Local Perceptions of Changes in Ecosystem Services and Climate

Case study in Ecuadorean Sierra

Anna Sundqvist

Supervisors: Mulualem Tigabu, SLU Southern Swedish Forest Research Centre
Eric Agestam, SLU Southern Swedish Forest Research Centre

Swedish University of Agricultural Sciences

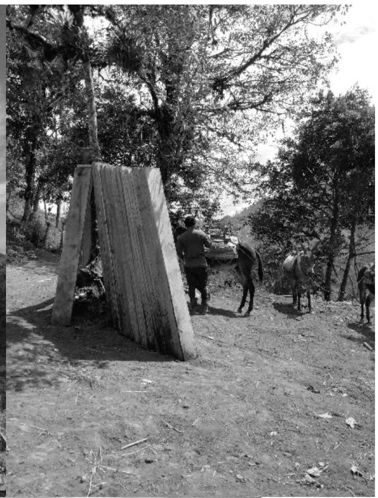
Master Thesis no. 291

Southern Swedish Forest Research Centre

Alnarp 2018

Local Perceptions of Changes in Ecosystem Services and Climate

Case study in Ecuadorean Sierra


Anna Sundqvist

Supervisors: Mulualem Tigabu, SLU Southern Swedish Forest Research Centre
Eric Agestam, SLU Southern Swedish Forest Research Centre
Examiner: Christer Odén, SLU Southern Swedish Forest Research Centre

Swedish University of Agricultural Sciences
Master Thesis no. 291
Southern Swedish Forest Research Centre
Alnarp 2018

MSc Thesis in Forest Management – Jägmästarprogrammet SY001
Advanced level (A2E), SLU course code EX0766, 30ECTS

Abstract

Anthropogenic-induced land-use and land-cover change is a threat to biodiversity and ecosystem services, and contribute to global climate warming. Forests are essential in the climate system and store a large part of the global carbon. Ecuador has experienced a rapid loss of forest cover over the last decades with degradation of ecosystems and decrease in biodiversity as part of the consequences. Indigenous or local people have a great body of knowledge about the environment; gained from a long-lived association with nature. This knowledge, called traditional ecological knowledge (TEK), has the potential to contribute to building resilience in social-ecological systems in the context of global change and environmental degradation. TEK is also recognized in formulation of environmental policy for sustaining ecosystem services and biodiversity, climate change adaptation strategies and as complimentary to ecological-based evidence in restoration.

The main objective of this study was to generate evidence that supports the on-going effort to conserve biodiversity and restore degraded ecosystems in the face of climate change in Ecuador by examining local people's perception of changes in forest cover, ecosystem services and goods and climate. The specific research questions of the study were: (i) Do knowledge of ecosystem goods and services and perception of their change depend on the demographic attributes of the local people and proximity to the forest remnants? (ii) Do local people perceive changes in forest cover? If so, is their perception of forest cover changes related to their demographic attributes? (iii) Do local people perceive changes in climate events? If so, to what extent does their perception depend on their demographic attributes? Are there any local adaptation mechanisms to changes in climate events?

To address these questions, relevant information was gathered through literature review, focus group discussion (community workshops) and semi-structured household interviews in two provinces of the Ecuadorean *Sierra*. For household interviews changes in ecosystem services and goods and forest cover, 84 households in five villages (communities) were involved. For local people's perception on climate change, 50 households were involved. The information generated through household interviews was translated into dummy variables for dichotomous response (yes or no) and into Likert scale (1-4) for more than two responses, and statistically analysed with logistic regression models. Ecosystem services and goods in the study area identified by local people were mapped according to the Common International Classification of Ecosystem Services (CICES) system.

The results showed that (i) a total of 21 ecosystem services, which belonged to three major sections (provisioning, regulation and maintenance, and cultural services), were recognised. The most frequently cited ecosystem services were water, timber and plants with symbolic or religious and medicinal value, and the perception among respondents significantly influenced by socio-demographic factors; namely land tenure status, distance to the forest, ethnicity, age class, education level ($p < 0.05$); (ii) The perception of forest cover change differed somewhat between male (63.2%) and female (35.6%) respondents as well as among age classes ($p < 0.05$) such that the young age class perceived a moderate change or no change to a greater degree than the other two age classes; (iii) Almost all respondents perceived an overall warming, drying up of rivers and springs, early onset of summer and monsoons and frequent dry season fires. Demographic attributes of the respondents had a significant ($p < 0.05$) effect on climate change awareness and on effects of climate change; (iv) there existed some local adaptation mechanisms to climate change events, such as cultivating different crops, reintroduction of native species and tree planting; suggesting the presence of 'pockets' of TEK. It can be concluded there is generally a good awareness of changes in forest cover and climate events in their area but socio-demographic attributes do affect to some extent how local people perceive ecosystem services and goods and climate change. Thus, incorporating TEK is advisable during formulating locally adapted management systems and for building long-term social-ecological resilience.

