www.sciencedirect.com/science/article/pii/S0308521X96000820

Banco de México, June 2012. Tasa de interés objetivo - Meta establecida por el Banco de México para la tasa de interés en operaciones de fondeo interbancario a un día. Promedio entre Julio 2011 y Junio 2012. Online by Banco de México, retrieved June 19th, 2012.
URL http://www.banxico.org.mx/SieInternet/consultarDirectorioInternetAction.do?accion=consultarCuadroAnalitico&idCuadro=CA51&sectorDescripcion=Precios&locale=es

Bartelheimer, P., 1993. Betriebswirtschaftliche Ansätze zur monetären Bewertung der Sozialleistungen des Waldes. In: Bergen, V., Brabänder, H. D., Bitter, A. W., Löwenstein, W. (Eds.), Monetäre Bewertung der landeskulturellen Leistungen der Forstwirtschaft. Vol. Band 1. Schriften zur Forstökonomie, pp. 1–9.

Bateman, I. J., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Özemiroglu, E., Pearce OBE, D. W., Sugden, R., Swanson, J., 2002. Economic Valuation with Stated Preference Techniques: A Manual. Edward Elgar Publishing Limited.

Baylis, K., Peplow, S., Rausser, G., Simon, L., 2008. Agri-environmental policies in the EU and United States: A comparison. Ecological Economics 65 (4), 753–764.
URL http://www.sciencedirect.com/science/article/pii/S0921800907004223

Bennett, M. T., 2008. China's sloping land conversion program: Institutional innovation or business as usual? Ecological Economics 65 (4), 699–711.
URL http://www.sciencedirect.com/science/article/pii/S0921800907004971

Bergen, V., Löwenstein, W., Olschewski, R., 2002. Forstökonomie - Volkswirtschaftliche Grundlagen. Verlag Franz Vahlen München.

Bolton, P., Dewatripont, M., 2005. Contract Theory. Massachusetts Institute of Technology.

Bolund, P., Hunhammar, S., 1999. Ecosystem services in urban areas. Ecological Economics 29 (2), 293–301.
URL http://www.sciencedirect.com/science/article/pii/S0921800999000130

Bonan, G. B., June 2008. Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests. Science 320 (5882), 1444–1449.
URL http://www.sciencemag.org/content/320/5882/1444.abstract

Boucher, D., Movius, D., Davidson, C., August 2008. Filling the REDD Basket: Complementary Financing Approaches. Report - Tropical Forests and Climate, Union of Concerned Scientists, retrieved September 9th, 2010.
URL http://www.ucsusa.org/assets/documents/global_warming/TFCI_REDD-Basket.pdf

Braat, L., ten Brink, P., Bakkes, J., Bolt, K., Braeuer, I., ten Brink, B., Chiabai, A., Ding, H., Gerdes, H., Jeuken, M., Kettunen, M., Kirchholtes, U., Klok, C., Markandya, A., Nunes, P., van Oorschot, M., Peralta-Bezerra, N., Rayment, M., Travisi, C., Walpole, M., May 2008. The Cost of Policy Inaction - The case of not meeting the 2010 biodiversity target. Study 2007 / S 95 – 116033, European Commission, DG Environment, retrieved October 22nd, 2011.
URL http://www.globio.info/downloads/85/Report%20-%20Braat%20&%20ten%20Brink%20eds%20%282008%29%20The%20Cost%20of%20Policy%20Ina.pdf

Bray, D. B., 2012. Carbon and Community Development: An Experiment in Oaxaca. Grassroots Development 33, 15–21.
URL http://www.iaf.gov/modules/showdocument.aspx?documentid=261

Bray, D. B., Merino-Pérez, L., September 2002. The Rise of Community Forestry in Mexico: History, Concepts, and Lessons Learned from Twenty-Five Years of Community Timber Production. A report in partial fulfillment of a grant from the ford foundation, The Ford Foundation, retrieved June 16th, 2010.
URL http://www.ccmss.org.mx/descargas/the_rise_of_community_forestry_in_mexico.pdf

Bray, D. B., Merino-Pérez, L., July 2004. La experiencia de las comunidades forestales en México - Veinticinco años de silvicultura y construcción de empresas forestales comunitarias, 1st Edition. Secretaría de Medio Ambiente y Recursos Naturales, Instituto Nacional de Ecología, Consejo Civil Mexicano para la Silvicultura Sostenible A.C., Fundación Ford.
URL `http://www.ccmss.org.mx/descargas/la_esperiencia_de_las_comunidades_forestales_en_mxico.pdf`

Brockhoff, K., 1975. The Performance of Forecasting Groups in Computer Dialoque and Face-to-face Discussion. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: techniques and applications. Addison-Wesley, Ch. IV. E., pp. 291–321.

Bruijnzeel, L. A., 2004. Hydrological functions of tropical forests: not seeing the soil for the trees? Agriculture, Ecosystems & Environment 104 (1), 185–228.
URL `http://www.sciencedirect.com/science/article/pii/S0167880904000404`

Burke-White, W. W., von Staden, A., 2007. Investment Protection in Extraordinary Times: The Interpretation and Application of Non-Precluded Measures Provisions in Bilateral Investment Treaties. Virginia Journal of International Law 48 (2), 307–410.
URL `http://ssrn.com/abstract=980107`

Burkett, J. P., 2006. Microeconomics: optimization, experiments, and behaviour. Oxford University.

Busch, J., Strassburg, B., Cattaneo, A., Lubowski, R., Bruner, A., Rice, D., Creed, A., Ashton, R., Boltz, F., 2009. OSIRIS and the Collaborative Modeling Initiative on REDD Economics. Tech. rep., Collaborative Modeling Initiative on REDD Economics include Conservation International (CI), the Terrestrial Carbon Group (TCG), Environmental Defense Fund (EDF), Woods Hole Research Center (WHRC) and the Center for Social and Economic Research on the Global Environment at the University of East Anglia (CSERGE), retrieved September 24th, 2010.
URL `http://www.conservation.org/osiris`

CAR, September 2010. Options for Managing CO2 Reversals, prepared for consideration in the Climate Action Reserve's Working Group for the Mexican Forestry Protocol.

CAR, November 2011a. Draft Mexico Forest Protocol Version 1.0. Online by the Climate Action Reserve, retrieved April 27th, 2012.
URL `http://www.climateactionreserve.org/how/protocols/mexico-forest/`

CAR, February 2011b. Permanence Draft - Version 1.0, prepared for consideration in the Climate Action Reserve's Working Group for the Mexican Forestry Protocol.

CAR, April 2012. Homepage - Protocols. Online by Climate Action Reserve, retrieved April 16th, 2012.
URL `http://www.climateactionreserve.org/how/protocols/`

Cárdenas, J. C., Ramos, P. A., August 2006. Manual de juegos económicos para el análisis del uso colectivo de los recursos naturales. Centro Internacional de la Papa (CIP), 1st Edition.

Caro Borrero, A. P., 2012. Evaluación del pago por servicios ambientales hidrológicos: una perspectiva socio-ambiental en la cuenca del río Magdalena, México, D.F. Master's thesis, Posgrado en Ciencias del Mar y Limnologia, Facultad de Ciencias, Universidad Nacional Autónoma de México.

Cattaneo, A., December 2008. How to Distribute REDD Funds Across Countries? A Stock-Flow Mechanism. Tech. rep., Woods Hole Research Center WHRC, retrieved February 23rd, 2012.
URL http://www.whrc.org/policy/pdf/cop14/Stock_Flow_Mechanism.pdf

Caveness, F. A., Kurtz, W. B., 1993. Agroforestry adoption and risk perception by farmers in Senegal. Agroforestry Systems 21 (1), 11–25.
URL http://dx.doi.org/10.1007/BF00704923

Chambers, R., Conway, G. R., December 1991. Sustainable rural livelihoods: Practical concepts for the 21st century. IDS Discussion Paper 296, Institute of Development Studies, retrieved May 21st, 2010.
URL http://opendocs.ids.ac.uk/opendocs/bitstream/handle/123456789/775/Dp296.pdf?sequence=1

Chambers, R. G., Foster, W. E., February 1983. Participation in the Farmer-Owned Reserve Program: A Discrete Choice Model. American Journal of Agricultural Economics 65 (1), 120–124.
URL http://www.jstor.org/stable/1240346

Chapela, F., June 2010. El proceso de deforestación en México, Power Point Presentation held by Francisco Chapela from Estudios Rurales y Asesoría (ERA) during the Workshop "Promover el diálogo y el intercambio de conocimiento y experiencias, desde la visión de las empresas forestales comunitarias y los dueños de los bosques, para generar una postura clara y viable sobre el diseño y operación local del mecanismo REDD en México" organized by Consejo Civil Mexicano para la Silvicultura Sustentable (CCMSS) and Comisión Nacional Forestal (CONAFOR) and Alianza de Comunidades Certificadas (ACC) on June 2nd, 2010.

Choe, C., Fraser, I., June 1998. A Note on Imperfect Monitoring of Agri-Environmental Policy. Journal of Agricultural Economics 49 (2), 250–258.
URL http://dx.doi.org/10.1111/j.1477-9552.1998.tb01267.x

CIA, 2012. The World Factbook - Mexico. Online by the Central Intelligence Agency (CIA), retrieved May 8th, 2012.
URL https://www.cia.gov/library/publications/the-world-factbook/geos/mx.html

CICC, August 2009. Programa Especial de Cambio Climático (PECC) 2009-2012 - Comisión Intersecretarial de Cambio Climático (CICC). Diario Oficial de la Federación (DOF) 28 de Agosto 2009, retrieved March 23rd, 2012.
URL http://dof.gob.mx/nota_detalle.php?codigo=5107404&fecha=28/08/2009

Claassen, R., Cattaneo, A., Johansson, R., 2008. Cost-effective design of agri-environmental payment programs: U.S. experience in theory and practice. Ecological Economics 65 (4), 737–752.
URL http://www.sciencedirect.com/science/article/pii/S0921800907004259

CNPSS, September 2012. Seguro Popular - ¿Qué es? Online by Comisión Nacional de Protección Social en Salud (CNPSS), retrieved September 11th, 2012.
URL http://www.seguro-popular.salud.gob.mx/

Coase, R. H., October 1960. The problem of social cost. Journal of Law and Economics 3, 1–44.
URL http://dx.doi.org/10.1086%2F466560

CONABIO, 2006. Capital natural y bienestar social. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) - Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT).
URL http://www.conabio.gob.mx/2ep/images/3/37/capital_natural_2EP.pdf

CONAFOR, October 2010a. Conductores de la Deforestación y Degradación Forestal en México, Figure elaborated by Comisión Nacional Forestal (CONAFOR) and presented during the Workshop "Taller de identificación de recursos y necesidades de capacidad para la instrumentación de estrategias REDD+ en México" organized by Centro de Diálogo y Análisis sobre América del Norte (CEDAN), Comisión Nacional Forestal (CONAFOR), Environmental Defense Fund (EDF) and World Wildlife Fund (WWF) on October 20-21th, 2010.

CONAFOR, 2010b. Visión de México sobre REDD+: Hacia una estrategia nacional. Tech. rep., Comisión Nacional Forestal (CONAFOR) - Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), retrieved January 4th, 2011.
URL http://www.conafor.gob.mx:8080/documentos/docs/7/1393Visi%C3%B3n%20de%20M%C3%A9xico%20sobre%20REDD_.pdf

CONAPO, 2005a. Índice de marginación urbana 2005. Tech. Rep. 1, Consejo Nacional de Población (CONAPO), retrieved November 11th, 2011.
URL http://www.conapo.gob.mx/publicaciones/IMU2005/IMU2005_principal.pdf

CONAPO, 2005b. Zona Metropolitana del Valle de México: Grado de marginación por AGEB urbana, 2005. Online by Consejo Nacional de Población (CONAPO), retrieved June 11th, 2012.
URL http://www.conapo.gob.mx/publicaciones/IMU2005/mapas/23-ZM_VMex.pdf

CONAPO, November 2007. Delimitación de las zonas metropolitanas de México. Tech. Rep. 1, Secretaría de Desarrollo Social (SDS), Consejo Nacional de Población (CONAPO) and Instituto Nacional de Estadística, Geografía e Informática (INEGI), retrieved July 21st, 2011.
URL http://www.conapo.gob.mx/publicaciones/dzm2005/zm_2005.pdf

CONEVAL, 2011. Informe de Evaluación de la Política de Desarrollo Social en México 2011. Tech. rep., Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL), retrieved May 8th, 2012.
URL http://web.coneval.gob.mx/Informes/Evaluaci%C3%B3n%202011/Informe%20de%20Evaluaci%C3%B3n%20de%20la%20Pol%C3%ADtica%20de%20Desarrollo%20Social%202011/Informe_de_evaluacion_de_politica_social_2011.pdf

Constanza, R., d'Arge, R., de Groot, R., Faber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., van den Belt, M., May 1997. The value of the world's ecosystem services and natural capital. Nature 387 (6630), 253–260.

Corbera, E., Brown, K., 2008. Building Institutions to Trade Ecosystem Services: Marketing Forest Carbon in Mexico. World Development 36 (10), 1956–1979.
URL http://www.sciencedirect.com/science/article/pii/S0305750X08001411

Corbera, E., Soberanis, C. G., Katrina Brown, K., 2009. Institutional dimensions of Payments for Ecosystem Services: An analysis of Mexico's carbon forestry programme. Ecological Economics 68 (3), 743–761.
URL http://www.sciencedirect.com/science/article/pii/S0921800908002632

CORENA, November 2011. Comisión de Recursos Naturales: El Suelo de Conservación del Distrito Federal. Online by Comisión de Recursos Naturales de la Secretaria del Medio Ambiente Distrito Federal, retrieved November 13th, 2011.
URL http://www.sma.df.gob.mx/corena/

Coulibaly-Lingani, P., Savadogo, P., Tigabu, M., Oden, P.-C., April 2011. Factors influencing people's participation in the forest management program in Burkina Faso, West Africa. Forest Policy and Economics 13 (4), 292–302.
URL http://www.sciencedirect.com/science/article/pii/S1389934111000177

Cropper, M., Griffiths, C., May 1994. The Interaction of Population Growth and Environmental Quality. The American Economic Review 84 (2), 250–254.
URL http://www.jstor.org/stable/2117838

Curtis, I. A., September 2004. Valuing ecosystem goods and services: a new approach using a surrogate market and the combination of a multiple criteria analysis and a Delphi panel to assign weights to the attributes. Ecological Economics 50 (3-4), 163–194.
URL http://www.sciencedirect.com/science/article/pii/S0921800904001491

da Fonseca, G. A. B., Rodriguez, C. M., Midgley, G., Busch, J., Hannah, L., Mittermeier, R. A., 2007. No Forest Left Behind. PLoS Biology 5 (8), 1645–1646.
URL http://dx.doi.org/10.1371%2Fjournal.pbio.0050216

Dalkey, N. C., 1975. Toward a Theory of Group Estimation. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: techniques and applications. Addison-Wesley, Ch. IV. B., pp. 236–261.

Delegación Magdalena Contreras, D.F., 2012. Geomorfología e Hidrología. Online by Delegación Magdalena Contreras, retrieved February 12th, 2012.
URL http://www.mcontreras.df.gob.mx/geografia/geomorfo.html

DFID, 1999. Sustainable livelihoods guidance sheets. Guidance Sheets 1-7, Department for International Development (DFID), retrieved May 21st, 2010.
URL http://www.ennonline.net/resources/667

Dinar, A., Albiac, J., Sánchez-Soriano, J., 2008. Game Theory and Policy Making in Natural Resources and the Environment, 1st Edition. Explorations in Environmental Economics. Routeledge.

DNA, November 2011. Countries Afforestation/Reforestation informations. Online by the Designated National Authority (DNA) of México, retrieved November 7th, 2011.
URL http://cdm.unfccc.int/DNA/allCountriesARInfos.html

Dobbs, T. L., Pretty, J., 2008. Case study of agri-environmental payments: The United Kingdom. Ecological Economics 65 (4), 765–775.
URL http://www.sciencedirect.com/science/article/pii/S0921800907004260

Dobler, C. E., 2010. Caracterización del clima y su relación con la distribución de la vegetación en el suroeste del D.F. México. Master's thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), México.

DOF, April 1924. Resolución en el expediente de tierras, promovido por vecinos del pueblo de San Nicolás Totolapan, Distrito Federal. 29 de abril de 1924. Diario Oficial de la Federación (DOF), retrieved June 11th, 2012.
URL http://dof.gob.mx/index.php?year=1924&month=04&day=29

DOF, June 1932. Acuerdo que declara Zona Protectora Forestal los bosques de la Cañada de Contreras, D.F. 27 de junio de 1932. Diario Oficial de la Federación (DOF), retrieved August 2nd, 2011.
URL http://dof.gob.mx/index.php?year=1932&month=06&day=27

DOF, November 1938. Resolución en el expediente de ampliación de ejidos al poblado San Nicolás Totolapan, Distrito Federal. 5 de noviembre de 1938. Diario Oficial de la Federación (DOF), retrieved June 11th, 2012.
URL http://dof.gob.mx/index.php?year=1938&month=11&day=05

DOF, May 1947. Decreto de creación de la Unidad Industrial de Explotación Forestal, para la Fábrica de papel de Loreto y Peña Pobre. Se declara Zona de Protección Forestal del Río de la Magdalena. 19 de mayo 1947. Diario Oficial de la Federación (DOF), retrieved June 11th, 2012.
URL http://dof.gob.mx/index.php?year=1947&month=05&day=19

DOF, April 1975. Resolución sobre reconocimiento y titulación de bienes comunales a favor del poblado La Magdalena Contreras, Delegación del mismo nombre, D. F. 7 de abril de 1975. Diario Oficial de la Federación (DOF), retrieved June 11th, 2012.
URL http://dof.gob.mx/index.php?year=1975&month=04&day=07

DOF, June 1992. Reglamiento Interior de la Secretaria de Desarrollo Social. 8 de Junio de 1992. Diario Oficial de la Federación (DOF), retrieved May 11st, 2012.
URL http://dof.gob.mx/index.php?year=1992&month=06&day=04

DOF, April 2001a. Decreto por el que se crea la Comisión Nacional Forestal. 4 de abril de 2001. Diario Oficial de la Federación (DOF), retrieved May 11st, 2012.
URL http://dof.gob.mx/index.php?year=2001&month=04&day=04

DOF, December 2001b. Ley de Desarrollo Rural Sustentable. 7 de diciembre de 2001. Diario Oficial de la Federación (DOF), retrieved January 5th, 2011.
URL http://dof.gob.mx/nota_detalle.php?codigo=756874&fecha=07/12/2001

DOF, May 2001c. Plan Nacional de Desarrollo. 30 de mayo de 2001. Diario Oficial de la Federación (DOF), retrieved May 17th, 2011.
URL http://dof.gob.mx/index.php?year=2001&month=05&day=30

DOF, January 2003a. Acuerdo por el que se dan a conocer los límites de 188 acuíferos de los Estados Unidos Mexicanos, los resultados de los estudios realizados para determinar su disponibilidad media anual de agua y sus planos de localización. 31 de enero de 2003. Diario Oficial de la Federación (DOF), retrieved April 25th, 2011.
URL http://dof.gob.mx/nota_detalle.php?codigo=706659&fecha=31/01/2003

DOF, October 2003b. Acuerdo que establece las Reglas de Operación para el otorgamiento de pagos del Programa de Servicios Ambientales Hidrológicos. 3 de octubre de 2003. Diario Oficial de la Federación (DOF), retrieved April 25th, 2011.
URL http://dof.gob.mx/nota_detalle.php?codigo=688512&fecha=03/10/2003

DOF, November 2004. Acuerdo que establece las Reglas de Operación para el otorgamiento de pagos del Programa para desarrollar el mercado de servicios ambientales por captura de carbono y los derivados de la biodiversidad y para fomentar el establecimiento y mejoramiento de sistemas agroforestales (PSA-CABSA). 24 de noviembre de 2004. Diario Oficial de la Federación (DOF), retrieved April 25th, 2011.
URL `http://dof.gob.mx/nota_detalle.php?codigo=706895&fecha=24/11/2004`

DOF, Abril 2005. Acuerdo de creación de la Comisión Intersecretarial de Cambio Climático. 25 de abril de 2005. Diario Oficial de la Federación (DOF), retrieved January 5th, 2011.
URL `http://dof.gob.mx/nota_detalle.php?codigo=2034062&fecha=25/04/2005`

DOF, February 2006. Acuerdo por el que se expiden las Reglas de Operación de los Programas de Desarrollo Forestal de la Comisión Nacional Forestal. 16 de febrero de 2006. Diario Oficial de la Federación (DOF), retrieved May 15th, 2011.
URL `http://dof.gob.mx/nota_detalle.php?codigo=2121235&fecha=16/02/2006`

DOF, February 2007. Acuerdo por el que se expiden las Reglas de Operación del Programa ProArbol de la Comisión Nacional Forestal. 20 de febrero de 2007. Diario Oficial de la Federación (DOF), retrieved May 17th, 2011.
URL `http://dof.gob.mx/nota_detalle.php?codigo=4962757&fecha=20/02/2007`

DOF, January 2009. Acuerdo por el que se establecen las Reglas de Operación del Programa ProArbol 2009. 31 de diciembre de 2008. Diario Oficial de la Federación (DOF), retrieved April 25th, 2011.
URL `http://dof.gob.mx/nota_detalle.php?codigo=5076668&fecha=31/12/2008`

DOF, January 2011. Reglas de Operación del Programa ProArbol 2010. 29 de diciembre de 2010. Diario Oficial de la Federación (DOF), retrieved May 16th, 2011.
URL `http://dof.gob.mx/nota_detalle.php?codigo=5172994&fecha=29/12/2010`

Echeverría, J., 2010. Guía práctica para el establecimiento de esquemas de pagos por servicios ambientales y otros instrumentos económicos para la gestión del riesgo en las cuencas hidrográficas prevda. Tech. rep., Programa Regional de Reducción de la Vulnerabilidad y Degradaci'on Ambiental - Sistema de la Integraci'on Centroamericana Ambiental, retrieved July 6th, 2011.
URL `http://www.sica.int/busqueda/busqueda_archivo.aspx?Archivo=odoc_49776_1_08062010.pdf`

Eguiarte, F. A., Cruz, U. F., Ramírez del Razo, I., Apolinar, B. d. J., Márquez, V. A., 2002. Evaluación del avance de la mancha urbana sobre el área natural protegida de la Cañada de los Dinamos. Gaceta Ecológica - INE (Instituto Nacional de Ecología) 1 (62), 56–67.
URL `http://redalyc.uaemex.mx/pdf/539/53906205.pdf`

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological Economics 65 (4), 663–674.
URL `http://www.sciencedirect.com/science/article/pii/S0921800908001420`

Engel, S., Palmer, C., 2008. Payments for environmental services as an alternative to logging under weak property rights: The case of Indonesia. Ecological Economics 65 (4), 799–809.
URL `http://www.sciencedirect.com/science/article/pii/S0921800907004284`

ETH-Zürich, 2009. Investigation Program - 4.4.3 Cluster C: Agriculture/Forestry, (unpublished).

European Communities, 2008. The Economics of Ecosystems and Biodiversity (TEEB). An interim report, TEEB is hosted by the United Nations Environment Programme and supported by the European Commission, the German Federal Environment Ministry and the UK government's Department for Environment, Food and Rural Affairs, recently joined by Norway's Ministry for Foreign Affairs and The Netherlands' Ministry of Housing, Spatial Planning and the Environment, retrieved September 26th, 2010.
URL http://www.teebweb.org/Portals/25/Documents/TEEB-InterimReport-English.pdf

FAO, 2000a. Ecological zones in Mexico: Global Forest Resources Assessment 2000. Online by Food and Agriculture Organization of the United Nations (FAO), retrieved May 8th, 2012.
URL http://www.fao.org/forestry/country/19971/en/mex/

FAO, 2000b. Forest cover map of Mexico: Global Forest Resources Assessment 2000. Online by Food and Agriculture Organization of the United Nations (FAO), retrieved May 8th, 2012.
URL http://www.fao.org/forestry/country/18314/en/mex/

FAO, 2005a. Disturbances statistics: Global Forest Resources Assessment 2005. Online by Food and Agriculture Organization of the United Nations (FAO), retrieved May 9th, 2012.
URL http://www.fao.org/forestry/country/32267/en/mex/

FAO, 2005b. Forest area statistics: Global Forest Resources Assessment 2005. Online by Food and Agriculture Organization of the United Nations (FAO), retrieved May 9th, 2012.
URL http://www.fao.org/forestry/country/32185/en/mex/

FAO, 2005c. Global Forest Resources Assessment 2005 - Progress towards sustainable forest management. Tech. rep., Food and Agriculture Organization of the United Nations (FAO), Rome, retrieved September 16th, 2010.
URL ftp://ftp.fao.org/docrep/fao/008/A0400E/A0400E00.pdf

FAO, 2005d. Growing stock statistics: Global Forest Resources Assessment 2005. Online by Food and Agriculture Organization of the United Nations (FAO), retrieved May 9th, 2012.
URL http://www.fao.org/forestry/country/32183/en/mex/

FAO, 2005e. Ownership of forest and other wooded land: Global Forest Resources Assessment 2005. Online by Food and Agriculture Organization of the United Nations (FAO), retrieved May 11th, 2012.
URL http://www.fao.org/forestry/country/61587/en/mex/

FAO, 2009. Pago por Servicios Ambientales en Áreas Protegidas en América Latina. Fortalecimiento del manejo sostenible de los recursos naturales en las Áreas protegidas de américa latina, Programa FAO/OAPN, Food and Agriculture Organization of the United Nations (FAO), retrieved April 20th, 2011.
URL http://www.rlc.fao.org/uploads/media/DotecPSA.pdf

FAO, 2010. Planted forests: Description of plantation resources. Last updated: Tuesday, February 23rd, 2010. Online by Food and Agriculture Organization of the United Nations (FAO), retrieved May 9th, 2012.
URL http://www.fao.org/forestry/country/18316/en/mex/

Farber, S., Griner, B., March 2000. Using Conjoint Analysis To Value Ecosystem Change. Environmental Science & Technology 34 (8), 1407–1412.
URL http://dx.doi.org/10.1021/es990727r

Faysse, N., April 2005. Coping with the Tragedy of the Commons: Game Structure and Design of Rules. Journal of Economic Surveys 19 (2), 239–261.
URL http://dx.doi.org/10.1111/j.0950-0804.2005.00246.x

FCPF, March 2008. REDD Country Participants: México. Online by Forest Carbon Partnership Facility (FCPF), retrieved May 16th, 2012.
URL http://www.forestcarbonpartnership.org/fcp/

Fearnside, P. M., 2002. Why a 100-Year Time Horizon should be used for Global Warming Mitigation Calculations. Mitigation and Adaptation Strategies for Global Change 7 (1), 19–30.
URL http://dx.doi.org/10.1023/A:1015885027530

Fearnside, P. M., Lashof, D. A., Moura-Costa, P., 2000. Accounting for time in Mitigating Global Warming through land-use change and forestry. Mitigation and Adaptation Strategies for Global Change 5 (3), 239–270.
URL http://dx.doi.org/10.1023/A:1009625122628

FERN, 2003. What is EU FLEGT? Power point presentation, Fern, retrieved September 26th, 2010.
URL http://www.fern.org/sites/fern.org/files/What%20is%20EU%20FLEGT_1.pdf

Ferraro, P. J., 2008. Asymmetric information and contract design for payments for environmental services. Ecological Economics 65 (4), 810–821.
URL http://www.sciencedirect.com/science/article/pii/S0921800907004272

FIRA, June 2007. Extracción Forestal en Durango y Chihuahua - Análisis de Costos y Rentabilidad. Power point presentation, Fideicomisos Instituidos en Relación con la Agricultura (FIRA), retrieved June 4th, 2010.
URL http://www.fira.gob.mx/Nd/Extraccion_forestal_en_Durango_y_Chihuahua-Costos_y_rentabilidad.pdf

Flores-Velázquez, R., October 2005. Competitividad de la cadena productiva de madera aserrada en México: el caso de la región Chignahuapan-Zacatlan, Puebla. Ph.D. thesis, Centro de Investigaciones Económicas, Sociales y Technológicas de la Agroindustria y la Agricultura Mundial, Universidad Autónoma de Chapingo, México.
URL http://tesis.ciestaam.edu.mx/index.php?option=com_remository&Itemid=57&func=startdown&id=14

FRA, 2004. Global Forest Resources Assessment update 2005 - Terms and definitions. Working Paper 83, Food and Agriculture Organization of the United Nations (FAO), retrieved June 3rd, 2010.
URL http://www.fao.org/docrep/007/ae156e/ae156e00.htm

García Cubas, A., 1993. Geografía e historia del Distrito Federal, 2nd Edition. Colección Facsímiles. Instituto de Investigaciones Dr. José María Luis Mora, México DF.

GDF, 2012. Atlas geográfico del suelo de conservación del Distrito Federal. Gobierno del Distrito Federal.

GODF, August 2000. Decreto de Programa General de Ordenamiento Ecologico del Distrito Federal. 1 de agosto de 2000. Gaceta Oficial del Distrito Federal (GODF), retrieved June 11th, 2012.
URL http://www.consejeria.df.gob.mx//uploads/gacetas/2000_agosto_1_139.pdf

Godoy, R. A., 1992. Determinants of smallholder commercial tree cultivation. World Development 20 (5), 713–725.
URL http://www.sciencedirect.com/science/article/pii/0305750X9290147N

Gordon, T. J., Helmer, O., September 1964. Report on a Long-Range Forecasting Study. Paper P-2982, The RAND Corporation, retrieved March 22nd 2012.
URL http://www.rand.org/pubs/papers/2005/P2982.pdf

Green, P. E., Krieger, A. M., Wind, Y. J., 2001. Thirty Years of Conjoint Analysis: Reflections and Prospects. Interfaces 31 (3), 56–73.
URL http://www.jstor.org/stable/25062702

Grieg-Gran, M., Porras, I., Wunder, S., 2005. How can market mechanisms for forest environmental services help the poor? Preliminary lessons from Latin America. World Development 33 (9), 1511–1527.
URL http://www.sciencedirect.com/science/article/pii/S0305750X05000999

Griffiths, T., June 2007. Seeing RED - Avoided Deforestation and the Rights of Indigenous Peoples and Local Communities. Briefing paper, Forest Peoples Programme, retrieved October 24th, 2011.
URL http://www.forestpeoples.org/sites/fpp/files/publication/2010/01/avoideddeforestationredjun07eng_0.pdf

Griscom, B., Cortez, R., May 2011. Establishing Efficient, Equitable, and Environmentally Sound Reference Emissions Levels for REDD+: A Stock-Flow Approach. Tech. rep., The Nature Conservancy (TNC), retrieved February 23rd, 2012.
URL http://www.theredddesk.org/sites/default/files/resources/pdf/2011/tnc_rel_proposal_final.pdf

Guillermo Aguilar, A., Santos, C., 2011. Asentamientos informales y preservación del medio ambiente en la Ciudad de México. Un dilema para la política de uso del suelo. In: Pérez Campuzano, E., Perevochtchikova, M., Ávila Foucat, V. S. (Eds.), Suelo de Conservación del Distrito Federal - ¿hacia una gestión y manejo sustentable?, 1st Edition. Estudios Urbanos. Instituto Politécnico Nacional, Ch. V, pp. 93–124.

Gutman, P., 2007. Ecosystem services: Foundations for a new rural-urban compact. Ecological Economics 62 (3-4), 383–387.
URL http://www.sciencedirect.com/science/article/pii/S0921800907001449

Hardin, G., December 1968. The Tragedy of the Commons. Science 162 (3859), 1243–1248.
URL http://dx.doi.org/10.1126/science.162.3859.1243

Henry, C., Sharma, M., Lapenu, C., Zeller, M., September 2003. Microfinance Poverty Assessment Tool. Technical Tools Series 5, The World Bank (WB), Consultative Group to Assist the Poor (CGAP) and International Food Policy Research Institute (IFPRI).
URL http://www.cgap.org/gm/document-1.9.3004/TechnicalTool_05.pdf

Herath, G., July 2006. Game theory applications in natural resource management : review of evidence, problems and potential. In: Meeting on Game Theory and Practice Dedicated to Development, Natural Resources and the Environment. Deakin University, Instituto Agronomico Mediterraneo de Zaragoza, Spain.
URL http://hdl.handle.net/10536/DRO/DU:30014625

Herrerías Aristi, E., Bravo Álvarez, H., Sosa Echeverría, R., May-August 2007. Evaluación nacional e internacional del medioambiente por expertos. Contaduría y Administración 225, 39–57.
URL http://www.revistas.unam.mx/index.php/rca/article/download/4703/4234

Herzog, H., Caldeira, K., Reilly, J., 2003. An Issue of Permanence: Assessing the Effectiveness of Temporary Carbon Storage. Climatic Change 59 (3), 293–310.
URL http://dx.doi.org/10.1023/A:1024801618900

Holmstrom, B. R., Tirole, J., 1989. The Theory of the Firm. In: Schmalensee, R., Willig, R. D. (Eds.), Handbook of Industrial Organization. Vol. 1. North-Holland, Amsterdam, Ch. 2, pp. 61–133.
URL http://www.sciencedirect.com/science/article/pii/S1573448X89010058

Hosier, R. H., 1989. The economics of smallholder agroforestry: Two case studies. World Development 17 (11), 1827–1839.
URL http://www.sciencedirect.com/science/article/pii/0305750X89902027

Huang, S.-L., Chen, Y.-H., Kuo, F.-Y., Wang, S.-H., 2011. Emergy-based evaluation of peri-urban ecosystem services. Ecological Complexity 8 (1), 38–50.
URL http://www.sciencedirect.com/science/article/pii/S1476945X10000917

Hughes, T. P., Baird, A. H., Bellwood, D. R., Card, M., Connolly, S. R., Folke, C., Grosberg, R., Hoegh-Guldberg, O., Jackson, J. B. C., Kleypas, J., Lough, J. M., Marshall, P., Nyström, M., Palumbi, S. R., Pandolfi, J. M., Rosen, B., Roughgarden, J., August 2003. Climate Change, Human Impacts, and the Resilience of Coral Reefs. Science 301 (5635), 929–933.
URL http://dx.doi.org/10.1126/science.1085046

Hyman, E. L., 1983. Pulpwood treefarming in the Philippines from the viewpoint of the smallholder: An ex post evaluation of the PICOP project. Agricultural Administration 14 (1), 23–49.
URL http://www.sciencedirect.com/science/article/pii/0309586X83900043

Ibargüen, L., November 2003. Presupuesto y financiamiento al sector forestal - diagnóstico y propuestas. Tech. rep., Consejo Civil Mexicano para la Silvicultura Sostenible, AC (CCMSS).
URL http://www.ccmss.org.mx/descargas/presupuesto_y_financiamiento_al_sector_forestal._diagnstico_y_propuestas.pdf

Ibarra Gené, E., December 2007. The profitability of forest protection versus logging and the role of payments for environmental services (PES) in the Reserva Forestal Golfo Dulce, Costa Rica. Forest Policy and Economics 10 (1-2), 7–13.
URL http://www.sciencedirect.com/science/article/pii/S138993410700010X

Illukpitiya, P., October 2005. Technical Efficiency in Agriculture and Dependency on Forest Resources: An Economic Analysis of Rural Households and the Conservation of Natural Forests in Sri Lanka. Technical paper, Economy and Environment Program for Southeast Asia (EEPSEA) and International Development Research Centre (IDRC), retrieved February 24th, 2012.
URL http://web.idrc.ca/uploads/user-S/11521683271Prabodh%28Tech%29.pdf

INEGI, 2010. Censo de Población y Vivienda 2010. Online by Instituto Nacional de Estadísticas y Geografía (INEGI), retrieved May 8th, 2012.
URL http://www.censo2010.org.mx/

INEGI, May 2012. México en Cifras: Información Nacional, por Entidad Federativa y Municipios - Distrito Federal. Online by Instituto Nacional de Estadísticas y Geografía (INEGI), retrieved May 23rd, 2012.
URL http://www.inegi.org.mx/sistemas/mexicocifras/default.aspx?e=9

IPCC, 2000. IPCC Special Report on Land Use, Land-Use Change, and Forestry. Summary for policymakers, Intergovernmental Panel on Climate Change (IPCC).
URL http://www.ipcc.ch/pdf/special-reports/spm/srl-en.pdf

IPCC, 2001. Climate Change 2001: Impacts, Adaptation and Vulnerability. Tech. rep., Intergovernmental Panel on Climate Change (IPCC), working Group II, retrieved May 23rd, 2010.
URL http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/index.htm

IPCC, 2003. Good Practice Guidance for Land Use, Land-Use Change and Forestry. Tech. rep., Intergovernmental Panel on Climate Change (IPCC), retrieved May 9th, 2011.
URL www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

IPCC, 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Tech. rep., Intergovernmental Panel on Climate Change (IPCC), retrieved May 9th, 2011.
URL www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

IPCC, 2007. Climate change 2007: The Physical Science Basis. Cambridge University Press - Intergovernmental Panel on Climate Change (IPCC), Solomon, S. and Qin, D. and Manning, M. and Marquis, M. and Averyt, K. and Tignor, M. M. B. and LeRoy-Miller, H. Jr. and Chen, Z. (Eds.). Working Group 1 Contribution to the Fourth Assessment Report of the IPCC. Technical Summary.
URL http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-ts.pdf

Jehle, G. A., Reny, P. J., 2000. Advanced Microeconomic Theory, 2nd Edition. Prentice Hall.

Jones, C. G., 1975. A Delphi Evaluation of Agreement between Organizations. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: techniques and applications. Addison-Wesley, Ch. III. B.4., pp. 160–167.

Jujnovsky, J., 2006. Servicios ecosistémicos relacionados con el recurso agua en la cuenca del río Magdalena, Distrito Federal, México. Master's thesis, Facultad de Ciencias - Universidad Nacional Autónoma de México.

Jujnovsky, J., Almeida-Leñero, L., Bojorge-García, M., Monges, Y. L., Cantoral-Uriza, E., Mazari-Hiriart, M., 2010. Hydrologic ecosystem services: Water quality and quantity in the Magdalena River, Mexico City. Hidrobiológica 20 (2), 113–126.
URL http://www.scielo.org.mx/pdf/hbio/v20n2/v20n2a3.pdf

Kabat, P., Martin, C., Dirmeyer, P. A., Gash, J. H. C., De Guenni, L. B., Meybeck, M., Pielke Sr, R. A., Vörösmarty, C. J., Hutjes, R. W. A., Lütkemeier, S., June 2004. Vegetation, Water, Humans and the Climate: A New Perspective on an Interactive System, 1st Edition. Springer-Publishing.

Kant, S., January 2003. Extending the boundaries of forest economics. Forest Policy and Economics 5 (1), 39–56.
URL http://www.sciencedirect.com/science/article/pii/S138993410200045X

Karousakis, K., April 2007. Incentives to Reduce GHG Emissions from Deforestation: Lessons Learned from Costa Rica and Mexico. COM/ENV/EPOC/IEA/SLT(2007)1, Organisation for Economic Co-operation and Development (OECD), retrieved October 24th, 2011.

URL http://unfccc.int/files/methods_science/redd/application/pdf/incentives_to_reduce_ghg_emissions_from_deforestation_lesson_learned_from_costa_rica_and_mexico.pdf

Keller, S., October 2008. A Systematic Analysis of Mechanisms for Reducing Emissions from Deforestation and Degradation. Master's thesis, ETH - Swiss Federal Institute of Technology Zurich.

Kelley, K., Clark, B., Brown, V., Sitzia, J., 2003. Good practice in the conduct and reporting of survey research. International Journal for Quality in Health Care 15 (3), 261–266.
URL http://dx.doi.org/10.1093/intqhc/mzg031

Kim, M.-K., McCarl, B. A., Murray, B. C., February 2008. Permanence discounting for land-based carbon sequestration. Ecological Economics 64 (4), 763–769.
URL http://www.sciencedirect.com/science/article/pii/S0921800907002704

Klooster, D., 2003. Forest Transitions in Mexico: Institutions and Forests in a Globalized Countryside. The Professional Geographer 55 (2), 227–237.
URL http://dx.doi.org/10.1111/0033-0124.5502010

Kondratyev, K. Y., Krapivin, V. F., Varostos, C. A., 2003. Global Carbon Cycle and Climate Change. Springer Praxis Books in Environmental Sciences. Springer.

Korhonen, R., Pingoud, K., Savolainen, I., Matthews, R., December 2002. The role of carbon sequestration and the tonne-year approach in fulfilling the objective of climate convention. Environmental Science & Policy 5 (6), 429–441.
URL http://www.sciencedirect.com/science/article/pii/S1462901102000916

Kosoy, N., Corbera, E., April 2010. Payments for ecosystem services as commodity fetishism. Ecological Economics 69 (6), 1228–1236.
URL http://www.sciencedirect.com/science/article/pii/S0921800909004510

Kosoy, N., Corbera, E., Brown, K., 2008. Participation in payments for ecosystem services: Case studies from the Lacandon rainforest, Mexico. Geoforum 39 (6), 2073–2083.
URL http://www.sciencedirect.com/science/article/pii/S0016718508001541

Landell-Mills, N., Porras, I. T., 2002. Silver bullet or fools' gold? A global review of markets for forest environmental services and their impact on the poor. Report, International Institute for Environment and Development (IIED), London, series: Instruments for Sustainable Private Sector Forestry.
URL http://pubs.iied.org/pdfs/9066IIED.pdf

Landeta Rodríguez, J., 1999. El metódo Delphi: una técnica de previsión para la incertidumbre, 1st Edition. Ariel.

Latacz-Lohmann, U., Van der Hamsvoort, C., May 1997. Auctioning Conservation Contracts: A Theoretical Analysis and an Application. American Journal of Agricultural Economics 79 (2), 407–418.
URL http://dx.doi.org/10.2307/1244139

Linstone, H. A., 1975. Eight Basic Pitfalls: A Checklist. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: Techniques and applications. Addison-Wesley, Ch. VIII., pp. 573–586.

Linstone, H. A., Turoff, M., 1975. The Delphi method: techniques and applications. Addison-Wesley.

Lohmann, L., 2010. Uncertainty Markets and Carbon Markets: Variations on Polanyian Themes. New Political Economy 15 (2), 225–254.
URL http://dx.doi.org/10.1080/13563460903290946

Long, J. S., 1997. Regression models for categorical and limited dependent variables. No. 7 in Advanced quantitative techniques in the social sciences. Thousand Oaks: Sage.

Long, J. S., Freese, J., 2006. Regression models for categorical dependent variables using Stata, 2nd Edition. A Stata Press publication.

Ludlow, J., 1975. Delphi Inquiries and Knowledge Utilization. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: techniques and applications. Addison-Wesley, Ch. III. B.2., pp. 102–123.

Magaña, O., May 2010. El inventario nacional forestal y el proceso de deforestación en México, Power Point Presentation held by Octavio Magaña from Comisión Nacional Forestal (CONAFOR) during during the Workshop "Foro sobre la deforestación en México" organized by Facultad de Economía de la UNAM, Greenpeace-México y Estudios Rurales y Asesoría on May 26th, 2010.

Marland, G., Fruit, K., Sedjo, R., December 2001. Accounting for sequestered carbon: the question of permanence. Environmental Science & Policy 4 (6), 259–268.
URL http://www.sciencedirect.com/science/article/pii/S1462901101000387

Marshall, L., Kelly, A., November 2010. The Time Value of Carbon and Carbon Storage: Clarifying the terms and the policy implications of the debate. WRI Working Paper, World Resources Institute (WRI), retrieved May 26th, 2011.
URL http://pdf.wri.org/working_papers/time_value_of_carbon_and_carbon_storage.pdf

Martínez, R., October 2008. Guía conceptual y metodológica para el diseño de esquemas de pagos por servicios ambientales en latino América y el Caribe. Documento borrador, Departamento de Desarrollo Sostenible (DDS) y Organización de Estados Americanos (OEA), Washington DC.
URL http://www.oas.org/dsd/Spanish/PSA/Guia_Conceptual_y_Metodologica_PSA_Draft_2.pdf

Mas-Colell, A., Whinston, M. D., Green, J. R., 1995. Microeconomic Theory. Oxford University Press.