Key-words: traditional ecological knowledge, ecosystem services and goods, climate change

Sammanfattning

Antropogen förändring i markanvändning och marktäcke har en negativ inverkan på biodiversitet och ekosystemtjänster samt bidrar till global klimatuppvärmning. Skogar är viktiga i klimatsystemet och lagrar en stor det av det globala kolet. I Ecuador har det skett en snabb förlust av skogstäcke under de senaste årtiondena med utarmning av ekosystem och minskad biologisk mångfald som konsekvens. Urbefolkningar eller lokalbefolkning har stor kunskap om sin omgivande miljö uppnådd genom en långvarig samexistens med naturen. Denna kunskap, kallad traditionell ekologisk kunskap (TEK), har potential att bidra till att bygga motståndskraft i sociala ekologiska system i en kontext av global förändring och miljöförstöring. TEK används också vid utformning av miljöpolitik för att bevara ekosystemtjänster och biologisk mångfald, anpassningsstrategier för klimatförändringar och som komplement till ekologiskt baserade bevis vid restaurering.

Huvudsyftet med denna studie var att hitta bevis som stödjer insatserna för att bevara biologisk mångfald och återställa ekosystem som utarmats av klimatförändringarna i Ecuador. Detta genom att undersöka lokalbefolkningens uppfattning om förändringar i skogstäcke, ekosystemtjänster och klimat. Huvudfrågeställningen var: (I) Beror kunskap om ekosystemtjänster och uppfattningen om dess förändring på lokalbefolkningens demografiska egenskaper och närhet till skogen? (II) Upplever lokalbefolkningen förändringar i skogstäcke? Om så är fallet, är lokalbefolkningens uppfattning om förändring i skogstäcke relaterad till deras demografiska egenskaper? (III) Upplever lokalbefolkningen förändringar i klimathändelser? Om så är fallet, i vilken utsträckning beror deras uppfattning på demografiska egenskaper? Finns det några lokala anpassningsmekanismer för dessa klimathändelser?

För att besvara dessa frågor samlades relevant information in genom litteraturstudier, diskussioner i fokusgrupper (studiecirklar i byarna) och halvstrukturerade intervjuer med byinvånarna i två provinser i det ecuadorianska höglandet. 84 hushåll i fem olika byar deltog i intervjuerna om förändringar i ekosystemtjänster och skogstäcke. 50 hushåll deltog i intervjuerna om lokalbefolkningens uppfattning om klimatförändringar. Informationen som genererades genom intervjuerna översattes till dummyvariabler för dikotoma svar (ja eller nej) och till Likert-skala (1-4) för mer än två svar, och analyserades statistiskt med logistiska regressionsmodeller. Ekosystemtjänster som lokalbefolkningen identifierade i studieområdet kartlades i enlighet med Systemet för gemensam internationell klassificering av ekosystemtjänster (CICES).

Resultaten visade att (I) Totalt 21 ekosystemtjänster, som tillhörde de tre huvudsektionerna (tillhandahållande, reglering och underhåll, och kulturella tjänster), kändes igen. De mest frekvent nämnda ekosystemtjänsterna var vatten, timmer, växter med symboliskt eller religiöst värde och växter med medicinskt värde. Respondenternas uppfattning påverkades väsentligt av sociodemografiska faktorer så som; besittningsrättsstatus, avstånd till skog, etnicitet, åldersklass, utbildningsnivå ($p < 0.05$); (II) Uppfattningen av förändring i skogstäcke skilde sig mellan manliga (63.2%) och kvinnliga (35.6%) respondenter, såväl som bland åldersklasser ($p < 0.05$). Den yngsta åldersklassen uppfattade en måttlig eller ingen förändring i större grad än de andra två åldersklasserna; (III) Nästan alla respondenter upplevde en generell uppvärmning, uttorkning av floder och vattendrag, tidig start på somrar och monsuner, och frekventa torrsäsongsbränder. Respondenternas demografiska egenskaper hade en signifikant ($p < 0.05$) inverkan på medvetenheten om klimatförändringar och om effekterna av klimatförändringar; (IV) Lokala anpassningsmekanismer för klimatförändringar som identifierades var bland annat odling av olika grödor, återintroduktion av inhemska arter och trädplantering, vilket tyder på ”fickor” av TEK. Det kan konstateras att i allmänhet är medvetenheten om förändringar i skogstäcke och klimathändelser i området god, men sociodemografiska egenskaper påverkar i viss mån hur lokalbefolkningen uppfattar ekosystemtjänster och klimatförändringar. Det är därför lämpligt att införliva TEK vid utformning av lokalt anpassade förvaltningssystem och för att bygga långsiktig social ekologisk motståndskraft.