Mayrand, K., Paquin, M., September 2004. Pago por servicios ambientales: Estudio y evaluación de esquemas vigentes. Report, Unisféra - Centre Internacional Centre, Montreal.
URL http://www.cec.org/Storage/56/4896_PES-Unisfera_es.pdf

MCII, August 2012. MCII - Homepage. Online by Munich Climate Insurance Initiative (MCII), retrieved August 31th, 2012.
URL http://www.climate-insurance.org

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.
URL http://www.millenniumassessment.org/documents/document.356.aspx.pdf

Mitroff, I. I., Turoff, M., 1975. Philosophical and Methodological Foundations of Delphi. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: techniques and applications. Addison-Wesley, Ch. II, B., pp. 17–36.

Mortensen, T. L., Leistritz, F. L., Leitch, J. A., Ekstrom, B. L., December 1988. A Baseline Analysis of Participants in the Conservation Reserve Program in North Dakota. Agricultural Economics Miscellaneous Reports 119548, North Dakota State University, Department of Agribusiness and Applied Economics.
URL http://ideas.repec.org/p/ags/nddmrs/119548.html

Moura-Costa, P., March 2000. Project duration and accounting methods, ecoSecurities Unpublished Manuscript, retrieved May 26th, 2011.
URL http://www.ecosecurities.com/Assets/23520/Pubs_%20Project%20duration%20and%20accounting%20methods.pdf

Moura-Costa, P., 2002. Carbon Accounting, Trading and the Temporary Nature of Carbon Storage. Paper, EcoSecurities, prepared for The Nature Conservancy and supported by USAID under the terms of Award No. LAG-A-00-00-00019-00.
URL http://pdf.usaid.gov/pdf_docs/PNACY491.pdf

Moura-Costa, P., Wilson, C., 2000. An equivalence factor between CO2 avoided emissions and sequestration - description and applications in forestry. Mitigation and Adaptation Strategies for Global Change 5 (1), 51–60.
URL http://dx.doi.org/10.1023/A:1009697625521

Moxey, A., White, B., Ozanne, A., May 1999. Efficient Contract Design for Agri-Environment Policy. Journal of Agricultural Economics 50 (2), 187–202.
URL http://dx.doi.org/10.1111/j.1477-9552.1999.tb00807.x

Muñoz Piña, C., Alarcón, G., Fernández, J. C., 2003. Pixel Patterns of Deforestation in Mexico 1993-2000. INE Working Paper Series INE-0401, Instituto Nacional de Ecología (INE) - Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), retrieved April 26th, 2011.
URL http://www.ine.gob.mx/descargas/dgipea/approach_def.pdf

Muñoz Piña, C., Guevara, A., Torres, J. M., Braña, J., 2008. Paying for the hydrological services of Mexico's forests: Analysis, negotiations and results. Ecological Economics 65 (4), 725–736.
URL http://www.sciencedirect.com/science/article/pii/S0921800907004247

Murillo-Hernández, R., 2008. El Programa de Pago de Servicios Ambientales y su aplicación en un núcleo agrario con manejo comunitario del bosque. Ph.D. thesis, Facultad de Economía, Universidad Nacional Autónoma de México (UNAM), México.

Nagubadi, V., McNamara, K. T., Hoover, W. L., Mills, W. L. J., December 1996. Program participation behavior of nonindustrial forest landowners: A probit analysis. Journal of Agricultural and Applied Economics 28 (2), 323–336.
URL https://fp.auburn.edu/sfws/Nagubadi/nagubadi_JAAE.PDF

Nava, M., 2003. Los bosques de la cuenca alta del río Magdalena, D.F., México. Tesis de Licenciatura en Biología, Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), México.

Neitzel, K. C., 2007. Economic Analysis of Land-Use Systems in Esmeraldas (Ecuador) with Reference to Ecosystem Services - Socioeconomic Monitoring and Evaluation of Project Impacts in the Gran Reserva Chachi, Esmeraldas, Ecuador. Master's thesis, Faculty of Forest Sciences and Forest Ecology, Georg-August-University of Göttingen, Germany.

Neupane, R. P., Sharma, K. R., Thapa, G. B., 2002. Adoption of agroforestry in the hills of Nepal: a logistic regression analysis. Agricultural Systems 72 (3), 177–196.
URL http://www.sciencedirect.com/science/article/pii/S0308521X0100066X

New Forests Advisory Inc., January 2011. Key Questions in Nested REDD Policy Design, document elaborated for the formulation of CAR's Mexico Forest Protocol and presented during the Workgroup Meeting 6 on January 24th, 2011, retrieved February 11th, 2011.
URL http://www.climateactionreserve.org/wp-content/uploads/2011/01/Key-Questions-in-Nested-REDD-Policy-Design-v4-English-_2_.pdf

Niemelä, J., Saarela, S.-R., Söderman, T., Kopperoinen, L., Yli-Pelkonen, V., Väre, S., Kotze, D. J., 2010. Using the ecosystem services approach for better planning and conservation of urban green spaces: a Finland case study. Biodiversity and Conservation 19 (11), 3225–3243.
URL http://dx.doi.org/10.1007/s10531-010-9888-8

Norgaard, R. B., April 2010. Ecosystem services: From eye-opening metaphor to complexity blinder. Ecological Economics 69 (6), 1219–1227.
URL http://www.sciencedirect.com/science/article/pii/S0921800909004583

Nowak, P. J., 1987. The Adoption of Agricultural Conservation Technologies: Economic and Diffusion Explanations. Rural Sociology 52 (2), 208–220.
URL http://chla.library.cornell.edu/cgi/t/text/text-idx?c=chla;idno=5075626_4337_002

Ogonowski, M., Guimaraes, L., Ma, H., Movius, D., Schmidt, J., May 2009. Utilizing Payments for Environmental Services for Reducing Emissions from Deforestation and Forest Degradation (REDD) in Developing Countries: Challenges and Policy Options. Report - international developing country analysis and dialogue, Center for Clean Air Policy (CCAP), retrieved October 4th, 2010.
URL http://www.ccap.org/docs/resources/620/CCAPUsingPESforREDDFINAL.pdf

Ogonowski, M., Helme, N., Movius, D., Schmidt, J., August 2007. Reducing Emissions from Deforestation and Degradation: The Dual Markets Approach. Report - international developing country analysis and dialogue, Center for Clean Air Policy (CCAP), retrieved April 4th, 2012.
URL http://www.ccap.org/docs/resources/69/FINAL_REDD_report.pdf

Olschewski, R., Benítez, P. C., November 2005. Secondary forests as temporary carbon sinks? The economic impacts of accounting methods on reforestation projects in the tropics. Ecological Economics 55 (3), 380–394.
URL http://www.sciencedirect.com/science/article/pii/S0921800904004215

Ostrom, E., 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Political Economy of Institutions and Decisions. Cambridge University Press.

Ostrom, E., Ahn, T. K., 2003. Foundations of Social Capital. Critical Studies in Economic Institutions Series. Edward Elgar Publishing Limited.

Ozanne, A., Hogan, T., Colman, D., 2001. Moral hazard, risk aversion and compliance monitoring in agri-environmental policy. European Review of Agricultural Economics 28 (3), 329–348.
URL http://dx.doi.org/10.1093/erae/28.3.329

Pagiola, S., December 2003. Can Programs of Payments for Environmental Services Help Preserve Wildlife?, Environment Department, World Bank. Power Point Presentation held during a workshop on economic incentives and trade policies: Convention on International Trade in Endangered Species of Wild Fauna and Flora, Geneva, December 1-3, 2003, retrieved May 24th, 2010.
URL `http://www.cites.org/eng/prog/economics/ppt/World_Bank.pdf`

Pagiola, S., 2008. Payments for environmental services in Costa Rica. Ecological Economics 65 (4), 712–724.
URL `http://www.sciencedirect.com/science/article/pii/S0921800907004235`

Pagiola, S., Agostini, P., Gobbi, J., de Haan, C., Ibrahim, M., Murgueitio, E., Ramírez, E., Rosales, M., Ruíz, J. P., May 2004. Paying for Biodiversity Conservation Services in Agricultural Landscapes. Environment Department Paper 96, The World Bank (WB), environmental Economics Series, retrieved May 24th, 2010.
URL `ftp://ftp.fao.org/docrep/nonfao/lead/x6154e/x6154e00.pdf`

Pagiola, S., Arcenas, A., Platais, G., 2005. Can Payments for Environmental Services Help Reduce Poverty? An Exploration of the Issues and the Evidence to Date from Latin America. World Development 33 (2), 237–253.
URL `http://www.sciencedirect.com/science/article/pii/S0305750X04001925`

Palmer, C., Engel, S., 2009. Avoided Deforestation: Prospects for Mitigating Climate Change, 1st Edition. Routledge.

Parker, C., Mitchell, A., Trivedi, M., Mardas, N., 2009. The Little REDD+ Book. Global Canopy Programme.
URL `http://www.theredddesk.org/sites/default/files/lrb_en.pdf`

Parks, P. J., January 1995. Explaining "Irrational" Land Use: Risk Aversion and Marginal Agricultural Land. Journal of Environmental Economics and Management 28 (1), 34–47.
URL `http://www.sciencedirect.com/science/article/pii/S0095069685710030`

Perevochtchikova, M., August 2010. Pago por Servicios Ambientales Hidrológicos en Suelo de Conservación, DF. Resultados del 2do año de estudio, Power Point Presentation held during the III Seminario de Evaluación de políticas públicas ambientales 31 de agosto del 2010.

Perevochtchikova, M., 2011. Programa de Pago por Servicios Ambientales Hidrológicos. In: Pérez Campuzano, E., Perevochtchikova, M., Ávila Foucat, V. S. (Eds.), Suelo de Conservación del Distrito Federal - ¿hacia una gestión y manejo sustentable? Instituto Politécnico Nacional, pp. 175–202.

Pérez Campuzano, E., Perevochtchikova, M., Ávila Foucat, V. S., 2011. Suelo de Conservación del Distrito Federal - ¿hacia una gestión y manejo sustentable?, 1st Edition. Estudios Urbanos. Instituto Politécnico Nacional.

Peters-Stanley, M., Hamilton, K., Marcello, T., Sjardin, M., 2011. Back to the Future - State of the Voluntary Carbon Markets 2011. Report, Ecosystem Marketplace & Bloomberg New Energy Finance, retrieved March, 26th 2012.
URL `http://www.forest-trends.org/documents/files/doc_2828.pdf`

PMRE, 2008. Plan Maestro Subcuenca del Río Eslava. Diagnóstico integral, Gobierno del Distrito Federal - Secretaría del Medio Ambiente (GCF-SMA) y Universidad Autónoma Metropolitana (UAM), retrieved November 13th, 2011.

URL http://www.sma.df.gob.mx/sma/links/download/biblioteca/riomagdalenayeslava/rioeslava/sint-ejecut-espanol.pdf

PMRM, October 2008. Plan Maestro Río Magdalena - Plan Maestro de Manejo Integral y Aprovechamiento Sustentable de la Cuenca del Río Magdalena del Distrito Federal. Diagnóstico integral, Gobierno del Distrito Federal - Secretaría del Medio Ambiente (GCF-SMA) y Universidad Nacional Autónoma de México (UNAM), retrieved December 6th, 2010.
URL http://www.sma.df.gob.mx/sma/links/download/biblioteca/diagnostico_integral.pdf

PointCarbon, April 2009. CDM/JI/AAU - US developer invests in Mexican ag methane projects. Online article written by Kim Moore, retrieved May 24th, 2010.
URL http://www.pointcarbon.com/news/1.1104070

PROFEPA, October 2011. About PROFEPA. Online by Procuraduría Federal de Protección al Ambiente (PROFEPA), retrieved October 27th, 2011.
URL http://www.profepa.gob.mx/

Quadri, G., 2008. El cambio climático en México y el potencial de reducción de emisiones por sectores. In: Galindo, L. M. (Ed.), La Economía del Cambio Climático en México - Síntesis. Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT).
URL http://www.ine.gob.mx/descargas/dgipea/2009_economia_cc_mex.pdf

Rahm, M. R., Huffman, W. E., 1984. The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables. American Journal of Agricultural Economics 66 (4), 405–413.
URL http://dx.doi.org/10.2307/1240918

Ramos, A., 2008. Propuesta de reclasificación y zonificación participativa de la Zona Protectora Forestal Cañada de Contreras, Distrito Federal, México. Master's thesis, Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), México.

RAN, November 2011. Distribución de la propiedad social en México, Maps presented by the Registro Agrario Nacional (RAN) during the Workshop "Taller: Propiedad social y servicios ambientales para el desarrollo territorial" organized by Registro Agrario Nacional (RAN), Instituto Interamericano de Cooperación para la Agricultura (IICA) and Comisión Nacional Forestal (CONAFOR) on November 8th, 2011, retrieved on February 28th, 2012.
URL http://www.ran.gob.mx/ran/seminario/

Revollo Fernández, D. A., Julio 2006. Información pública sobre el desempeño ambiental: efectos de la certificación sobre el consumo ecoturístico en el Parque Natural Tayrona. Master's thesis, Universidad de los Andes - Facultad de Economía.

Rico García-Amado, L., Ruíz-Pérez, M., Reyes-Escutia, F., Barrasca-García, S., Contreras-Mejía, E., October 2011. Efficiency of Payments for Environmental Services: Equity and additionality in a case study from a Biosphere Reserve in Chiapas, Mexico. Ecological Economics 70 (12), 2361–2368.
URL http://dx.doi.org/10.1016/j.ecolecon.2011.07.016

Ritchie, B., McDougall, C., Haggith, M., Burford de Oliveira, N., 2000. Criteria and indicators of sustainability in community managed forest landscapes. Center for International Forest Research (CIFOR).
URL http://www.cifor.org/publications/pdf_files/Books/cmf.pdf

Robertson, N., Wunder, S., 2005. Huellas frescas en el bosque. Evaluación de iniciativas incipientes de pagos por servicios ambientales en Bolivia. Center for International Forest Research (CIFOR).
URL http://www.cifor.org/publications/pdf_files/Books/BRobertson0501S.pdf

Roe, B., Boyle, K. J., Teisl, M. F., September 1996. Using Conjoint Analysis to Derive Estimates of Compensating Variation. Journal of Environmental Economics and Management 31 (2), 145–159.
URL http://www.sciencedirect.com/science/article/pii/S0095069696900376

Rosa, H., Kandel, S., Dimas, L., 2004. Compensación por servicios ambientales y comunidades rurales: Lecciones de las Américas y temas críticos para fortalecer estrategias comunitarias, 1st Edition. Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), Instituto Nacional de Ecología (INE), Programa Salvadoreño de Investigación sobre Desarrollo y Medio Ambiente, Consejo Civil Mexicano para la Silvicultura Sostenible A.C. (CCMSS).
URL http://www.ccmss.org.mx/descargas/compensacin_por_servicios_ambientales_y_comunidades_rurales.pdf

Runge, C. F., 1981. Common Property Externalities: Isolation, Assurance, and Resource Depletion in a Traditional Grazing Context. American Journal of Agricultural Economics 63 (4), 595–606.
URL http://dx.doi.org/10.2307/1241202

Runge, C. F., May 1986. Common property and collective action in economic development. World Development 14 (5), 623–635.
URL http://dx.doi.org/10.1016/0305-750X(86)90128-2

Rzedowski, J., 1978. Vegetación de México, 1st Edition. Limusa, S.A.

Sackman, H., 1975. Delphi critique: expert opinion, forecasting, and group process. Lexington.

Scheele, D. S., 1975. Reality Construction as a Product of Delphi Interaction. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: techniques and applications. Addison-Wesley, Ch. II. C., pp. 37–72.

Scheibe, M., Skutsch, M., Schofer, J., 1975. Experiments in Delphi Methodology. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: techniques and applications. Addison-Wesley, Ch. IV. C., pp. 262–287.

Scherr, S. J., 1992. Not Out of the Woods Yet: Challenges for Economic Research on Agroforestry. American Journal of Agricultural Economics 74 (3), 802–808.
URL http://dx.doi.org/10.2307/1242599

Schneider, E.-M., 2005. Economic evaluation of hydrological services in a watershed in the province of Pastaza, Ecuador. Master's thesis, University of Göttingen, Faculty of Forest Sciences and Forest Ecology, Germany.

Schnell, R., Hill, P. B., Esser, E., 1993. Methoden der empirischen Sozialforschung, 5th Edition. R. Oldenbourg Verlag München Wien.

Scholz, I., Schmidt, L., 2008. Reducing emissions from deforestation and forest degradation in developing countries: meeting the main challenges ahead. Briefing Paper 6, Deutsches Institut für Entwicklungspolitik (DIE), retrieved October 25th, 2011.
URL http://www.die-gdi.de/CMS-Homepage/openwebcms3.nsf/%28ynDK_contentByKey%29/ANES-7KGH27?Open

Schteingart, M., Salazar, C. E., 2005. Expansión urbana, sociedad y ambiente. El caso de la Ciudad de México, 1st Edition. El Colegio de México.

Schuck, E. C., Nganje, W., Yantio, D., 2002. The role of land tenure and extension education in the adoption of slash and burn agriculture. Ecological Economics 43 (1), 61–70.
URL http://www.sciencedirect.com/science/article/pii/S0921800902001805

Schwab, K., 2009. The Global Competitiveness Report 2009-2010. Report, World Economic Forum.
URL http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2009-10.pdf

Scott, R. E., December 2006. The Law and Economics of Incomplete Contracts. Annual Review of Law and Social Science 2, 279–297.
URL http://dx.doi.org/10.1146/annurev.lawsocsci.2.081805.105913

Scott, R. E., Stephan, P. B., 2006. The Limits of Leviathan: Contract Theory and the Enforcement of International Law. Cambridge University Press.

SEMARNAT, 2009. Programa Especial de Cambio Climático 2009-2012. Public program, Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), retrieved January 4th, 2011.
URL http://www.semarnat.gob.mx/temas/cambioclimatico/Documents/pecc/090828_PECC.Capitulos_DOF.pdf

SEMARNAT-INE, November 2009. México - Cuarta Comunicación Nacional ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático. Tech. rep., Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) - Instituto Nacional de Ecología (INE), retrieved, January 4th, 2011.
URL http://cc2010.mx/assets/001/5140.pdf

Shavell, S., 1980. Damage measures for breach of contract. The Bell Journal of Economics 11 (2), 466–490.
URL http://www.jstor.org/stable/3003374

SHCP, July 2011. Presupuesto Ciudadano 2012. Online by Secretaría de Hacienda y Crédito Público (SHCP), retrieved August 11th, 2012.
URL http://www.hacienda.gob.mx/EGRESOS/Presupuesto%20Ciudadano/PresupuestoCiudadanoWEB_OP-2012.pdf

SHCP, September 2012. Presupuesto de Egresos de la Federación 2012. Online by Secretaría de Hacienda y Crédito Público (SHCP), retrieved September 11th, 2012.
URL http://www.transparenciapresupuestaria.gob.mx/ptp/contenidos/?id=14&group=Preguntas&page=%C2%BFQui%C3%A9n%20gasta?

Sheinbaum Pardo, C., 2011. La compleja problemática del Suelo de Conservación del Distrito Federal: apuntes para su conservación. In: Pérez Campuzano, E., Perevochtchikova, M., Ávila Foucat, V. S. (Eds.), Suelo de Conservación del Distrito Federal - ¿hacia una gestión y manejo sustentable?, 1st Edition. Estudios Urbanos. Instituto Politécnico Nacional, Ch. I, pp. 13–38.

SIAP, April 2010. Producción Agricola, Ciclo: Ciclicos y Perennes 2010, Modalidad: Riego + Temporal, Estado: Distrito Federal, Delegación: La Magdalena Contreras. Online by Servicio de Información Agroalimentaría y Pesquera (SIAP), retrieved April 12th, 2012.
URL http://www.siap.gob.mx/index.php?option=com_wrapper&view=wrapper&Itemid=351

Skerratt, S., 1998. Socio-economic evaluation of UK agri-environmental policy: lessons from an ESA case study. Etudes et Recherches sur les Systèmes Agraires et le Développement 31, 317–331.
URL http://www.inra.fr/internet/Departements/SAD/rub3resu/EtudEtRech/er31_chap17.pdf

Smith, T. M. F., 1983. On the Validity of Inferences from Non-Random Sample. Journal of the Royal Statistical Society 146 (4), 394–403, series A (General).
URL http://www.jstor.org/stable/2981454

Soldevilla García, E., Grande Esteban, I., 1987. Análisis Económico de la Demanda en la Gestión Empresarial. El Ateneo, Barcelona.

Speranza, C. I., van de Sand, I., 2010. Can the rural economy deliver ecosystem services? CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 5 (031), 1–16.
URL http://www.cabi.org/cabreviews/?loadmodule=review&page=4051&reviewid=148760&site=167

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., de Haan, C., 2006. Livestock's long shadow: Environmental issues and options. Food and Agriculture Organization of the United Nations (FAO), Rome.
URL ftp://ftp.fao.org/docrep/fao/010/a0701e/a0701e00.pdf

Stern, N., 2006. Stern review on the economics of climate change. Report, UK Treasury.
URL http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/media/4/3/Executive_Summary.pdf

Stewart, T. R., 1987. The Delphi technique and judgmental forecasting. Climatic Change 11 (1-2), 97–113.
URL http://dx.doi.org/10.1007/BF00138797

Teklewold, H., Köhlin, G., August 2010. Risk Preferences as Determinants of Soil Conservation Decisions in Ethiopia. Discussion Paper Series EfD DP 10-19, Environment for Development (EfD).
URL http://www.rff.org/RFF/documents/EfD-DP-10-19.pdf

Thacher, T., Lee, D., Schelhas, J., 1996. Farmer participation in reforestation incentive programs in Costa Rica. Agroforestry Systems 35 (3), 269–289.
URL http://dx.doi.org/10.1007/BF00044458

Todd, L. C., Kroll, S., Shogren, J., 2009. Environmental Economics, Experimental Methods. Routledge Explorations in Environmental Economics. Routledge.