Nyckelord: traditionell ekologisk kunskap, ekosystemtjänster, klimatförändringar

Table of Contents

List of tables

Statistics

List of figures

Abbreviations

CBD	Convention on Biological Diversity
CICES	The Common International Classification of Ecosystem Services
FAO	Food and Agriculture Organization of the United Nations
FRA	Forest Resource Assessment
IPCC	Intergovernmental Panel on Climate Change
MAE	Ministry of Environment (Ecuador)
MEA	Millennium Ecosystem Assessment
REDD+	Reduce Emissions from Deforestation and Forest Degradation
TEK	Traditional Ecological Knowledge
UNDP	United Nations Development Programme

1. Introduction

1.1 General background

Anthropogenic-induced land-use and land-cover change is a threat to biodiversity and ecosystem services (Foley et al. 2005; Lambin et al. 2001), and contribute to climate change and global climate warming (Chase et al. 1999). Together, land use and climate change pose a great threat to humid tropical forests (Asner et al. 2010). Forests play an important role in the climate system in general, and tropical forests in particular store a substantial part of the global carbon (Bonan, 2008). Tropical forests also hold a significant part of the world's tree species (Poorter et al. 2015). Some of the world's biodiversity hotspots are found in the tropical Andes where endemic species are suffering exceptional habitat losses (Myers et al. 2000). Despite the high biodiversity, deforestation rates in Ecuador have been among the highest in the world according to the Food and Agriculture Organization of the United Nations (FAO, 2011). Tropical deforestation rates are linked to population growth and poverty, as well as shifting cultivation in large forest areas (Myers et al. 2000). However, the drivers of forest cover change and the deforestation rate varies between regions and localities.

There is consensus around the fact that forest degradation leads to reduction of biodiversity, which in turn reduces resilience of forest ecosystems (CBD[1]). The view of the main function of forests has shifted during the last decades, from being merely a source of timber to a more multi-functional view, including recreation, biodiversity, ecosystem services and mitigation of climate change. These are now regarded as essential components of sustainable forest management and forest biodiversity (CBD[2]).

Local communities have a great body of knowledge about changes in their environment, which has developed out of experience gained from a long-lived association with nature (Berkes, 1993). Indigenous or local people have depended on local environments for the provision of natural resources and it is in their interest to conserve and enhance biodiversity (Gadgil et al. 1993). This knowledge of biodiversity conservation can make a substantial contribution to sustainable development (CBD[3]). In this thesis, the traditional ecological knowledge (TEK) of local people in Ecuador is examined to find out how it is used to meet the challenge of a changing climate, a changed access to ecosystem services and goods and the conservation of biodiversity.

1.2 Overview of Ecuador

Ecuador is one of the poorest countries in South America and the gap between rich and poor is huge. The country has suffered from high unemployment for long periods of time. High inflation and a weak modern sector has slowed down the economic development and created political instability. The country is still highly dependent on few raw materials, mainly oil and bananas, making the economy vulnerable to price fluctuations on the world market. Agriculture is the sector employing most people, but the methods used are poorly developed. The infrastructure is in poor condition due to lack of investment, difficult terrain and natural disasters. Moreover, Ecuador is a country with many different ethnic groups that often have been mixed together (UI, 2014)

The country faces many social and economic challenges. However, it is one of the world's richest countries in terms of biodiversity, both for total number of species and species per area (FAO, 2003).

[1] Convention on Biological Diversity, available: https://www.cbd.int/forest/problem.shtml
[2] Convention on Biological Diversity, available: https://www.cbd.int/forest/importance.shtml
[3] Convention on Biological Diversity, available: https://www.cbd.int/traditional/intro.shtml

Despite being one of the smallest countries in South America, Ecuador comprises a mega-diversity of climate and life zones. Nevertheless, Ecuador has the highest number of threatened higher plant species (over 1700) in Latin America and the Caribbean.

Three ecological zones can be outlined on the mainland of Ecuador (the Galapagos Islands excluded): the coastal plains in the West (*la Costa*), the Andean highlands (*la Sierra*) and the Amazon lowlands (*el Oriente*) in the east, where most of the forests are found. The country is divided in the middle by the Andes that run from north to south. The climate varies in relation to the topography of each zone and with the adjacent sea currents. In the northern part of the coast, precipitation can exceed 6 000 mm per year while in the southwest it only reaches 355 mm (MAE, 2010).