Tognetti, S. S., Mendoza, G., Aylward, B., Southgate, D., Garcia, L., 2004. Guía para el desarrollo de opciones de pago por servicios ambientales (PSA) de las cuencas hidrológicas. Tech. rep., Departamento de Ambiente del Banco Mundial, Bank-Netherlands Watershed Partnership Program, Washington DC, retrieved July 6th, 2011.
URL http://www.ibcperu.org/doc/isis/8296.pdf

Tomich, T. P., Thomas, D. E., van Noordwijk, M., September 2004. Environmental services and land use change in Southeast Asia: from recognition to regulation or reward? Agriculture Ecosystems & Environment 104 (1), 229–244.
URL http://www.sciencedirect.com/science/article/pii/S0167880904000428

Trejo, I., May 2010. Aspectos metodológicos y tendencias de la deforestación en México, Power Point Presentation held by Irma Trejo from Instituto de Geografía UNAM (IG-UNAM) during the Workshop "Foro sobre la deforestación en México" organized by Facultad de Economía de la UNAM, GreenpeaceMéxico y Estudios Rurales y Asesoría on May 26th, 2010.

Turoff, M., 1975. The Policy Delphi. In: Linstone, H. A., Turoff, M. (Eds.), The Delphi method: techniques and applications. Addison-Wesley, Ch. III. B.1., pp. 84–101.

UN-HABITAT, 2003. Guide to Monitoring Target 11: Improving the lives of 100 million slum dwellers. Progress towards the Millennium Development Goals. Tech. rep., United Nations Human Settlements Programme (UNHABITAT), retrieved November 14th, 2011.
URL http://www.unhabitat.org/

UNEP-RISOE, October 2011. CDM/JI Pipeline Analysis and Database. Online by United Nationas Environmental Program and Risoe Centre (UNEP-RISOE), retrieved October 22nd, 2011.
URL http://cdmpipeline.org/

UNFCCC, 2006. Land Use, Land-Use Change and Forestry (LULUCF). Methods & science, United Nations Framework Convention on Climate Change (UNFCCC), retrieved May 24th, 2010.
URL www.unfccc.int/methods_and_science/lulucf/items/3060.php

UNFCCC, 2007. Tool for the demonstration and assessment of additionality (Version 03). Tool, CDM-EB, EB 29, United Nations Framework Convention on Climate Change (UNFCCC), retrieved May 24th, 2010.
URL http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v3.pdf

UNFCCC, 2008. Report of the Conference of the Parties on its Thirteenth Session, Held in Bali from 3 to 15 December 2007. Report FCCC/CP/2007/6/Add.1, United Nations Framework Convention on Climate Change (UNFCCC), retrieved September 16th, 2010.
URL http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf

UNFCCC, 2009a. Copenhagen Accord. Decision 2/CP.15, United Nations Framework Convention on Climate Change (UNFCCC), retrieved March 23rd, 2012.
URL http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf#page=4

UNFCCC, 2009b. Glossary of CDM terms Version 05. Glossary, EB47, United Nations Framework Convention on Climate Change (UNFCCC), retrieved October 4th, 2010.
URL http://cdm.unfccc.int/Reference/glossary.html

UNFCCC, 2009c. Methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries. Decision 4/CP.15, United Nations Framework Convention on Climate Change (UNFCCC), retrieved January 4th, 2011.
URL http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf#page=11

UNFCCC, December 2010. Press release - UN Climate Change Conference in Cancún delivers balanced package of decisions, restores faith in mulilateral process. Online by United Nations Framework Convention on Climate Change (UNFCCC), retrieved January 3rd, 2012.
URL http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/pr_20101211_cop16_closing.pdf

UNFCCC, October 2011. Approved methodologies for large and small scale afforestation and reforestation CDM project activites. Online by United Nations Framework Convention on Climate Change (UNFCCC), retrieved October 22nd, 2011.
URL http://cdm.unfccc.int/methodologies/index.html

UNFCCC, April 2012a. Annex B. Online by United Nations Framework Convention on Climate Change (UNFCCC), retrieved April 16th, 2012.
URL http://unfccc.int/kyoto_protocol/items/3145.php

UNFCCC, April 2012b. Joint Implementation. Online by United Nations Framework Convention on Climate Change (UNFCCC), retrieved April 16th, 2012.
URL http://unfccc.int/kyoto_protocol/mechanisms/joint_implementation/items/1674.php

UNFCCC, April 2012c. Parties & Observers. Online by United Nation Framework Convention on Climate Change (UNFCCC), retrieved April 16th, 2012.
URL http://unfccc.int/parties_and_observers/items/2704.php

United Nations, 2006. World Urbanization Prospects - The 2005 Revision. Economic & social affairs, United Nations (UN), Department of Economic and Social Affairs (DESA), Population Division, retrieved July 21st, 2011.
URL http://www.un.org/esa/population/publications/WUP2005/2005WUPHighlights_Final_Report.pdf

UNSD, 2007. Millennium development goals indicators - Goal 7. Ensure environmental sustainability: Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources - Carbon dioxide emissions (CO2), thousand metric tons CO2 (compiled by CDIAC). Report, United Nations Statistics Division (UNSD), retrieved May 24th, 2010.
URL http://mdgs.un.org/unsd/mdg/Data.aspx

Van Aaken, A., 2009. International Investment Law and Rationalist Contract Theory. Working paper, University of St. Gallen Law School, retrieved May 24th, 2010.
URL http://www.iilj.org/courses/documents/2009Colloquium.Session2.Aaken.pdf

Vásquez Lavín, F., Cerda Urrutia, A., Orrego Suaza, S., 2007. Valoración Económica del Ambiente: Fundamentos Económicos, Econométricos y Aplicaciones, 1st Edition. Vol. 1. CENGAGE, Thomson Learning, Buenos Aires.

VCS, 2010. Verified Carbon Standard - About the VCS. Online by Verified Carbon Standard Association (VCS), retrieved on December 4th, 2010.
URL http://www.v-c-s.org

VCS, October 2011a. Verified Carbon Standard - Approved methodologies under the sectoral scope of AFOLU. Online by Verified Carbon Standard Association (VCS), retrieved on October 24th, 2011.
URL http://www.v-c-s.org/methodologies/find

VCS, October 2011b. Verified Carbon Standard - Project Database. Online by Verified Carbon Standard Association (VCS), retrieved on October 24th, 2011.
URL http://www.vcsprojectdatabase.org/

VCS, April 2012. Verified Carbon Standard - Mission statement. Online by Verified Carbon Standard Association (VCS), retrieved April 16th, 2012.
URL http://www.v-c-s.org/

Warman, A., 2001. El campo mexicano en el siglo XX. Fondo de Cultura Económica (FCE).

WB, 2012. Countries & Regions - Mexico. Online by the World Bank (WB), retrieved May 8th, 2012.
URL http://www.worldbank.org/en/country/mexico

WCI, April 2012. About the WCI. Online by Western Climate Initiative (WCI), retrieved April 16th, 2012.
URL http://www.westernclimateinitiative.org/index.php

Whitby, M., September 2000. Challenges and Options for the UK Agri-Environmental: Presidential Address. Journal of Agricultural Economics 51 (3), 317–332.
URL http://dx.doi.org/10.1111/j.1477-9552.2000.tb01234.x

Worm, B., Barbier, E. B., Beaumont, N., Duffy, J. E., Folke, C., Halpern, B. S., Jackson, J. B. C., Lotze, H. K., Micheli, F., Palumbi, S. R., Sala, E., Selkoe, K. A., Stachowicz, J. J., Watson, R., November 2006. Impacts of Biodiversity Loss on Ocean Ecosystem Services. Science 314 (5800), 787–790.
URL http://dx.doi.org/10.1126/science.1132294

Wossink, G. A. A., van Wenum, J. H., 2003. Biodiversity conservation by farmers: analysis of actual land contingent participation. European Review of Agricultural Economics 30 (4), 461–485.
URL http://dx.doi.org/10.1093/erae/30.4.461

Wunder, S., 2005. Payments for environmental services: Some nuts and bolts. Occasional Paper 42, Center for International Forestry Research (CIFOR), retrieved June 1st, 2010.
URL http://www.cifor.org/publications/pdf_files/occpapers/op-42.pdf

Wunder, S., 2008. Necessary Conditions for Ecosystem Service Payments. In: Economics and Conservation in the Tropics: A Strategic Dialogue. Conference paper January 31 – February 1, 2008. Retrieved May 24th, 2010.
URL http://www.rff.org/documents/08_tropics_conference/tropics_conference_papers/tropics_conference_wunder_pes_markets.pdf

Wunder, S., Albán, M., 2008. Decentralized payments for environmental services: The cases of Pimampiro and PROFAFOR in Ecuador. Ecological Economics 65 (4), 685–698.
URL http://www.sciencedirect.com/science/article/pii/S0921800907005320

Wunder, S., Engel, S., Pagiola, S., 2008. Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. Ecological Economics 65 (4), 834–852.
URL http://www.sciencedirect.com/science/article/pii/S0921800908001432

Wunder, S., Wertz-Kanounnikoff, S., June 2009. Payments for environmental services: Guidance paper for the scientific and technical advisory panel (STAP). Guidance Paper GEF/C.35/ Inf.12, Center for International Forestry Research (CIFOR) and Institut du Développement Durable et des Relations Internationales (IDDRI), retrieved May 24th, 2010.
URL http://www.thegef.org/gef/sites/thegef.org/files/documents/C.35.Inf_.12_STAP_Guidance_on_PES.pdf

Wünscher, T., Engel, S., Wunder, S., 2008. Spatial targeting of payments for environmental services: A tool for boosting conservation benefits. Ecological Economics 65 (4), 822–833.
URL http://www.sciencedirect.com/science/article/pii/S092180090700568X

Yamane, T., 1967. Statistics: An Introductory Analysis, 2nd Edition. New York: Harper and Row.

Yin, R. K., 1984. Case Study Research: Design and Methods. Sage Publications.

Zabel, A., Roe, B., June 2009. Performance payments for environmental services: Lessons from economic theory on the strength of incentives in the presence of performance risk and performance measurement distortion. Working Paper 7, Institute for Environmental Decisions (IED), retrieved May 24th, 2010.
URL http://www.ied.ethz.ch/pub/pdf/IED_WP07_Zabel_Roe.pdf

Zbinden, S., Lee, D. R., 2005. Paying for Environmental Services: An Analysis of Participation in Costa Rica's PSA Program. World Development 33 (2), 255–272.
URL http://www.sciencedirect.com/science/article/pii/S0305750X04001937

Zeller, M., Sharma, M., Henry, C., Lapenu, C., June 2001. An operational tool for evaluating poverty outreach of development policies and projects. Discussion Paper 111, Food Consumption and Nutrition Division (FCND) - International Food Policy Research Institute (IFPRI), retrieved April 30th, 2011.
URL http://www.ifpri.cgiar.org/sites/default/files/pubs/divs/fcnd/dp/papers/fcndp111.pdf

ZONU, 2012. Delegaciones de la Ciudad de México DF. Online by ZONU, retrieved June 11th, 2012.
URL http://www.zonu.com/detail/2011-09-18-14574/Delegaciones-de-la-Ciudad-de-Mexico-DF.html

Glossary

Additionality

Carbon benefits created through a specific project activity are additional if they are higher than in the BAU scenario. For example, a small-scale A/R project activity under the CDM is additional if the actual net GHG removals by sinks are increased above the sum of the changes in carbon stocks in the carbon pools within the project boundary which would have occurred in the absence of the registered small-scale A/R project activity under the CDM (UNFCCC, 2009b).

Adverse selection

Adverse selection is commonly referred to as hidden information and occurs when a contract is negotiated. In the ambit of PES, the ES seller may have better information about opportunity costs and costs of contract compliance than the ES buyer or PES administrator. Thus, private information can be used as a market (bargaining) power in order to extract information rents from the ES buyer. Usually, these information rents can only be reduced if the ES buyer is able to obtain equal access to the same information in order to maximize ES provisions from a given budget.

Afforestation

Afforestation is the direct human-induced conversion of land which has not been forested for a period of, for example under the UNFCCC, at least 50 years to forested land through planting, seeding and/or human-induced promotion of natural seed sources (UNFCCC, 2009b).

Agent

The agent is the "contracted" party in the principal-agent relationship. It is someone assigned to act on behalf of a principal. In an environmental contract such as PES, the agent is the ES seller (provider). In the context of Mexico's PES program, the agent is typically a common property regime (agrarian community or *ejido*) which consists of several community members (individual ES providers).

Aggregator

The aggregator has the ability to group individuals, communicate between supply and demand side, and channel and distribute benefits obtained from the commercialization of forest carbon stocks. Aggregators may be of varying nature such as indigenous groups, smallholders occupying a delimited territory or jurisdictions.

Agrarian community

The Agrarian Community is a common property regime of land and labeled as private common property. This property is created where interest groups, mainly indigenous communities, can prove with documentation and testimonies that they lived and managed the land area already in colonial times. The common land is marked with an Agrarian Certificate where the property is recognized and inscribed in the RAN.

Annex B

Annex B Parties include the Parties of the Annex I with individual emission targets under the Kyoto Protocol (UNFCCC, 2012a).

Annex I

Annex I Parties include the industrialized countries which were members of the Organization for Economic Co-operation and Development (OECD) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States (UNFCCC, 2012c).

Avoidable reversal

An avoidable or intentional reversal is commonly referred to as an event where the ES seller is in the position to prevent forest carbon loss (deforestation and degradation). Thus, the main feature of the driver causing the loss is intentional from an ES seller's perspective.

Baseline

A baseline is used to distinguish the BAU scenario in the absence of the project activity from factors that are induced through a carbon project activity or pertain to natural variability and indirect effects of human activity. Baselines help quantifying the additional carbon benefit of the proposed and executed activity which avoids GHG emissions and improves forest carbon stocks.

Biomass

Biomass is non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms. This also includes products, by-products, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes. Furthermore, biomass comprises gases and liquids recovered from the decomposition of non-fossilized and biodegradable organic material. Biomass residues are biomass by-products, residues and waste streams from agriculture, forestry and related industries (UNFCCC, 2009b).

Carbon accounting

Since LULUCF activities (e.g., REDD) have a storage and time component with related non-permanence issues, it is of interest to have knowledge about the behavior of emitted GHGs in the atmosphere, its absorption from the atmosphere and integration into the biosphere. The information about temporal issues in the forestry sector is fundamental for determining the amount of carbon benefits from the different mitigation options. The challenge of carbon accounting is to design a system which allows transparent, consistent, complete, accurate, measurable, verifiable, and efficient recording and reporting of changes in carbons stocks and/or changes by sources and removals by sinks from applicable forest activities under the relevant carbon regime.

Carbon pool

Forests have the capacity to accumulate or release carbon in different pools. Examples of carbon pools are forest biomass, wood products, soils, and the atmosphere. Carbon pools according to the UNFCCC (2009b) are: above-ground biomass, below-ground biomass, litter, dead wood and soil organic carbon.

Carbon stock

The carbon stock is the absolute quantity of carbon held within a pool at a specific time (IPCC, 2000).

Certified Emission Reduction

Certified Emission Reduction or CER is a unit issued pursuant to Article 12 and requirements there under, as well as the relevant provisions in the CDM modalities and procedures, and is equal to one metric ton of CO_2-e, calculated using GWPs defined by Decision 2/CP.3 or as subsequently revised in accordance with Article 5 of the Kyoto Protocol (UNFCCC, 2009b).

Clean Development Mechanism

Article 12 of the Kyoto Protocol defines the Clean Development Mechanism (CDM): "The purpose of the CDM shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex

I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3" (UNFCCC, 2009b).

Conservation

Conservation refers to the forest carbon stock that is already or additionally stored in intact forest. As part of a REDD+ approach, the rationale is that forest stewards with demonstrated good management practice in the past and probably in the future should benefit from any international financial funding, although an immediate threat of carbon loss is not detected.

Crediting period

The crediting period for, for example, an A/R CDM project activity is the period for which net anthropogenic GHG removals by sinks are verified and certified by a DOE in order to issue long-term CERs (lCERs) or temporary CERs (tCERs). The crediting period begins at the starting date of the A/R CDM project activity. A crediting period shall not extend beyond the operational lifetime of the A/R CDM project activity. The project participants may choose between two options for the length of a crediting period: (i) fixed crediting period (maximum of 30 years) or (ii) renewable crediting period (maximum of 20 years) (UNFCCC, 2009b).

Deforestation

Deforestation, as defined by the Marrakech Accords, is the direct human-induced conversion of forested land to non-forested land. A forest is defined as a minimum area of land of 0.05-1 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 percent with trees with the potential to reach a minimum height of 2-5 meters at maturity *in situ*. Actual definitions can vary by country as the Kyoto Protocol permits countries to specify the precise definition within these parameters to be used for national accounting of emissions. In contrast, the FRA (2004) defines deforestation as "the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold".

Degradation

A definition for forest degradation has not yet been agreed under the Kyoto Protocol and the IPCC has also not provided a specific definition. According to the FRA (2004), forest degradation is the reduction of the canopy cover or stocking within a forest, provided that the canopy cover stays above 10 percent.

Designated Operational Entity

Designated Operational Entity or DOE is an entity designated by the COP/MOP, based on the recommendation by the EB, as qualified to validate proposed CDM project activities as well as verify and certify reductions in anthropogenic emissions by sources of GHGs and net anthropogenic GHG removals by sinks. A DOE shall perform validation or verification and certification on the same CDM project activity. Upon request, the EB may however allow a single DOE to perform all these functions within a single CDM project activity. COP at its eighth session decided that the EB may designate on a provisional basis operational entities (see Decision 21/CP.8) (UNFCCC, 2009b).

Ejido

The *Ejido* is a common property regime of land and labeled as private *ejidal* property. This property is created where interest groups, often former *Hacienda* workers, request the Mexican President's permission to cultivate a certain delineated land area. The common land is marked with an Agrarian Certificate where the property is recognized and inscribed at the RAN. However, in contrast to Agrarian Communities, *Ejidos* are allowed to sell their land since the Agrarian Reform from 1992.

Enhancement

Enhancement of forest carbon stocks is referred to a change in forest management practice intended to increase the wood biomass (carbon stock) per area unit in an existing forest that is managed or going to be managed.

Environmental safeguards

Environmental safeguards assure that any carbon incentive scheme recognizes the importance of the environmental integrity beyond climate issues and protects against any perverse incentives such as forcing forest owners to threat their natural capital in order to be eligible for participation in a REDD regime. Other issues would be prioritizing forest owners that provide additional environmental benefits such as biodiversity protection.

Environmental Services

Environmental or Ecosystem Services (ES) in the realm of PES are commonly referred to as public goods which are provided by the forest ecosystem. Public goods are characterized by non-excludability and non-rivalry. The ES carbon sequestration or emission avoidance from forest carbon stocks is, in theory, such a public good. Other ESs used in PES design are water, biodiversity and scenic beauty. Although most research makes no strict distinction between ecosystem and environmental services, this research uses more the term environmental services. This research believes that environmental services are subordinated to ecosystem services in the taxonomy and refer to a more specific use value that can be derived from a good or service that is provided from an ecosystem.

Expert

Experts are all individuals that can contribute valid objective and/or subjective information to the provision process (Landeta Rodríguez, 1999).

Fixed crediting period

A fixed crediting period is one of two options for determining the length of a crediting period. In this case, the length and starting date of the period is determined for an A/R CDM project activity with no possibility of renewal or extension once the proposed A/R CDM project activity has been registered. The length of the period can be a maximum of 30 years for a proposed A/R CDM project activity (Paragraph 23b of CDM A/R modalities and procedures) (UNFCCC, 2009b).

Forest

Forest is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 percent with trees that potentially reach a minimum height of 2-5 meters at maturity *in situ*. A Party not included in Annex I may host an A/R CDM project activity if it has selected and reported to the EB through its DNA for the CDM the parameters it has chosen for the definition of forest to be used for the purposes of hosting A/R project activities under the CDM. A Party not included in Annex I may host an A/R CDM project activity if it has selected and reported to the EB through its DNA for the CDM: a) a single minimum tree crown cover value between 10-30 percent; and b) a single minimum land area value between 0.05 and 1 hectares; and c) a single minimum tree height value between 2-5 meters (UNFCCC, 2009b).

Fungible

Fungible is a feature referring to a situation where one part or quantity may be replaced by another equal part or quantity in the satisfaction of an obligation. In the context of GCC, the fungibility refers to a ton of CO_2-e (Parker et al., 2009).

Global Climate Change

Climate change refers to any long-term significant change in the expected patterns of average weather of a specific region (or, more relevantly to contemporary socio-political concerns, of the Earth as a whole) over an appropriately significant period of time. In recent usage, especially in the context of environmental policy, climate change usually refers to Global Climate Changes (GCC) in modern climate and is attributed to anthropogenic factors. Anthropogenic factors are human activities that change the environment. Of most concern among anthropogenic influence factors is the increase of CO_2 levels as one of the important GHGs which contribute to global warming.

Hot air

Hot air refers to ERs that are not additional.

Interval

Interval data is similar to an ordinal data, except that the intervals between the values of the interval variable are equally spaced. Examples include age and family size. The numbers represent systematic sequence adhering to an underlying scale, usually with a measurement unit (Henry et al., 2003).

Joint Implementation

Article 6 of the Kyoto Protocol defines Joint Implementation as a mechanism which: "allows a country with an ER or limitation commitment under the Kyoto Protocol (Annex B Party) to earn Emission Reduction Units (ERUs) from an ER or emission removal project in another Annex B Party, each equivalent to one ton of CO_2, which can be counted towards meeting its Kyoto target (UNFCCC, 2012b).

Leakage

Leakage is defined as the net change of anthropogenic emissions by sources of GHGs which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity (IPCC, 2000; UNFCCC, 2009b).

Liability

Liability refers to the assigned obligation of maintaining created and rewarded carbon benefits for an agreed time span. Specifically, it asks the question: If credit is given when carbon stocks are maintained, who then assumes the liability if the rewarded carbon stock is lost? The magnitude of the liability for any reversal will have to be clarified.

Linear accounting

Linear accounting defines a time frame which suffices the condition of permanence and assumes that carbon stock maintained over this period may be equally distributed over time (e.g. 1/100 per year for 100 years). Hence, in the case of a reversal, it divides the period of non-compliance by the required time frame and the resulting percentage of the carbon benefits is the portion a party is liable for.

Long-term average

The long-term average estimates the average changes of carbon stocks or GHG emissions over time in a project area. This approach has been adopted by the VCM under the VCS. In this approach, baseline carbon stocks are subtracted from actual carbon stocks over the considered time frame and divided by the years equal to the time frame selected. Hence, this method accounts for dynamics in carbon stocks and allows for comparison of different projects. Normally, a project receives credits as carbon is fixed until the long-term average is reached.

Long-term CER

Long-term Certified Emission Reduction or lCER is a unit issued pursuant to Article 12 of the Kyoto Protocol for an A/R CDM project activity, which expires at the end of the crediting period of the A/R CDM project activity under the CDM for which it was issued. It is equal to one metric ton of CO_2-e. Where project participants have chosen the lCER approach in order to address non-permanence, a request to the EB is required for issuance of lCERs equal to the verified amount of net anthropogenic GHG removals by sinks achieved by the A/R CDM project activity since the previous certification (UNFCCC, 2009b).

Monitoring

Monitoring refers to the collection and archiving of all relevant data necessary for estimating or measuring the net anthropogenic GHG removals by sinks during the crediting period as, for example, stipulated by the Paragraph 25 of the Kyoto Protocol (UNFCCC, 2009b).

Moral hazard

Moral hazard is commonly referred to as hidden action and occurs after a contract is negotiated. For example, in a PES scheme monitoring contract compliance might be costly and the ES buyer or PES administrator is probably unwilling to pay for full control. Thus, both are interested to verify compliance with a degree of uncertainty. This circumstance makes it likely that ES sellers exploit the monitoring gap. The information asymmetry is the principal's (ES buyer/PES administrator) inability to observe and/or verify the agent's (ES seller) action.

Nominal

Nominal data are these where the number codes represent labels for categories of responses. These codes tend to identify and classify information. Examples are marital status, gender, and location codes. The code numbers do not represent systematic sequencing that adhere to an underlying scale (Henry et al., 2003).

Offset

The premise of an offset is that the atmosphere is indifferent to where and how GHG reductions or removals are achieved (CAR, 2010). To be an offset, the net effect of sequestration has to be identical to that of avoiding emissions (Moura-Costa and Wilson, 2000). Thus, offsets are reductions in GHG emissions from outside the capped sectors, such as forestry and agriculture, and offset credits may be traded in an ETS (WCI, 2012).

Ordinal

Ordinal data are these where the sequence of number codes for a variable reflects an ordered relationship. Code responses for ordinal data are assumed to measure points along an underlying continuous function which may specify graduations in quality or cost. Examples of ordinal data are education levels of adults (least education to most education), or the quality of drinking water and toilet facilities (lowest quality to highest quality) (Henry et al., 2003).

Payment for Environmental Services

Payment for Environmental (Ecosystem) Services (PES) is based on economic incentives for the landowners and their effort to conserve ecosystems. There are various ESs which can be used in a PES scheme such as water regulation and carbon sequestration. A variety of PES definitions exist ranging between simple and complex formulations. The differences reflect the level of agreement among experts. But all are rather based on a "beneficiary-pays" principle. An example of a formulation widely found in scientific literature and originated by Wunder (2005) is that PES is a voluntary transaction where a well-defined ES (or a land use likely to secure its provision) is being "bought" by at least one buyer from at least one provider if, and only if, the ES provider secures service provision (conditionality).

Payment structure

While carbon accounting methods are applied in order to quantify the amount of created environmental benefits, financial transactions for reimbursing ES sellers involve aspects of price level determination, payment differentiation, and scheduling payments.

Permanence

Permanence is the longevity of a certain carbon pool and the stability of its stocks, given the management and disturbance environment in which it occurs (IPCC, 2000). A requirement of effective GCC mitigation strategies in the AFOLU sector is that they must result in long-term changes in terrestrial carbon storage and CO_2 concentrations in the atmosphere.

Potential Water Reserve

Potential Water Reserves (RPA, for its Spanish acronym) are an instrument under the National Water Act. RPAs are water reserves which ensure the flow for the ecological protection and maintenance of ecosystem services on which people depend. They are located in areas with water availability, ecological and biological importance, and low hydrological pressure. The proposed network of RPAs for Mexico is a measure of adaptation to GCC, which ensures the functionality of the hydrological cycle as a water source and sustenance of ecological processes, with a watershed approach and based on administrative units. 99 percent of the 189 RPAs have parts within an agrarian nucleus. This includes 7,452 communities with more than 23.4 million hectares or 52 percent of the designated RPAs in the country (RAN, 2011).

Principal

The principal is the "contracting" party in the principal-agent relationship. It is someone who empowers an agent to carry an act on her/his behalf. In an environmental contract such as PES, the principal is the ES buyer (user). In the context of Mexico's PES program, the principal is the government through the CONAFOR.

Principal-agent relationship

The principal-agent relationship describes the generic contractual arrangement between two partys: principal (contracting party) and agent (contracted party). The difficulty in this relationship is to motivate (e.g. through contract attributes such as the payment structure) the agent to act on behalf of the principal. The problem is that the two parties have asymmetric information about each other and usally different interests. In an environmental contract such as PES, the principal is the ES buyer (user) and the agent is the ES seller (provider).

Priority Hydrological Region

Priority Hydrological Regions (RHP, for its Spanish acronym) are areas defined by their high value of biodiversity in freshwater environments and guide conservation strategies in Mexico. The RHP is defined under a watershed approach by using criteria that consider the environmental value of biotic and abiotic resources, economic value as well as risks and threats. 100 percent of the 110 RHPs have parts within an agrarian nucleus. This includes 12,717 communities with a total of more than 38.7 million hectares or 48 percent of the total surface of RHPs in the country (RAN, 2011).

Priority Terrestrial Region

Priority Terrestrial Regions (RTP, for its Spanish acronym) are areas defined by their high value of biodiversity and guide conservation strategies in Mexico. The RTP is defined by bio-ecological criteria, threat to the maintenance of biodiversity and conservation opportunity, and consultation with experts. 100 percent of the 152 RTPs have parts within an agrarian nucleus. This includes 6,592 communities with more than 25.7 million hectares or 50 percent of the total RTP area in the country (RAN, 2011).

Ratio-scaled

Ratio-scaled data are these where an absolute zero point is required. These data represent an actual unit of measurement such as value, quantity, size, weight, or distance. The expenditure on clothing and footwear is an example of a scale variable. Ratio data does not require coding (Henry et al., 2003).

Reducing Emissions from Deforestation and Degradation

Reducing Emissions from Deforestation and forest Degradation (REDD) generally refers to a commitment in a post-2012 Kyoto Protocol related to financial schemes for adaptation and technology transfer and a blueprint for reducing emissions from deforestation in developing nations. However, several definitions of REDD exist and do not always refer to a potential inclusion into the compliance market under the Kyoto Protocol.

Reforestation

Reforestation is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. In the case of CDM, it is stipulated that for the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989 (IPCC, 2000; UNFCCC, 2009b).

Renewable crediting period

A renewable crediting period is one of the two options for determining the length of a crediting period under the CDM. In the case of this option, a single crediting period may be of a maximum of twenty years. The crediting period may be renewed at most twice (maximum 60 years), provided that, for each renewal, a DOE determines that the original project baseline is still valid or has been updated taking account of new data, where applicable, and informs the EB accordingly (see Paragraph 23a). The starting date and length of the first crediting period has to be determined before registration (UNFCCC, 2009b).

Reversal

A reversal is the intended or unintended re-release of stored carbon under a LULUCF management activity (CAR, 2010).

Sequestration

Sequestration is the process of increasing the carbon content of a carbon pool other than the atmosphere (Parker et al., 2009).

Sink

A sink is any process or mechanism which removes a GHG, an aerosol, or a precursor of a GHG from the atmosphere. A given pool (reservoir) can be a sink for atmospheric carbon if, during a given time interval, more carbon is flowing into it than is flowing out (IPCC, 2000).

Small property

The Small Property is a land property title inscribed at the Public Property Registry.

Social safeguards

Social safeguards assure that any incentive scheme recognizes the importance of social aspects beyond climate issues and protects against any socially unethical performance such as preventing poor forest dwellers from subsistence activities vital for their survival. Other examples would be prioritizing of forest owners that provide additional social benefits such as community involvement in conservation activities and poverty reduction in general.

Source

A source is the opposite of a sink. A carbon pool (reservoir) can be a source of carbon to the atmosphere if less carbon is flowing into it than is flowing out of it (IPCC, 2000).

Stakeholders

Stakeholders refer the public, including individuals, groups or communities affected, or likely to be affected, by the proposed CDM project activity or actions leading to the implementation of such an activity (UNFCCC, 2009b).

Stock-change method

The stock-change method estimates carbon stocks and GHG emissions as a difference between baseline and forest activities at a given point in time. The stock-change method has been adopted by the compliance market under the Kyoto Protocol. Changes are usually expressed in tons of carbon per hectare and credits are issued as carbon is fixed or emissions avoided. The approach is reflecting a point in time and does not recognize variability over time.

Subsidy

In the context of ES provision, a subsidy is a governmental instrument where a polluter (potential ES provider) receives a compensation for avoiding an undesired land-use behavior. It is assumed that polluters are able to influence with their economic land-use activities (e.g., agriculture and/or forestry) ES provision, although the contribution towards improved ES provision is generally not quantified for each individual. The payable amount is usually constant and little differentiated. In this situation, the society pays, which is equal to the "common burden principle". The long history of subsidies in the agricultural sector, not only in developing countries, often prevents the application of a "polluter- or beneficiary-pays principle" (Baylis et al., 2008; Bergen et al., 2002; CONABIO, 2006; Millennium Ecosystem Assessment, 2005).

Sustainable Forest Management

Sustainable Forest Management (SFM) is the management of forests according to the principles of sustainable development. SFM uses very broad social, economic and environmental goals.

Temporary CER

Temporary Certified Emission Reduction or tCER is a unit issued pursuant to Article 12 of the Kyoto Protocol for an A/R CDM project activity under the CDM, which expires at the end of the commitment period following the one during which it was issued. It is equal to one metric ton of CO_2-e. Where project participants have chosen to issue tCERs in order to address non-permanence, a request to the EB is required for issuance of tCERs equal to the verified amount of net anthropogenic GHG removals by sinks achieved by the A/R CDM project since the start of the activity (UNFCCC, 2009b).

Ton-year accounting

Ton-year accounting was invented for incorporating the particular features of storage and time in forest activities. The method pretends to address the temporal dimension of carbon storage and express the climate benefits of different mitigation project types on an equitable basis. The approach accounts only for a share of the total changes in carbon stocks or GHG emissions which occurred each year over the projects' duration. The concept recognizes that delaying the release of carbon to the atmosphere deserves some credit regardless of the long-term fate of the carbon but will be greater the longer carbon remains stored in the forest.

Unavoidable reversal

An unavoidable or unintentional reversal is commonly referred to as an event where the ES seller virtually has no chance to prevent forest carbon stock loss. The main feature of the driver causing the loss is that it is unintentional from an ES seller's perspective.

Validation

Validation is the process of independent evaluation of a project activity. In the case of the CDM, this is done by a DOE against the requirements of the CDM as set out in Decision 3/CMP.1 its Annex and relevant decisions of the COP/MOP, on the basis of the project design document (CDM-PDD) (UNFCCC, 2009b).

Verification

Verification is the periodic independent review and ex post determination of the net anthropogenic GHG removals by sinks achieved, since the start of the project. Under the CDM, the certification is the written assurance by a DOE that an A/R CDM project activity achieved the net anthropogenic GHG removals by sinks since the start of the project, as verified (UNFCCC, 2009b).

A. Appendix

Extention of forest and other wooded land area in 1990, 2000 and 2005 (in 1,000)

Category	1990 (ha)	2000 (ha)	± (ha/a)	2000 (ha)	2005 (ha)	± (ha/a)
Forest	69,016	65,540	-347.6	65,540	64,238	-260.4
Other wooded land	20,705	20,174	-53.1	20,174	19,908	-53.2
Subtotal	89,721	85,714	-400.7	85,714	84,146	-313.6
Other land	101,148	105,155	400.7	105,155	106,723	313.6
…with tree cover	-	-	-	-	-	-
Total land areas	190,869	190,869	-	190,869	190,869	-
Inland water bodies	4,951	4,951	-	4,951	4,951	-
Total area	***195,820***	***195,820***	***-***	***195,820***	***195,820***	***-***

Formation	Forest			Other wooded land		
Category	**2000 (ha)**	**2005 (ha)**	**± (ha/a)**	**2000 (ha)**	**2005 (ha)**	**± (ha/a)**
Primary	34,825	32,850	-395.0	17,739	17,482	-51.4
Modified natural	29,657	30,330	134.6	2,435	2,426	-1.8
Semi-natural	-	-	-	-	-	-
Productive plantation	11	72	12.2	-	-	-
Protective plantation	1,047	986	-12.2	-	-	-
Total	***65,540***	***64,238***	***-260.4***	***20,174***	***19,908***	***-53.2***

Source: modified from FAO (2005b)

Forest and scrub area in 1993, 2002 and 2007 (in 1,000)

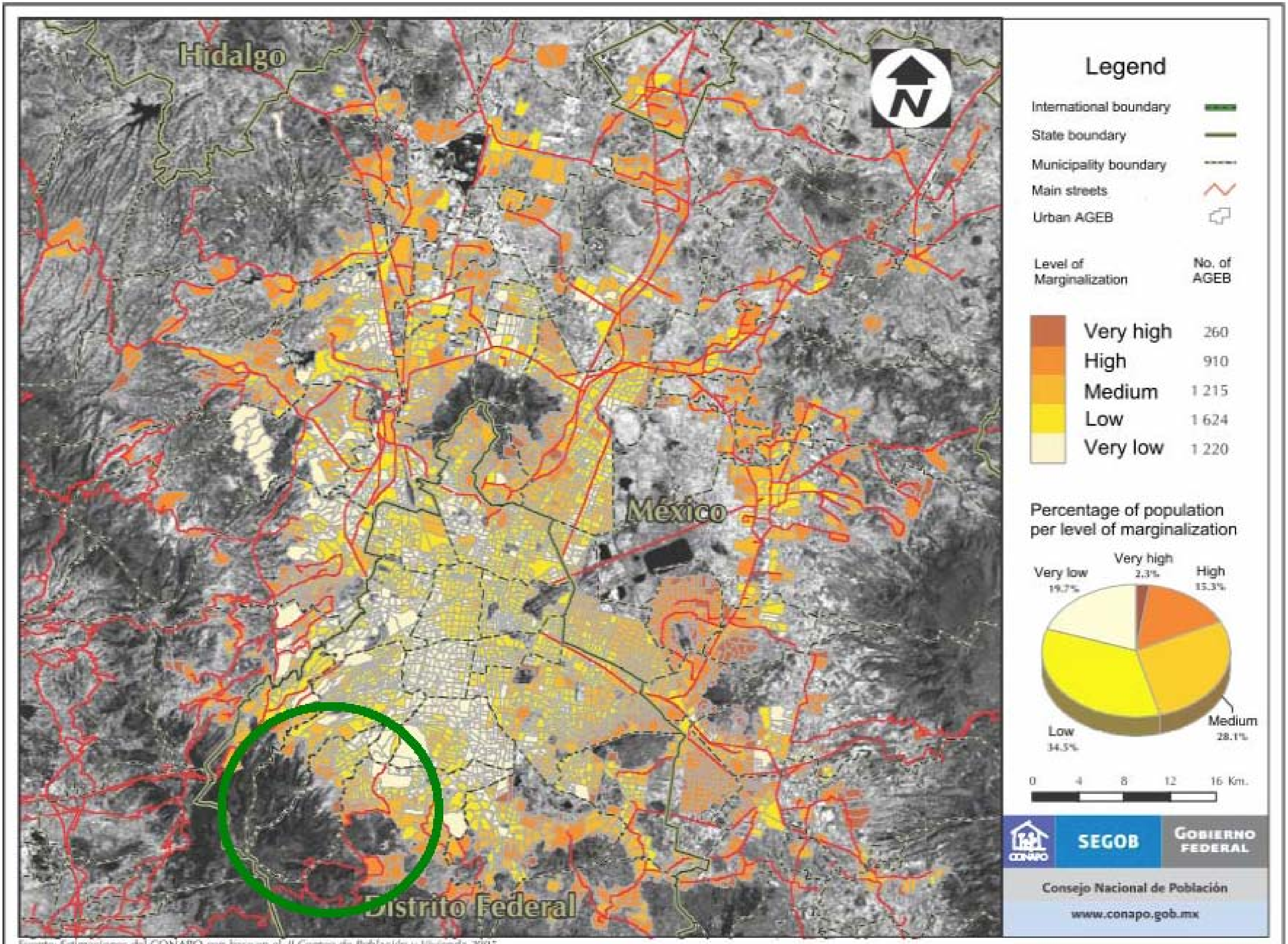
Category	1993 (ha)	2002 (ha)	± (ha/a)	2002 (ha)	2007 (ha)	± (ha/a)
Conifers	8,101	7,836	-29.5	7,836	7,840	0.9
Conif./broadleaf	13,332	13,015	-35.2	13,015	12,971	-8.9
Broadleaf	13,309	12,923	-42.9	12,923	12,917	-1.2
Hi./med. forest	15,591	14,591	-111.2	14,591	14,167	-84.8
Low forest	17,913	16,731	-131.4	16,731	16,380	-70.1
Other assoc.	982	947	-3.8	947	992	8.9
Subtotal forest	***69,229***	***66,043***	***-354.0***	***66,043***	***65,267***	***-155.1***
Semi-arid scrub	21,215	20,698	-57.4	20,698	20,529	-33.8
Arid scrub	37,190	36,792	-44.2	36,792	36,543	-49.7
Other forest	17,587	17,190	-44.2	17,190	16,730	-91.9
Subtotal scrub	***75,992***	***74,679***	***-145.9***	***74,679***	***73,802***	***-175.5***
Total	***145,221***	***140,722***	***-499.9***	***140,722***	***139,069***	***-330.7***

Formation	Primary			Secondary		
Category	**2002 (ha)**	**2007 (ha)**	**± (ha/a)**	**2002 (ha)**	**2007 (ha)**	**± (ha/a)**
Conifers	5,548	5,538	-1.9	2,288	2,303	-2.9
Conif./broadleaf	8,988	8,906	-16.2	4,027	4,064	7.4
Broadleaf	7,897	7,858	-7.8	5,026	5,059	6.6
Hi./med. forest	3,591	3,584	-1.3	10,999	10,582	-83.5
Low forest	7,745	7,632	-22.7	8,986	8,748	-47.5
Other assoc.	895	925	6.1	52	66	2.8
Subtotal forest	***34,663***	***34,444***	***-43.9***	***31,379***	***30,823***	***-111.2***
Semi-arid scrub	18,221	18,104	-23.5	2,476	2,425	-10.3
Arid scrub	34,057	33,805	-50.3	2,735	2,738	0.5
Other forest	12,863	12,585	-55.6	4,326	4,144	-36.4
Subtotal scrub	***65,142***	***64,495***	***-129.4***	***9,538***	***9,307***	***-46.1***
Total	***99,805***	***98,938***	***-173.3***	***40,917***	***40,130***	***-157.4***

Data are based on time series II, III and IV from INEGI.

Source: modified from CONAFOR (2010b)

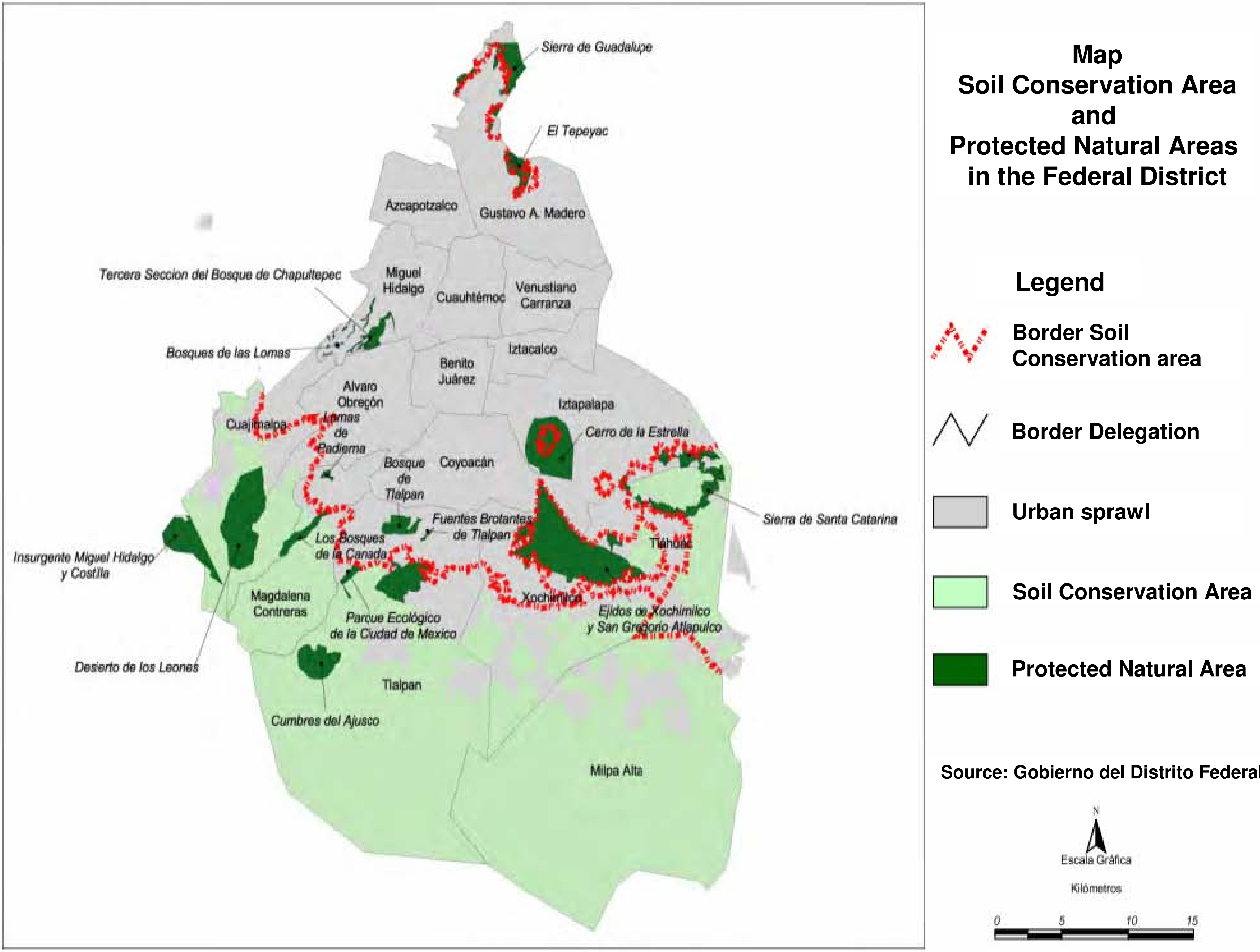
B. Appendix

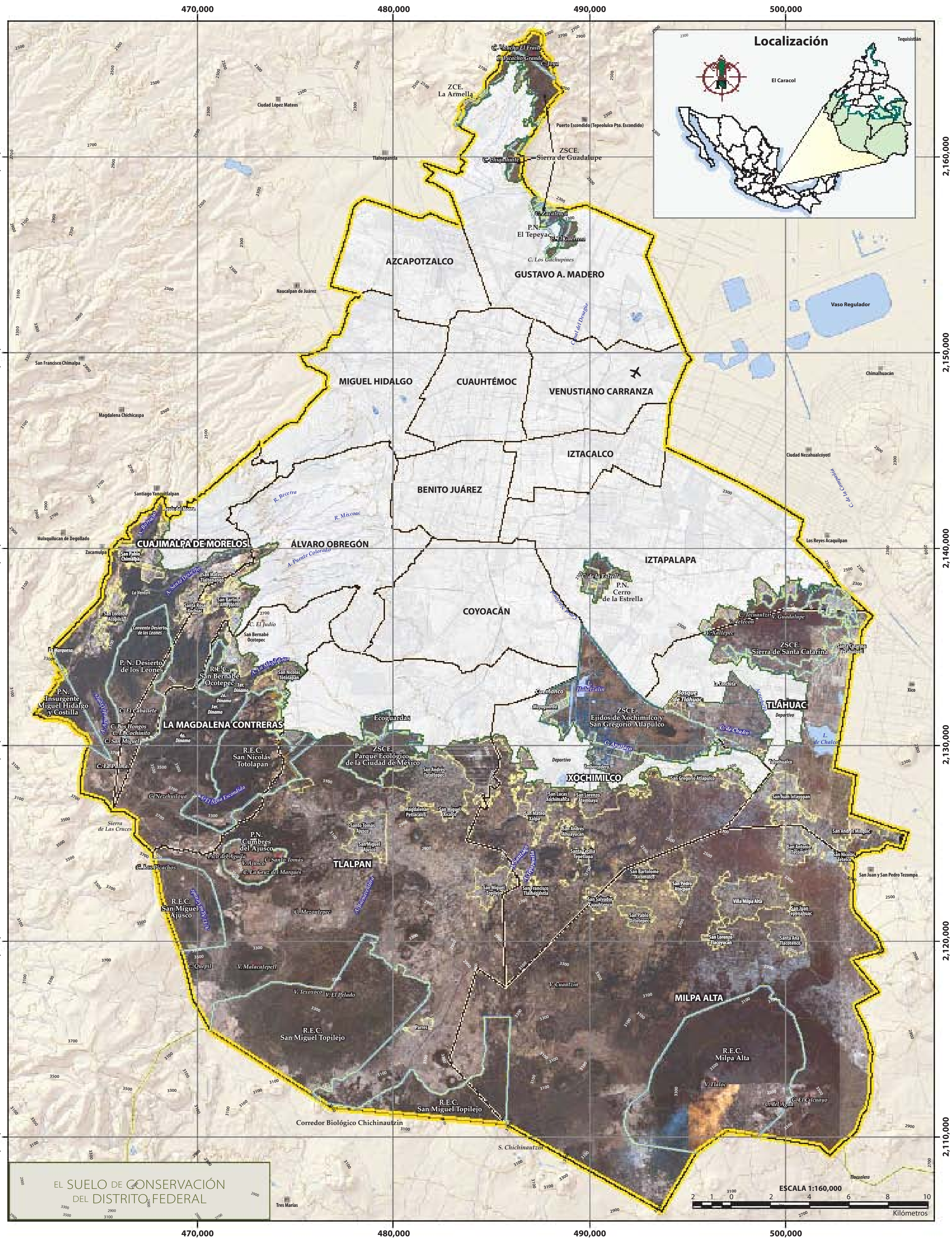


Fuente: Estimaciones del CONAPO con base en el *II Conteo de Población y Vivienda 2005.*

C. Appendix

Map
Soil Conservation Area and Protected Natural Areas in the Federal District





SIGNOS CONVENCIONALES

- Distrito Federal
- Estados
- Delegaciones
- Suelo de conservación
- Área natural protegida
- Curvas de nivel a 200 m
- Escurrimientos
- Canales
- Vialidades
- Cuerpos de agua
- Localidades con más de 5,000 hab.
- Suelo urbano
- Equipamiento
- Principales elevaciones
- Poblado rural

Mosaico de imágenes *Quickbird* 2007 - 2008
Resolución 60 centímetros

D. Appendix

Table: Scoring system for ProÁrbol 2011

Concept	Points
Social criteria	
Agrarian Nucleuses that so far have not benefited from ProÁrbol	7
Municipalities subject to the 100x100 strategy	5
Zones with a very high or high Index of Marginalization (as per SEDESOL)	3
Municipality with a majority of indigenous peoples	3
Female applicants	2
Encouraging good forest management	
Certification from the Forest Management Program or other alike	3
Certificaton of good forest management is in progress	1
Maximum score	**13**

Table: Scoring system for the concept of PSA under ProÁrbol 2011

Concept	Points
ANP (as per CONANP, INE or The Nature Conservancy (TNC))	
Core zone of the Biosfere Reserve	5
Federal ANP	4
Municipality, State or private ANP	2
Outside an ANP	1
Micro watershed (as per FIRCO) where other ES seller benefit from PSA	
Yes	5
No	1
Agrarian Nucleus with environmental surveillance committee (as per PROFEPA)	
Yes	3
No	1
Part of an area that is subject to a local PSA mechanism (as per CONAFOR)	
Yes	4
No	1
Forest land arrangement approved by the land owner (as per CONAFOR)	
Yes	4
No	1
Index of Deforestation (as per INE)	
Very high	6
High	4
Medium	2
Risk of natural desaster based on CENAPRED (as per CONAFOR)	
High	6
Medium	4
Low	2
Voluntarily georeferenced poligons in eligible zones	
Yes	4
No	1
Maximum score	**36**

Table: Scoring system for PSA 2011

Concept	A.	B.
Percentage of forest tree cover (as per CONAFOR and satellite imagery)		
>70 %	5	-
61 to 70 %	3	-
50 to 60 %	1	-
Over-exploited aquifers (as per CONAGUA)		
Over-exploitation >100 %	6	-
Over-exploitation <100 %	3	-
Average available surface water in a watershed (as per CONAGUA and INE)		
Availability <4 or between 4 to 7, both in the upper basin	7	-
Availability <4 in the medium basin or >7 in the upper basin	5	-
Availability <4 in the lower basin or between 4 to 7 in the medium basin	3	-
Availability between 4 to 7 in the lower basin or >7 in the medium basin	2	-
Availability >7 in the lower basin	1	-
Signs of antropogenic degradation (as per SEMARNAT and COLPOS)		
Low	3	-
Medium	2	-
High	1	-
Strategic zones for restoration or attention (as per CONAFOR)		
Yes	3	-
No	1	-
Different biomass densities based on data from the INFyS (as per ECOSUR)		
High	5	-
Medium	3	-
Low	1	-
AICA (as per CONABIO) or RAMSAR (as per CONANP)		
Yes	-	4
No	-	1
Hydrological (RHP) or Terrestial (RTP) Priority Area (as per CONABIO)		
Yes	-	4
No	-	1
Hosts species of NOM-059-Semarnat-2001		
Probably extinct or endangered	-	7
Threatened or special protection	-	4
Outside areas of distribution	-	1
Priority for biodiversity conservtion (as per CONABIO, CONANP, TNC and Pronatura)		
High	-	7
Medium	-	4
Low	-	1
Biological Corridor (as per CONABIO)		
Yes	-	4
No	-	1
Agroforestry system with shade trees (as per ASERCA)		
Yes	-	3
No	-	1
Maximum score	**29**	**29**

Source: modified from DOF (2011)

E. Appendix

CUESTIONARIO UNAM
Entrevista Socio-Económica
Comunidad Magdalena Atlitic & Ejido San Nicolás Totolapan

Introducción
Buenos (días) tardes. Somos estudiantes de la UNAM colaborando con la Dra. Lucía Almeida quien ha trabajado en la cuenca y con la comunidad desde hace diez años. Somos parte de proyectos de investigación académica, cuyo objetivo es la conservación de la cuenca, en colaboración con la comunidad.
Su participación es voluntaria y **estrictamente confidencial**. Los datos se procesarán para ser presentados de forma general y **anónima** en asamblea con la comunidad y en un trabajo de tesis. Por esto le solicitamos su colaboración para que la información que nos entregue, corresponda a su pensamiento y actitud, ya que el resultado de esta entrevista dará información importante sobre la situación en la Cuenca. Muchas gracias!

Nota para el entrevistador:
- *En general las preguntas hacen referencia a los últimos 12 meses (1 año). En el caso contrario eso será señalado.*
- *Se utilizarán los siguientes códigos genéricos, aunque no se especifique en cada pregunta:*
  - *El código **NA** indica que la pregunta "no aplica" a las circunstancias del entrevistado.*
  - *El código **NS** será utilizado para la alternativa "no sé" o "el encuestado no sabe".*
  - *El código **NQ** será utilizado cuando el entrevistado "no quiera" contestar.*
- *La encuesta está exclusivamente a ejidatarios (ó el cónyuge / la cónyuge) que se encuentran en el Registro Agrario.*

A. Filtro / Identificación
Nota: La mayoría en esta sección se puede llenar antes de empezar con la entrevista.

1. # de entrevista:		2. Nombre del entrevistador:	
3. Fecha:		4. Duración:	: - :
5. Nombre del entrevistado y/o # de registro (*opcional*):		6. NIP	
7. Hombre (0) / Mujer (1)	**0 / 1**	8. Edad	
9. Usted vive en: a. Dentro del polígono (bosque / bienes ejidales) b. Fuera del polígono, pero dentro de la Deleg. M-C o Tlalpan c. Fuera del polígono, en otra delegación	**1** **2** **3**	10. ¿Usted participa actualmente en un esquema de PSA?	**Sí–0** **No–1**
11. ¿Cuántas veces en **las últimas 12 meses** usted o un miembro de su hogar participó en la asamblea general?		**0 / 1 / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 / 10 / 11 / 12**	

Observaciones del encuestador:

B. Composición del hogar / Capital humano
1. ¿Cuántas personas forman parte del hogar actualmente?
Nota: Miembros son todos aquellos que viven en la casa y trabajan cerca la mayoría del año.

¿Quiénes son los miembros del hogar actualmente?

2. Número de identificación personal (NIP); *en relación con el jefe de hogar*[1)]	3. Edad o año de nacimiento (*aaaa*)	4. Sexo (*0=masc./1=fem.*)	5. Educación *Nivel*[2)]

*1)Códigos: 1=**jefe de hogar** (es la persona registrada en el registro agrario); 2=**esposa/o**; 3=**hijo/a**; 4=**yerno/nuera**; 5=**nieto/a**; 6=**madre/padre**; 7=**suegro/a**; 8=**hermano/a**; 9=**cuñado/a**; 10=**tío/a**; 11=**sobrino/a**; 12=**entenados/hijos adoptivos**; 13=**otros familiares**; 14=**no emparentados***
*2) Códigos: 0=**Ninguno**; 1=**Preescolar**; 2=**Primaria**; 3=**Secundaria**; 4=**Preparatoria o bachillerato**; 5=**Normal**; 6=**Carrera técnica o comercial**; 7=**Profesional**; 8=**Maestría**; 9=**Doctorado***

6. Derechohabiencia - ¿Tiene derecho a servicio médico? | Sí | **1** | No | **0** |
Nota: Se refiere a los miembros del hogar / de la casa.
Ejemplos: IMSS, ISSSTE, por Pemex, Defensa o Marina, Seguro popular, o otro.

C. Percepción de Servicios / Capital natural

Conteste a las siguientes preguntas:	**Sí=1/No=0**
1. ¿Usted es dueño de un predio o una parcela dentro del ejido?	
2. **Si sí** → ¿Cuántas hectáreas? _______**(ha)** ó _______**(m²)**	
3. ¿Usted trabaja o cultiva un predio o parcela dentro del ejido?	
4. **Si sí** → ¿Cuántas hectáreas? _______**(ha)** ó _______**(m²)**	
5. ¿Usted estaría a favor de vender su tierra? *Nota: Es una pregunta hipotética!*	
6. Sea **no o si** → ¿Por qué?	

C.1 Servicios de Provisión

1. ¿Usted o su familia bebe agua del río o de manantial?	Sí	**1**	No	**0**
2. **Si sí** → ¿Alguna vez se ha enfermado por tomar agua del río?	Sí	**1**	No	**0**

3. ¿Usted piensa que la presencia de casas y comercios cercanos al río:

Mejoran la ***limpieza*** del agua del río?	**1**	**Indiferente**	**2**	Empeoran la ***limpieza*** del agua del río?	**3**

4. ¿Usted piensa que la presencia de casas y comercios cercanos al río:

Mejoran la ***cantidad*** de agua del río?	**1**	**Indiferente**	**2**	Empeoran la ***cantidad*** de agua del río?	**3**

5. ¿Usted considera que los criaderos de truchas:

Mejoran la ***limpieza*** del agua del río?	**1**	**Indiferente**	**2**	Empeoran la ***limpieza*** del agua del río?	**3**

6. ¿Usted considera que la presencia de ganado dentro de los bienes ejidales:

Afectan de manera positiva?	**1**	**Indiferente**	**2**	**Afectan** de manera negativa?	**3**

7. En los últimos **7 años** ¿usted considera que el bosque dentro de los bienes ejidales?

Ha disminuido considerablemente	**1**	Ha permanecido igual	**3**	Ha aumentado considerablemente	**5**
Ha disminuido	**2**	Ha aumentado poco	**4**		

8. ¿Considera que tiene relación la presencia del bosque con la **cantidad** del agua del río?

No tiene **ninguna** relación	**1**	Se relaciona muy **poco**	**2**	Se relaciona **estrechamente**	**3**

9. ¿Considera que el bosque está relacionado con que el agua del río está más **limpia**?

No tiene **ninguna** relación	1	Se relaciona muy **poco**	2	Se relaciona **estrechamente**	3

10. ¿Cree que el agua del río se puede acabar algún día? Sí 1 No 0

11. Sea **no o sí** → ¿Por qué?

D. Capital físico

1. ¿Qué clase de vivienda / vivienda particular tiene?

Casa independiente	1	Local no construido para habitación	5
Departamento en edificio	2	Vivienda móvil	6
Vivienda o cuarto en vecindad	3	Refugio	7
Vivienda o cuarto en la azotea	4		

2. Pisos - ¿De qué material es la **mayor** parte del piso de su vivienda / casa?

Tierra	1	Cemento o firme	2	Madera, mosaico u otro material	3

Número de cuartos –

3. ¿Cuántos cuartos tiene en total su vivienda contando la cocina (no cuente pasillos ni baños)?		4. ¿Cuántos de estos cuartos se usan para dormir sin contar pasillos?	

5. Disponibilidad de agua - ¿En su vivienda / casa tiene agua de:

Nota: Respuestas múltiples son posibles.

la red pública dentro de la vivienda?	1	una pipa?	5
la red pública fuera de la vivienda, pero dentro del terreno?	2	un pozo?	6
una llave pública (o hidrante)?	3	un río, arroyo, lago u otro?	7
otra vivienda?	4		

6. ¿Su vivienda tiene excusado, retrete, sanitario, letrina u hoyo negro? Sí 1 No 0

7. **Si sí** → ¿Este servicio:	tiene conexión de agua?	1	no puede echar agua?	3
	le echan agua con cubeta?	2		

8. Drenaje - ¿Su vivienda tiene drenaje o desagüe conectado a:

la red pública?	1	una tubería que va a dar a una barranca o grieta?	3	¿No tiene drenaje?	5
una fosa séptica?	2	una tubería que va a dar a un río, lago o mar?	4		

9. ¿Tiene luz/electricidad en su vivienda / casa? Sí 1 No 0

10. ¿El combustible que más usan para cocinar es

gas?	1	leña para estufa?	2a	carbón?	3	petróleo?	4	electricidad?	5
		leña para fuego abierto?	2b						

11. ¿En esta vivienda tienen

Nota: Respuestas múltiples son posibles.

televisión?	1	internet?	5	coche?	9
refrigerador?	2	radio?	6	motosierra?	10
lavadora?	3	teléfono fijo?	7	planta de luz/generador (p.ej. de diesel)?	11
computadora?	4	celular?	8		

E. Capital social

1. ¿Usted tiene algún cargo dentro de la comunidad? Sí 1 No 0

Ejemplo: Comisariado, Miembro de algún comisariado auxiliar.

2. ¿Usted o un miembro de su hogar es miembro de algún grupo organizado? Sí 1 No 0

Ejemplo: Cooperativas (agrarias, forestal), Grupo de mujeres, Partido político.

3. ¿Para realizar trabajo en su terreno u hogar usted comparte mano de obra con ejidatarios?

Sí sin costo o con algún tipo de compensación	1	No se hace	0

Por favor indique en una escala del 1 al 5 [**1=muy en desacuerdo, 2=desacuerdo, 3=indiferente, 4=de acuerdo, 5=muy de acuerdo)** si las siguientes instituciones son de confianza:

Nota: Utiliza la hoja con la escala en el anexo.

4. La CONAGUA	1	2	3	4	5
5. La CONAFOR	1	2	3	4	5
6. La Universidad de Chapingo	1	2	3	4	5
7. La UNAM	1	2	3	4	5
8. La CORENA	1	2	3	4	5
9. La Comisaría de los Bienes Ejidales (*Nota: Se refiere a la institución*)	1	2	3	4	5
10. Una ONG verde (p.ej. ProNatura, WWF)	1	2	3	4	5

F. Capital financiero

1. ¿Quién toma las decisiónes sobre el gasto de dinero en el hogar?

M=mujer	1	H=hombre	2	A=ambos	3

F.1 Financiamiento

1. ¿Su hogar cuenta con fuentes de financiamiento diferentes al ingreso? Sí 1 No 0

*Ejemplo: Remesas, Créditos, Ahorros en el banco, Pensión, Gobierno **(no PSA)**, ONGs, Intermediarios, Regalos/apoyo de amigos y parientes.*

F.2 Pago por Servicios Ambientales

Pregunta *Nota: Aunque se conteste negativo pregunta 1.) sigue preguntando lo demás, suponiendo que el ejido en el conjunto recibe PSA y varias preguntas no requieren una participación activa.*	**Sí=1/ No=0**
1. ¿Ha recibido algún apoyo o pago para no tirar árboles, cuidar el bosque/ agua dentro del ejido?	
2. ¿Sabe el nombre del Programa que le (y/o el ejido) ha apoyado? - 3. **Si sí** → ¿Cúal es el nombre?	
4. ¿Sabe si el apoyo viene del Gobierno o de otro tipo de organización? - 5. **Si sí** → Nombre de la dependencia u organización que opera el programa:	
6. ¿Sabe porqué le interesa al programa apoyar a usted para cuidar el bosque y el agua aquí? - 7. **Si sí** →¿Por qué?:	
8. ¿Por parte del programa le han dado alguna plática o capacitación para explicarle porqué es importante cuidar el bosque y el agua? - 9. **Si sí** → ¿Qué le dijeron?	
10. ¿El programa es lo que usted esperaba o le dijeron que sería? - 11. **Si no** → ¿Por qué?	
12. ¿Sabe por cuánto tiempo recibirá apoyo del Programa? - 13. **Si sí** → Número de años:	
14. ¿Sabe que características debe tener el terreno que recibe el PSA? - 15. **Si sí** → Características del terreno para entrar al programa:	
16. ¿Se hacen cosas diferentes a partir de que recibe la comunidad el apoyo? - 17. **Si sí** → Especifique:	
18. ¿Sabe que actividades se deben realizar en el bosque para recibir el PSA? - 19. **Si sí** → ¿Qué puede hacer en su terreno? - 20. **Si sí** → ¿Qué no puede hacer en el terreno?	
21. ¿Se cumplen las reglas? - 22. **Si no** → ¿Qué no cumplen?	

23. ¿En qué consiste el apoyo que le da el Programa?
24. Dinero
- 25. **Si sí** → ¿Cuánto es? Indica si es por hectárea ó familia ó total.
26. Otros apoyos
- 27. **Si sí** → ¿En qué consiste?

28. ¿Usted considera que el apoyo que recibe es suficiente?
29. Sea **si o no** → Explique:

30. ¿En qué ha usado el dinero dado por el Programa?
- A. Gastos personales, para la casa y/o para la familia
- B. Acitividades lucrativas y/o autoconsumo

31. ¿Sí usted pudiera, a que dedicaría su terreno?
- A. Conservar estricto sin trabajar la tierra
- B. Conservar pero permitir un uso planificado
- C. Acceso libre; cada quién según su preferencia

32. ¿Usted, modificaría algo del programa?
33. **Si sí** → ¿Diga qué?

34. ¿Prefiere por parte del programa un pago en efectivo? / pago en especie?
35. **Si sí en especie** → ¿De qué tipo?

36. ¿Volvería a renovar su participación en el programa?
37. Sea **si o no** → ¿Por qué?

G. Estrategias

1. ¿Cuál es su situación laboral actual?

Empleo de tiempo completo / medio tiempo / independiente	1	Empleo eventual / hogar / no trabaja	0

2. ¿Usted recibe su principal ingreso de actividades dentro o fuera del polígono ejidal?

Dentro	1	Fuera	0

G.1 Servicios Directos

Benificios del polígono / bosque / terreno del Ejido:

a) ¿Cuáles son los beneficios que se puedan (***hipotético***) obtener del o aprovechar en el bosque / polígono? (**Si=1/No=0**)

b) ¿Qué actividad realizan en su hogar para subsistencia (***autoconsumo***) o fuentes de ingreso en su hogar (***actividades lucrativas***)? (**Si=1/No=0**)

Actividad	**a)**	**b)**
1. **Actividad/producto forestal** *Ejemplo: madera y leña*		
2. **PFNM (NTFP)** *Ejemplo: hongos comestibles, plantas medicinales, animales silvestres*		
3. **Crianza de animales** *Ejemplo: truchas, vacas, puercos, ovejas, caballos*		
4. **Agricultura** *Ejemplo: verduras/legumbres, granos (maíz, trigo), frutas, flores*		

H. Resultados medios de vida

H.1 Bienestar – Usted se siente o considera en una escala del 1 al 5 [**1=muy en desacuerdo, 2=desacuerdo, 3=indiferente, 4=de acuerdo, 5=muy de acuerdo**] que...

Nota: Utiliza la hoja con la escala en el anexo.

1. es orgulloso de ser miembro de su ejido.	1	2	3	4	5
2. participa activamente en la toma de decisión de su ejido.	1	2	3	4	5
3. su herencia cultural está siendo respetada y aceptada por la sociedad y el estado.	1	2	3	4	5
4. vivir en el ejido es seguro.	1	2	3	4	5
5. los miembros de su casa se enferman frecuentemente.	1	2	3	4	5
6. la basura dentro de la cuenca le afecta.	1	2	3	4	5

H.2 Contexto de vulnerabilidad

1. ¿En el lugar donde usted vive se presenta algún riesgo de desastres naturales (tipo choque)? Sí 1 No 0

Ejemplos: Incendios forestales, Incendios por falla eléctrica, Deslaves/erosión (pérdida de suelo), Inundaiones.

2. **Si sí**, cúales?

3. ¿Hay tendencias de conflicto sobre el terreno en el Ejido **internamente**? Sí 1 No 0

Ejemplo: Entre ejidatarios.

4. ¿Hay tendencias de conflicto sobre el terreno en el Ejido **externamente**? Sí 1 No 0

Ejemplo: Comunidades/ejidos, Administración del DF, Asientamientos irregulares.

5. Percibe que la pauta de lluvias ha cambiado en los últimos 10 años? Sí 1 No 0

6. **Si sí**, en que sentido (ejemplo: irregularidad, cantidad)?

7. Percibe que la temparatura/ el tiempo ha cambiado en los últimos 10 años? Sí 1 No 0

8. **Si sí**, en que sentido (ejemplo: seco/humedo, frío/calor)?

9. El clima/tiempo afecta a sus actividades lucrativas? Sí 1 No 0

10. **Si sí**, en que sentido: positivo=1 / negativo=0?

11. El clima/tiempo afecta a sus actividades de subsistencia (autoconsumo)? Sí 1 No 0

12. **Si sí**, en que sentido: positivo=1 / negativo=0?

13. Para su familia ¿cúales son los problemas principales de la vida cotidiana?

Nota: Respuestas múltiples son posibles.

Catástrofe natural	1	Pestes y plagas	5	Salud	9
Conflictos de terreno	2	Seguridad (delincuencia)	6	Corrupción	10
Incertidumbre sobre precios	3	Oportunidades económicas	7	Intervención del estado	11
Cambio de clima	4	Discriminación	8	Otros (nombrar):	12

H.3 Situación económica

Favor de calificar las siguiente declaraciones en una escala del 1 al 5, [**siendo 1=muy en desacuerdo, 2=desacuerdo, 3=indiferente, 4=de acuerdo, 5=muy de acuerdo**].

Nota: Utiliza la hoja con la escala en el anexo.

1. Antes de llevar un producto propio al mercado **se sabe** qué precio va a obtener.	1	2	3	4	5
2. Antes de llevar un producto propio al mercado **se sabe** que lo puede vender.	1	2	3	4	5
3. Las fuentes de ingreso (***lucrativas***) y actividades de subsistencia (***autoconsumo***) son suficientes para mantener el hogar.	1	2	3	4	5

4. ¿Dentro de un año, hay meses en los que varían los ingresos familiares? Sí 1 No 0

5. **Si sí**, ¿Cúando y por qué?

6. ¿Cúal es el ingreso mensual promedio (dinero disponible) en su hogar?

Nota: Utiliza la hoja con los rangos en el anexo.

Menos de $1,700	1	$5,101 - $6,800	4	$10,201 - $11,900	7
$1,701 - $3,400	2	$6,801 - $8,500	5	Mas de $11,901	8
$3,401 - $5,100	3	$8,501- $10,200	6		

F. Appendix

Indicator Variables for Index Construction

Indicator variables for Human Capital

Human capital (section B and H of the questionnaire)

Section	Variable	Explanation
(B)	HHEADAGE	Age of household head
(B)	HHEADSEX	Sex of household head
(B)	HHEADEDU	Education of household head
(B)	MARSTAT	Marital status of household head
(B)	SPOUAGE	Age of spouse
(B)	SPOUSEX	Sex of spouse
(B)	SPOUEDU	Education of spouse
(B)	FAMSIZE	Family size
(B)	NUMCHILD	Number of children (< 18 years)
(B)	NUMADULT	Number of adults (>17 years)
(B)	NUMWF	Number of work force (18-60 years)
(B)	NUMOLDER	Number of older (> 60 years)
(B)	ADULTAGE	Average age of adults
(B)	ADULTEDU	Percentage of adults with some sort of schooling
(B)	ADULTPRI	Percentage of adults with primary schooling
(B)	ADULTSEC	Percentage of adults with secondary schooling
(B)	ADULHIG	Percentage of adults with higher schooling
(B)	CHILDEDU	Percentage of children (6-14 years) with no schooling
(B)	SECONEDU	Percentage of members (> 14 years) with no schooling
(B)	CHILDWF	Dependency ratio of children to work force
(B)	OLDERWF	Dependency ratio of older to work force
(B)	CHIOLDWF	Dependency ratio of children and older to work force
(B)	HCARE	Access to health care insurance
(H)	HEALTH1	Bad health status of household members at 5 levels
(H)	HEALTH2	Bad health status of household members at 2 levels
(H)	HEALTH3	Daily living affected by health concerns

Indicator variables for Natural Capital

Natural capital (section C, F, G and H of the questionnaire)

Section	Variable	Explanation
(C)	PARCEL	Individual land property in RAN
(C)	PARCSIZE	Size (ha) of individual land property in RAN
(C)	PARSIZPE	Size of landholdings per person
(C)	PARSIZAD	Size of landholdings per adult
(C)	PARVALUE	Value of landholdings with MXN 80 per m2
(C)	PARVALPE	Value of landholdings per person
(C)	PARVALAD	Value of landholdings per adult
(C)	WORKCULT	Work or cultivate a land parcel
(C)	WORKSIZE	Size (ha) worked or cultivated
(C)	WLSIZPE	Size of worked land per person
(C)	WLSIZAD	Size of worked land per adult
(C)	WLVALUE	Value of worked land
(C)	WLVALPE	Value of worked land per person
(C)	WLVALAD	Value of worked land per adult
(C)	WTS	Willing to sell the land
(C)	WATERDRI	Household member drink water from the river
(C)	WATERSIC	Household member got sick from river water
(C)	WATERQL1	Impact of houses and restaurants on the quality of water at 3 levels
(C)	WATERQL2	Impact of houses and restaurants on the quality of water at 2 levels
(C)	WATERQN1	Impact of houses and restaurants on the quantity of water at 3 levels
(C)	WATERQN2	Impact of houses and restaurants on the quantity of water at 2 levels
(C)	WATERQL3	Impact of trout breeding on the quality of water at 3 levels
(C)	WATERQL4	Impact of trout breeding on the quality of water at 2 levels
(C)	WATERQL5	Impact of cattle on the quality of water at 3 levels
(C)	WATERQL6	Impact of cattle on the quality of water at 2 levels
(C)	FORCOV1	Development of forest cover in the last 7 years at 5 levels
(C)	FORCOV2	Development of forest cover in the last 7 years at 2 levels
(C)	FORWAQN1	Relation between forest and water quantity at 3 levels
(C)	FORWAQN2	Relation between forest and water quantity at 2 levels
(C)	FORWAQL1	Relation between forest and water quality at 3 levels
(C)	FORWAQL2	Relation between forest and water quality at 2 levels
(C)	RUNDRY	River at risk to run dry
(F)	LANDCO	Favors strict conservation of communal land
(F)	LANDMGMT	Favors conservation of communal land but with management plan
(F)	LANDOA	Favors open access to communal land
(G)	POFOREST	Potential forest benefits from communal land
(G)	PONTFP	Potential NTFP benefits from communal land
(G)	POLIVEST	Potential livestock benefits form communal land
(G)	POAGRI	Potential agriculture benefits from communal land
(G)	ECFOREST	Income or subsistence benefits from forestry activities on communal land
(G)	ECNTFP	Income or subsistence benefits from NTFP activities on communal land
(G)	ECLIVEST	Income or subsistence benefits from livestock activities on communal land
(G)	ECAGRI	Income or subsistence benefits from agricultural activities on communal land
(H)	RAINFALL	Rainfall patterns changed in the last 10 years
(H)	TEMPER	Temperature patterns changed in the last 10 years
(H)	CLIMAINC	Climate affect income generation
(H)	CLIMASUB	Climate affect subsistence
(H)	NATDISAS	Daily living affected by natural disasters
(H)	CLIMACHA	Daily living affected by climate change
(H)	PESTDISE	Daily living affected by pests and diseases

Indicator variables for Physical Capital

Physical capital (section A, D and H of the questionnaire)		
Section	Variable	Explanation
(A)	LOC1	Residence relative to the polygon at 3 levels
(A)	LOC2	Residence relative to the polygon at 2 levels
(D)	TYPHOUSE	Type of housing
(D)	FLOOR1	Main flooring material at 3 levels
(D)	FLOOR2	Main flooring material at 2 levels (soil)
(D)	ROOMS	Number of rooms per household
(D)	SLEEP	Number of rooms for sleeping
(D)	ROSLEEP	Ratio sleeping room per total rooms
(D)	MEMROOMS	Ratio persons per room
(D)	OVERCROW	Overcrowding in the household >2 per room
(D)	WATERAV1	Quality of drinking water in the house at 7 levels
(D)	WATERAV2	Quality of drinking water in the house at 2 levels (public tap inside)
(D)	SANITARY	Sanitary availability in the house
(D)	SAWATER1	Quality of sanitary water connection in the house at 3 levels
(D)	SAWATER2	Quality of sanitary water connection in the house at 2 levels (flush)
(D)	DRAIN1	Quality of drainage connection at 5 levels
(D)	DRAIN2	Quality of drainage connection at 2 levels (public or septic tank)
(D)	ELECTRIC	Electricity connection in the house
(D)	COOK1	Quality of cooking material at 5 levels
(D)	COOK2	Quality of cooking material at 2 levels (gas)
(D)	ACCTELE	Access to telecommunication (internet, phone, cell-phone)
(D)	ACCNEWS	Access to news (TV, internet, radio)
(D)	ACCTRANS	Access to own transportation (car)
(D)	ACCREFRI	Access to refrigerator
(D)	ACCWASH	Access to washing machine
(D)	ACCHAIN	Access to chainsaw
(D)	ACCGEN	Access to generator
(D)	VALASSET	Value of appliances, electronics and transportation
(D)	VALASPER	Value of assets per person
(D)	VALASADU	Value of assets per adult
(H)	SECURE1	Security in the community at 5 levels
(H)	SECURE2	Security in the community at 2 levels
(H)	DUMP1	Affected by trash in the community at 5 levels
(H)	DUMP2	Affected by trash in the community at 2 levels
(H)	DISASTER	Risk of disasters near the residents
(H)	SECURE3	Daily living affected by security concerns

Indicator variables for Financial Capital

Financial capital (section F, G and H of the questionnaire)		
Section	Variable	Explanation
(F)	FINDEC1	Financial decision influenced by female at 3 levels
(F)	FINDEC2	Financial decision influenced by female at 2 levels
(F)	FINSRC	Financial sources different from income and PES
(F)	PESPART2	Participant of PES that receives compensation for conservation
(F)	PRONAME	Knowing the correct name of PES program
(F)	GOBNAME	Knowing the correct name of PES administrator
(F)	PESOBJ	Knowing the PES's objective
(F)	PESCAP	Received capacity-building from PES
(F)	PESEXP	PES meets expectations
(F)	PESTIME	Knowing the correct duration of PES
(F)	PESLAND	Knowing the land characteristics for land enrollment in PES
(F)	PESMGMT	Community changed management due to PES
(F)	PESACT	Knowing the activities encouraged by PES
(F)	PESRULES	Community complies with PES rules
(F)	PESCASH1	Knowing if PES provides benefits in cash
(F)	PESCASH2	Knowing the correct amount of PES payment
(F)	PESINK	Knowing if PES provides benefits in-kind
(F)	PESSUF	PES compensation is sufficient
(F)	PESFAM	PES benefits used for family expenses
(F)	PESECON	PES benefits used for income and subsistence activities
(F)	PESMOD	Modification of PES
(F)	PESPREF1	Preference of PES benefits paid in cash
(F)	PESPREF2	Preference of PES benefits paid in-kind
(F)	PESRENEW	Renovation of PES participation
(G)	LABSTAT	Employment status (regular work) of the household head
(G)	WORKLOC	Household head works inside the community
(H)	PRICEUNC	Daily living affected by price uncertainties
(H)	ECONOPT	Daily living affected by economic opportunities
(H)	PRPRICE1	Knowing the product price before sale at 5 levels
(H)	PRPRICE2	Knowing the product price before sale at 2 levels
(H)	PRSELL1	Knowing that the product will be sold before sale at 5 levels
(H)	PRSELL2	Knowing that the product will be sold before sale at 2 levels
(H)	ECOSUB1	Income and subsistence suffice at 5 levels
(H)	ECOSUB2	Income and subsistence suffice at 2 levels
(H)	INCOVARI	Income variation of the household
(H)	INCOMON	Monthly income range
(H)	INCOMOHH	Income in MXN per household
(H)	INCOMOPE	Income in MXN per person
(H)	INCOMOAD	Income in MXN per adult

Indicator variables for Social Capital

Social capital (section A, E and H of the questionnaire)		
Section	Variable	Explanation
(A)	EJICOM	Community type: agrarian community or ejido
(A)	ASSEMBLY	Number of attendance in the general assembly per year
(E)	COMREP	Household member form part of the community representation
(E)	GRMEMBER	Household member are organized in a group
(E)	COMCOOP	Household member cooperate with other community member
(E)	CONAGUA1	Trust in CONAGUA at 5 levels
(E)	CONAGUA2	Trust in CONAGUA at 2 levels
(E)	CONAFOR1	Trust in CONAFOR at 5 levels
(E)	CONAFOR2	Trust in CONAFOR at 2 levels
(E)	UCHAP1	Trust in University of Chapingo at 5 levels
(E)	UCHAP2	Trust in University of Chapingo at 2 levels
(E)	UNAM1	Trust in Autonomous National University of Mexico at 5 levels
(E)	UNAM2	Trust in Autonomous National University of Mexico at 2 levels
(E)	CORENA1	Trust in CORENA at 5 levels
(E)	CORENA2	Trust in CORENA at 2 levels
(E)	COMISAR1	Trust in Community Representation at 5 levels
(E)	COMISAR2	Trust in Community Representation at 2 levels
(E)	NGO1	Trust in NGOs at 5 levels
(E)	NGO2	Trust in NGOs at 2 levels
(H)	PROUD1	Proud of community membership at 5 levels
(H)	PROUD2	Proud of community membership at 2 levels
(H)	COMPART1	Active participation in community decisions at 5 levels
(H)	COMPART2	Active participation in community decisions at 2 levels
(H)	HERIT1	Respect of own cultural heritage at 5 levels
(H)	HERIT2	Respect of own cultural heritage at 2 levels
(H)	CONFLIC1	Internal land conflict in the community
(H)	CONFLIC2	External land conflict in the community
(H)	CONFLIC3	Daily living affected by land dispute
(H)	DISCRIMI	Daily living affected by discrimination
(H)	CORRUPT	Daily living affected by corruption
(H)	STATEINT	Daily living affected by state intervention

Indicator variables for Urban Marginalization

Marginalization (section B and D of the questionnaire)*		
Section	Variable	Explanation
(B)	CHILDEDU	Percentage of population 6 to 14 years with no schooling
(B)	SECONEDU	Percentage of population > 14 years without completed secondary schooling
(B)	HCARE	Percentage of population without healthcare insurance
**	DCHILD	Percentage of deceased children of women aged 15 to 49 years
(D)	WATERAV2	Percentage of private homes without running water inside the dwelling
(D)	DRAIN2	Percentage of private homes without drainage connected to the public network or septic tank
(D)	SAWATER2	Percentage of private homes without toilet flush
(D)	FLOOR2	Percentage of dwellings with dirt floors
(D)	OVERCROW	Percentage of private homes with some level of overcrowding
(D)	ACCREFRI	Percentage of private homes without a refrigerator

* The variables where calculated as a ratio per community.

** Questions about death at birth have not been asked for sensitive reasons and the limited scope of the research. Instead average values from CONAPO were used.

G. Appendix

Dear Delphi expert panel member!

You are invited to participate in a Delphi session conducted by Ph.D. student Christoph Neitzel and supervised by Dr. Alonso Aguilar Ibarra from the Institute of Economic Research at the UNAM. The purpose of this Delphi is to obtain expert judgment on a controversially discussed policy issue in the ambit of global climate change policy: permanence. The output of this survey is embedded in a broader research project linked to the faculty's PhD program on Natural Resources and Sustainable Development. The research topic is "Payments for environmental services - reducing emissions from deforestation and degradation (PES-REDD) in Mexico: a strategy to guarantee the permanence of forest carbon stocks?"

Your benefit of participating in this survey is immediate access to survey results and ex post provision of elaborated material. Note that panel members provide anonymous their answers so that a specific statement cannot be linked to a person. It is envisioned that the surveys' outcome, reflecting different stakeholders' perspectives, represents useful information for your own working area. More specific you are asked to provide your opinion about the consideration of permanence in REDD contract design at a local level. The hypothetical point of departure and respective questions that will be answered online are listed in Annex I for ex ante review. Additional background information (glossary of terms) for consideration, while answering the online catalogue of questions, is provided in Annex II.

The Delphi session (the generic process is illustrated in Annex III) is intended to last three rounds, where the answering of each round shall take you about 20 minutes. In each round the panel of experts is confronted successively with the same/similar questions in order to obtain consensus and/or stability in their answer choices. This goal shall be reached by providing feedback of the answers obtained from the previous round to the panel. Note that the feedback provided to the rest of the panel is not uncovering who provided a specific answer or comment. But the newly provided information may or may not lead to a correction of the individual answers in subsequent rounds.

In order to participate in the policy Delphi a link has been sent to you with this email. The link serves as a direct login to access the session and associated rounds of questions. **Please keep this email to guarantee your access now and in the future**. By clicking on the link or copy & paste it into the address bar of your browser you may access the session. In the session window you are able to view/answer current and past rounds. When entering into a current round you will be asked to provide input by answering questions. Note that you don't have to answer a round of questions immediately with your first login, instead your partial answers of the question catalogue will be saved and made available if you re-enter the round. Hence, you may take your time and answer the questions during multiple logins.

The preliminary schedule of the survey is as follows:

Time	January		February				March	
Action	W3	W4	W1	W2	W3	W4	W1	W2
Session start		26.01						
Round 1		26.01		09.02				
Round 2				10.02		22.02		
Round 3						23.02		14.03
Session end								15.03

Your time and input are greatly appreciated. If you have any questions please feel free to contact Christoph Neitzel at ck.neitzel@gmail.com.

Annex

- **Annex I: Scenario and question catalogue**
- **Annex II: Glossary**
- **Annex III: Delphi scheme**

Annex I: Scenario and question catalogue

Please, consider the following **hypothetical scenario** when answering the questions:

The Parties to the UNFCCC have accepted REDD+ as a mitigation strategy under the Kyoto Protocol. Parties agreed that long-term finance for REDD+ to support result-based outcomes is going to be achieved through non- and market-based approaches. However, it remains national sovereignty to suggest approaches how to incentivize local communities to implement REDD activities. In this context Mexico is looking at PES-like "environmental contracts" to compensate individually communities (in Mexico 70-80% of forest is owned by communities) that provide positive external effects to the climate with their forest management. Though, decision-makers are not sure how to consider some key attributes (e.g. time scale, accounting, liabilities and payment structures) to guarantee the permanence of forest carbon stocks. Therefore a panel of experts is consulted in an interactive Delphi process to answer a set of 13 questions and find out where experts can reach consensus (or stability) in their answer choices.

#	Topic/Question	Answer choices
	Definition	
1	What aspects should RED(D)(+)(+) cover explicitly? Please, order alternatives from 1 (high preference) to 9 (low preference).	1 - Deforestation 2 - Degradation 3 - Afforestation 4 - Reforestation 5 - Enhancement 6 - Sustainable management 7 - Conservation 8 - Social safeguards 9 - Environmental safeguards
	Adverse selection	
2	What right or access should the seller (provider) have over the Environmental Service (ES) REDD to be considered additional? Please, order alternatives from 1 (high preference) to 6 (low preference).	1 - The seller needs some property right over the land likely to provide the ES of forest carbon stocks. 2 - The seller has to change and/or improve his land-use behavior to provide verifiable carbon sequestration and/or emission avoidance greater than the agreed baseline. 3 - The seller has to be the one that can effectively control the land-use patterns within the agreed boundaries. 4 - The seller needs to have the right to sell the ES of stored carbon, which implies that the national legislation acknowledges that the ES is provided through forest and regulates the ownership of that service. 5 - The seller does not receive any other financial support for the provision of the ES. 6 - The land likely to provide the ES of forest carbon stocks is not protected otherwise (e.g. National Park).
	Time frames and accounting of permanence	
3	What is an adequate time frame in a REDD regime to consider carbon storage in and/or emission avoidance from the biosphere as permanent?	Unit: Years
4	Which carbon accounting methods should be used to calculate carbon benefits and/or losses? Please, order alternatives from 1 (high preference) to 4 (low preference).	1 - Stock-change method 2 - Long-term average 3 - Ton-year accounting 4 - Linear accounting
	Moral Hazard	
5	Should there be a distinction between unavoidable/unintentional and avoidable/intentional reversals?	1 (absolutely disagree) to 5 (absolutely agree)
6	Who should have the liability for avoidable reversals? Please, order alternatives from 1 (high preference) to 5 (low preference).	1 - Seller (i.e. Ejido, Agrarian Community, Small Property) 2 - Buyer (i.e. Private Sector) 3 - Administrator (i.e. Government) 4 - Third party (i.e. Insurer) 5 - Collective (i.e. Aggregator)
7	Who should have the liability for unavoidable reversals? Please, order alternatives from 1 (high preference) to 5 (low preference).	1 - Seller (i.e. Ejido, Agrarian Community, Small Property) 2 - Buyer (i.e. Private Sector) 3 - Administrator (i.e. Government) 4 - Third party (i.e. Insurer) 5 - Collective (i.e. Aggregator)

#	Topic/Question	Answer choices
8	What is the liability if an **avoidable** reversal occurs? Please, order alternatives from 1 (high preference) to 5 (low preference).	1 - Retirement of an equivalent quantity of carbon credits from, for example, a buffer pool 2 - Specific performance (i.e. replanting) 3 - Monetary penalty 4 - Exclusion from future payments 5 - Exclusion from future payments and repayment of benefits
9	What is the liability if an **unavoidable** reversal occurs? Please, order alternatives from 1 (high preference) to 5 (low preference).	1 - Retirement of an equivalent quantity of carbon credits from, for example, a buffer pool 2 - Specific performance (i.e. replanting) 3 - Monetary penalty 4 - Exclusion from future payments 5 - Exclusion from future payments and repayment of benefits
	Payment structure	
10	What is an adequate price for one tonne of CO_2?	Unit: USD/tCO_2
11	How should the price level be determined? Please, order alternatives from 1 (high preference) to 4 (low preference).	1 - Opportunity cost oriented 2 - Market oriented 3 - Auction oriented 4 - Otherwise fixed by public policy
12	How should be the payment schedule? Please, order alternatives from 1 (high preference) to 5 (low preference).	1 - Upfront, with contract celebration 2 - Front-loaded 3 - Annuity 4 - Tail-loaded 5 - Ex post, with end of contract period
	Administration	
13	Who should administer the REDD in the territory? Please, order alternatives from 1 (high preference) to 4 (low preference). Optional: Provide the name of your preferred institution/organization in COMMENTS.	1 - Government 2 - Private Sector 3 - Civil Society (NGO) 4 - Intergovernmental Organizations (IGO)

Annex II: Glossary

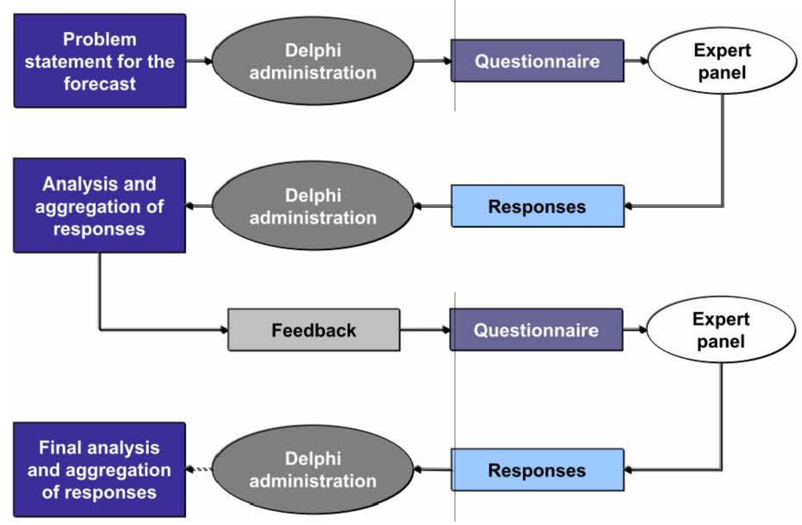
Note: Terms are presented in a non-exhaustive way and without the source to limit the influence on the opinion formation.

Term	Explanation
Additionality	Carbon benefits created through a specific project activity have to be higher than in the business-as-usual scenario.
Adverse selection	Adverse selection is a term used in economics, insurance, statistics, and risk management. The expression refers to a market process in which "bad" results occur when buyers and sellers have asymmetric information, which leads to an outcome where "bad" products or customers are more likely to be selected. Hidden information is generally referred to as adverse selection and occurs when a contract is negotiated. In the ambit of PES the ES seller may have better information on opportunity costs than the ES buyer or PES administrator. Thus private information is used as a market power to extract information rents from the ES buyer. In general one assumes that the ES seller can realize informational rents from any given PES scheme, since he probably knows more about the costs of contract compliance than the ES buyer. This private information increases the bargaining power of the ES seller, if the ES buyer is not able to have equal access to it and thus maximizing ES provision from a given budget.
Afforestation	Afforestation is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.
Aggregator	An aggregator has the ability to group individuals, communicate between demand and supply side, and channel and distribute benefits. Aggregators could be different in nature, varying from jurisdictional infrastructure (e.g., community, local government, NGOs and private sector) to an indigenous group as a whole or a delimitated territory with smallholders occupying it.
Agrarian Community	The Agrarian Community is a common property regime of land and labeled as private communal property. This property is created where interest groups, mainly indigenous communities, can prove with documentation and testimonies that they lived and managed the land area already in colonial times. The common land is marked with an Agrarian Certificate where the property is recognized and inscribed at the National Agrarian Register.
Avoidable reversal	An avoidable or intentional reversal is generally referred to as an event where the ES seller is in the position to prevent forest carbon loss (deforestation and degradation). Thus the main feature of the driver causing the loss is intentional from an ES seller's perspective.
Baseline	Baselines are used to distinguish the business-as-usual scenario in the absence of the project activity from factors that are induced through a carbon project activity or pertain to natural variability and indirect effects of human activity. Baselines thus help to quantify the additional carbon benefit of the proposed and executed activity to avoid greenhouse gas emissions and improve forest carbon stocks.

Term	Explanation
Carbon accounting	Since REDD has a storage and time component with related non-permanence issues, it is of interest to have knowledge about the behavior of emitted greenhouse gases in the atmosphere, its absorption from the atmosphere and integration into the biosphere. The information about temporal issues in the forestry sector is fundamental to determine the amount of carbon benefits from the different mitigation options. The challenge of carbon accounting is to design a system that allows transparent, consistent, complete, accurate, measurable, verifiable, and efficient recording and reporting of changes in carbons stocks and/or changes by sources and removals by sinks from applicable forest activities under the relevant carbon regime.
Conservation	Conservation refers to the forest carbon stock that is already or additionally stored in intact forest. As part of a REDD+ approach the rationale is that forest stewards with demonstrated good management practice in the past and probably in the future should benefit from any international financial funding, although an immediate threat of carbon loss is not detected.
Deforestation	Deforestation is the direct human-induced conversion of forested land to non-forested land and/or the conversion of forest to another land use or the long-term reduction of the tree canopy below a minimum threshold. In Mexico forest is defined as a minimum area of land of one hectare with a tree crown cover (or equivalent stocking level) of more than 30 percent with trees that have the potential to reach a minimum height of four meters at maturity *in situ*.
Degradation	The FAO defines degradation as the reduction of the canopy cover or stocking within a forest, provided that the canopy cover stays above 10 percent.
Ejido	The *Ejido* is a common property regime of land and labeled as private *ejidal* property. This property is created where interest groups, often former *Hacienda* workers, request the Mexican President's permission to cultivate a certain delineated land area. The common land is marked with an Agrarian Certificate where the property is recognized and inscribed at the National Agrarian Register. However, in contrast to Agrarian Communities, *Ejidos* are allowed to sell their land since the Agrarian Reform from 1992.
Enhancement	Enhancement of forest carbon stocks is referred to a change in forest management practice intended to increase the wood biomass and thus carbon stock level per area unit in an existing forest that is already managed or going to be managed.
Environmental safeguards	Environmental safeguards assure that any carbon incentive scheme recognizes the importance of environmental integrity beyond climate issues and protects against any perverse incentives, such as forcing forest owners to threat their natural capital in order to be eligible for participation in a REDD regime. Other issues would be prioritizing of forest owners that provide additional environmental benefits, such as biodiversity protection.
Environmental Services (ES)	Environmental/ecosystem services in the realm of PES are generally referred to public goods that are provided by the forest ecosystem. Public goods are characterized by non-excludability and non-rivalry. The ES carbon sequestration or emission avoidance from forest carbon stocks is, in theory, such a public good. Other ES used in PES design are water, biodiversity and scenic beauty.
Expert	Experts are all individuals that can contribute valid objective and/or subjective information to the provision process.
Global Climate Change	Climate change refers to any long-term significant change in the expected patterns of average weather of a specific region (or, more relevantly to contemporary socio-political concerns, of the Earth as a whole) over an appropriately significant period of time. In recent usage, especially in the context of environmental policy, climate change usually refers to global climate changes in modern climate and is attributed to anthropogenic factors. Anthropogenic factors are human activities that change the environment. Of most concern among anthropogenic influence factors is the increase in carbon dioxide (CO_2) levels as one of the important greenhouse gases that contribute to global warming.
Liability	The liability refers to the assigned obligation to maintain created and rewarded carbon benefits for an agreed time span. Specifically, it asks the question: If credit is given when carbon stocks are maintained, who then assumes the liability if the rewarded carbon stock is lost? The liability of any reversal will have to be clarified.
Linear accounting	The linearly accounting assumes a time frame that suffices the condition of permanence and assumes that carbon stock maintained over that period may be equally distributed over time (e.g. 1/100 per year for a 100 year time frame). Hence, in the case of a reversal it divides the period of non-compliance by the required time frame and the resulting percentage of the carbon benefits is the portion a party is liable for.
Long-term average	The approach estimates the average changes of carbon stocks or greenhouse gas emissions over time in a project area. The long-term average approach has been adopted by the voluntary market under the Verified Carbon Standard (VCS). Under this approach baseline carbon stocks are subtracted from actual carbon stocks over the considered time frame and divided by the years equal to the time frame selected. Hence, this method accounts for dynamics in carbon stocks and allows for comparison of different projects. Normally a project receives credits as carbon is fixed, until the long-term average is reached according to the time frame selected.
Moral hazard	Hidden action is referred to as moral hazard. It exists after a contract is negotiated. For example, in a PES scheme monitoring contract compliance might be costly and the ES buyer or PES administrator is probably unwilling to pay for full control. Thus both are interested to verify compliance with a degree of uncertainty. This circumstance makes it likely that ES sellers exploit the monitoring gap. The information asymmetry is the principal's (ES buyer/PES administrator) inability to observe and/or verify the agent's (ES seller) action.

Term	Explanation
Payment for Environmental Services (PES)	The payment for environmental/ecosystem services is based on economic incentives for the land owners and their effort to conserve ecosystems. There are various ES that can be used in a PES scheme, such as paying for water regulation and carbon sequestration. A variety of PES definitions exist, reaching from complex to simplistic formulations. Therefore most PES schemes executed in practice are more a non-PES with PES-like characteristics, depending on the definition applied. The differences reflect the level of agreement among experts. But all are rather based on a beneficiary-pays principle. An example of a formulation widely found in scientific literature and originated by Wunder (2005) is that PES is a voluntary transaction where a well-defined ES (or a land use likely to secure its provision) is being “bought” by at least one buyer from at least one provider if, and only if, the ES provider secures service provision (conditionality).
Payment structure	While carbon accounting methods serve to quantify the amount of created environmental benefits, financial transactions to reimburse ES seller involve aspects of price level determination, payment differentiation, and scheduling payments.
Permanence	The permanence is defined by the longevity of a certain carbon pool and the stability of its stocks, given the management and disturbance environment in which it occurs. A requirement of effective climate mitigation strategies in the ambit of activities related to forestry is that they must result in long-term changes in terrestrial carbon storage and CO_2 concentrations in the atmosphere.
Reducing Emissions from Deforestation and forest Degradation (REDD)	Reducing emissions from deforestation and forest degradation generally refers to a commitment in a post-2012 Kyoto Protocol related to financial schemes for adaptation and technology transfer and a blueprint for reducing emissions from deforestation in developing nations. However, several definitions of REDD exist and do not always refer to a potential inclusion into the compliance market under the Kyoto Protocol.
Reforestation	Reforestation is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land.
Reversal	The intended or unintended release of forest carbon stocks rewarded under or designated for a carbon regime, such as REDD.
Sequestration	The process of increasing the carbon content of a carbon pool other than the atmosphere.
Small Property	Land property title inscribed at the Public Property Registry.
Social safeguards	Social safeguards assure that any incentive scheme recognizes the importance of social aspects beyond climate issues and protects against any socially unethical performance, such as preventing poor forest dwellers from subsistence activities vital for their survival. Other examples would be prioritizing of forest owners that provide additional social benefits, such as community involvement in conservation activities and poverty reduction in general.
Stock-change method	The method estimates carbon stocks and greenhouse gas emissions as a difference between baseline and forest activities at a given point in time. The stock-change method has been adopted by the compliance market under the Kyoto Protocol. Changes are usually expressed in tons of carbon per hectare and credits are issued as carbon is fixed or emissions avoided. The approach is reflecting a point in time and does not recognize variability over time.
Sustainable management	Sustainable management of forests is the management of forests according to the principles of sustainable development. Sustainable forest management uses very broad social, economic and environmental goals.
Ton-year accounting	Ton-year accounting was invented to incorporate the particular features of storage and time in forest activities. The method pretends to address the temporal dimension of carbon storage and express the climate benefits of different mitigation project types on an equitable basis. The approach accounts only for a share of the total changes in carbon stocks or greenhouse gas emissions that occurred each year over the projects’ duration. The concept recognizes that delaying the release of carbon to the atmosphere deserves some credit regardless of the long-term fate of the carbon but will be greater the longer carbon remains stored in the forest.
Unavoidable/unintentional reversal	An unavoidable or intentional reversal is generally referred to an event where the ES seller virtually has no chance to prevent forest carbon stock loss. The main feature of the driver causing the loss is that it is unintentional from an ES seller's perspective.

Annex III: Generic Delphi scheme



H. Appendix

CUESTIONARIO UNAM
Ejercicio de Opinión sobre la Gestión Ambiental
Comunidad Magdalena Atlitic & Ejido San Nicolás Totolapan

A. Introducción

Buenos (días) tardes. Somos estudiantes de la UNAM colaborando con la Dra. Lucía Almeida quien ha trabajado en la cuenca y con la comunidad desde hace diez años. Contribuimos a los proyectos de investigación, cuyo objetivo es la conservación de la cuenca, en colaboración con la comunidad.
Su participación es voluntaria y **estrictamente confidencial**. Los datos se procesarán para ser presentados de forma general y **anónima** en la asamblea de la comunidad y en un trabajo de tesis. Por esto le solicitamos su colaboración para que la información que nos entregue, corresponda a lo que piensa, ya que el resultado de esta entrevista dará información importante sobre la situación en la Cuenca. Muchas gracias!

Identificación
Nota: Llenado por el estudiante.
1. # de formato: ____

2. Fecha: ____

Índice
1. Página (**blanco**): Preguntas general (socio-económico)
2. Página (**verde**): Primera ronda
3. Página (**azul**): Segunda ronda

B. General

1. ¿Cuántas veces en los últimos 12 meses participó usted ó miembro de su hogar en la asamblea? ____ número

2. ¿Quién de su familia está en el Registro Agrario? □ Usted □ Cónyuge □ Familia □ Otro

3. Sexo de usted □ Hombre □ Mujer

4. Estado civil □ Soltero □ Casado □ Divorciado □ Viudo □ Unión libre

5. Edad

Usted		años
Cónyuge		años

6. Estudios realizados (marcar el nivel máximo alcanzado y terminado)

Usted	□ Ninguno (Ninguno / Pre-escolar)	□ Primaria	□ Secundaria	□ Preparatoria o bachillerato	□ Carrera técnica o comercial	□ Universidad (Licenciatura)	□ Posgrado (Maestria / Doctorado)
Cónyuge	□ Ninguno (Ninguno / Pre-escolar)	□ Primaria	□ Secundaria	□ Preparatoria o bachillerato	□ Carrera técnica o comercial	□ Universidad (Licenciatura)	□ Posgrado (Maestria / Doctorado)

7. Ocupación

Usted	□ Asalariado	□ Independiente	□ Pensionado	□ Estudiante	□ Ninguno
Cónyuge	□ Asalariado	□ Independiente	□ Pensionado	□ Estudiante	□ Ninguno

8. Cantidad más cercana al ingreso total de su hogar por mes

□ Menos de \$1,700	□ \$1,701 - \$3,400	□ \$3,401 - \$5,100	□ \$5,101 - \$6,800	□ \$6,801 - \$8,500	□ \$8,501- \$10,200	□ \$10,201 - \$11,900	□ Mas de \$11,901

9. ¿Cuántas personas forman parte de su hogar/familia actualmente? ____ número

10. ¿Usted es dueño de un predio o una parcela dentro de la comunidad? □ Sí □ No

11. ¿Usted trabaja o cultiva un predio o parcela dentro de la comunidad? □ Sí □ No

12. ¿Cuántos metros cuadrados trabaja o cultiva dentro de la comunidad? ____ m^2

13. ¿Usted participa actualmente en un esquema de Pago por Servicios Ambientales (PSA) de la CONAFOR? □ Sí □ No

C. Primera Ronda

Escenario: El bosque está protegido por el Suelo de Conservación. Pero el Gobierno Federal ofrece el próximo año dos alternativas de programas ambientales para conservar la cobertura forestal (el bosque).

*Nota: Indique un puntaje de preferencia entre **1** (muy bajo) a **10** (muy alto) para cada de las tres alternativas por tabla, tomando en cuenta que en una tabla **no deben tener el mismo puntaje**.*

1.

Atributos / Trato	Estatus quo	Alternativa 1	Alternativa 2
Opción	Suelo de Cons.	PSAH	PSA-REDD
Bien / Servicio	Cons. Ecológica	Agua	Carbono
Monto por hectárea por año	0 MXN	382 MXN	855 MXN
Duración	100 años	5 años	40 años
El responsable para la perdida evitable de cobertura forestal es la comunidad y si se detecta la sanción es el reembolso de beneficios obtenidos y la exclusión en el futuro.	⊘	✓	⊘
Inspección de cumplimiento por el Gobierno	★★★	★★	★
Corrupción en el Gobierno	✓	✓	✓
	Puntaje ___	Puntaje ___	Puntaje ___

2.

Atributos / Trato	Estatus quo	Alternativa 1	Alternativa 2
Opción	Suelo de Cons.	PSAH	PSA-REDD
Bien / Servicio	Cons. Ecológica	Agua	Carbono
Monto por hectárea por año	0 MXN	382 MXN	855 MXN
Duración	100 años	5 años	40 años
El responsable para la perdida evitable de cobertura forestal es la comunidad y si se detecta la sanción es el reembolso de beneficios obtenidos y la exclusión en el futuro.	⊘	⊘	⊘
Inspección de cumplimiento por el Gobierno	★★★	★	★
Corrupción en el Gobierno	✓	⊘	✓
	Puntaje ___	Puntaje ___	Puntaje ___

3.

Atributos / Trato	Estatus quo	Alternativa 1	Alternativa 2
Opción	Suelo de Cons.	PSAH	PSA-REDD
Bien / Servicio	Cons. Ecológica	Agua	Carbono
Monto por hectárea por año	0 MXN	382 MXN	855 MXN
Duración	100 años	5 años	40 años
El responsable para la perdida evitable de cobertura forestal es la comunidad y si se detecta la sanción es el reembolso de beneficios obtenidos y la exclusión en el futuro.	⊘	⊘	⊘
Inspección de cumplimiento por el Gobierno	★★★	★	★★★
Corrupción en el Gobierno	✓	⊘	⊘
	Puntaje ___	Puntaje ___	Puntaje ___

Leyenda:	Sí	No	1%	10%	20%
	✓	⊘	★	★★	★★★

D.Segunda Ronda

Escenario: Contrato PSA-REDD está celebrado por la Asamblea General el próximo año para mantener la cobertura forestal (el bosque) a través de un programa ofrecido por el Gobierno Federal. Pero existen dos alternativas para aprovechar la tierra sujeto a este programa.

*Nota: Indique un puntaje de preferencia entre **1** (muy bajo) a **10** (muy alto) para cada de las tres alternativas por tabla, tomando en cuenta que en una tabla **no deben tener el mismo puntaje**.*

1.

Atributos / Trato	Estatus quo	Alternativa 1	Alternativa 2
Opción	PSA-REDD	Agricultura	Infraestructura
Bien / Servicio	Carbono	Cultivo	Asentamiento
Monto por hectárea por año	855 MXN	12.055 MXN	15.675 MXN
Duración	40 años	1 año	50 años
El responsable para la perdida evitable de cobertura forestal es la comunidad y si se detecta la sanción es el reembolso de beneficios obtenidos y la exclusión en el futuro.	⊘	✓	⊘
Inspección de cumplimiento por el Gobierno	★★★	★★	★★★
Corrupción en el Gobierno	✓	✓	⊘
	Puntaje ___	Puntaje ___	Puntaje ___

2.

Atributos / Trato	Estatus quo	Alternativa 1	Alternativa 2
Opción	PSA-REDD	Agricultura	Infraestructura
Bien / Servicio	Carbono	Cultivo	Asentamiento
Monto por hectárea por año	855 MXN	12.055 MXN	15.675 MXN
Duración	40 años	1 año	50 años
El responsable para la perdida evitable de cobertura forestal es la comunidad y si se detecta la sanción es el reembolso de beneficios obtenidos y la exclusión en el futuro.	⊘	⊘	⊘
Inspección de cumplimiento por el Gobierno	★★★	★★★	★★★
Corrupción en el Gobierno	✓	⊘	⊘
	Puntaje ___	Puntaje ___	Puntaje ___

3.

Atributos / Trato	Estatus quo	Alternativa 1	Alternativa 2
Opción	PSA-REDD	Agricultura	Infraestructura
Bien / Servicio	Carbono	Cultivo	Asentamiento
Monto por hectárea por año	855 MXN	12.055 MXN	15.675 MXN
Duración	40 años	1 año	50 años
El responsable para la perdida evitable de cobertura forestal es la comunidad y si se detecta la sanción es el reembolso de beneficios obtenidos y la exclusión en el futuro.	⊘	⊘	⊘
Inspección de cumplimiento por el Gobierno	★★★	★★★	★
Corrupción en el Gobierno	✓	⊘	✓
	Puntaje ___	Puntaje ___	Puntaje ___

Leyenda:	Sí	No	1%	10%	20%
	✓	⊘	★	★★	★★★