The variation in topography and climate has created an enormous diversity of ecosystems and life zones. Of the approximately 100 different life zones found on our planet, 25 of them can be found in Ecuador according to the Holdridge system. Five of the ten global 'hot spots' for species biodiversity are located in South America of which two partly cover Ecuador: in the western plains, the coastal forests in the Chocó-Darien region, that also cover parts of Colombia and Peru, and the eastern sides of the Andes towards the Amazon (Myers et al. 2000). The Chocó-Darien-region is considered among the most diverse and at the same time one of the world's most threatened hot spot zones (Wunder, 2000).

Governments have an essential role in regulating ecosystem services since they involve public goods and benefits. Ecuador's environmental policy changed fundamentally in 2008 when a new national constitution was promulgated. Management of environmental services was relegated to the state according to Article 74 (Mohebalian and Aguilar, 2015). Ecuador is also the first country in the world to declare the rights of nature in its constitution (Mariscal, 2016). The declaration states the rights of natural ecosystems to exist, to be maintained and their evolutionary processes are regenerated, and the rights of nature to be restored (Articles 71-74). The same year, the government of Ecuador developed a national program called the 'Social Forest Programme' (Socio Bosque Programme), with the main objective of combining conservation with poverty alleviation. It is part of Ecuador's national efforts to Reduce Emissions from Deforestation and Degradation (REDD+) (de Koning et al. 2011), and consists of providing monetary incentives to private forest owners and communities to maintain their forest land (Mohebalian and Aguilar, 2015). The forest owner signs a 20-year contract and the 'Social Forest Programme' provides payments per hectare every second year. The participants are asked to develop a plan on how the conservation payment will be spent (Mohebalian and Aguilar, 2015). Hence, through the 'Social Forest Programme', people dependent on forests are offered an alternative to an unsustainable use of natural resources.

Ecuador has been shaped by a history of external and internal colonization and land reforms (Hansen et al. 2015). The deforestation and forest degradation started already during the colonial period when forests where exploited for timber (Mariscal, 2016). This marginalized many indigenous groups, mainly in the Andean highlands and the coastal areas. In the Amazon region, the discovery of oil and other natural resources started during the 1950s and 1960s, which caused migration to the Amazon lowlands (Hansen et al. 2015). This lead to further forest clearance and the highest deforestation rates in South America (FAO, 2011). The forest cover loss is mainly due to harvesting, agricultural and livestock husbandry. Other causes of deforestation are poorly controlled land settlement policies and laws that have encouraged deforestation (FAO, 2003.) To protect the remaining forests, several initiatives for conservation and restoration have been launched during the past decades (Mariscal, 2016).

It is difficult to find reliable numbers concerning deforestation rates for Ecuador. However, the FAO Forest Resource Assessment (FRA) provides statistics of deforestation by merging surveys and models with data from both national and regional sources and are thus among the most accurate ones. The percentage of forest cover declined for the whole of South America from 1990 to 2011, but was greatest in Ecuador in comparison with other countries on the continent. During this period, the percentage of forest cover declined from 49.9 to 38.9% (FAO, 2014). However, recent prognosis from FRA shows a slow-down in deforestation rates of tropical forests (Wunder, 2000). Nonetheless, the net deforestation rates for 1980-1990 was 189 000 ha per year and for 1990-1995, 238 000 ha per year, which is one of the highest deforestation rates in South America (Wunder, 2000). Estimates by FAO show a yearly forest loss of 1.6%, the second highest on the continent (FAO, 2011). The percentage of primary forest was 48.7% in 2010 and over 25% of the total land area is nationally protected areas (FAO, 2014). All three regions in Ecuador are affected by deforestation even though the dynamics of forest loss differ between the regions.

Today, the main timber extraction from native forests is taking place in the Coastal region in the province of Esmeraldas. Lack of primary material from native forests is perhaps the main obstacle for the forestry sector which has led to an increased interest for plantations as a source of timber. Another recent incentive for the establishment of plantations is the role that forests play in carbon sequestration, and the sale of carbon credits is viewed as a possible source of income for Ecuador (Farley, 2007).

1.3 Ecosystem services and goods

Ecosystem services and goods are the benefits provided by ecosystems to human populations (Cardinale et al. 2012). They are of vital importance to human well-being, health, livelihoods and survival. Ecosystem functions can be defined as “the habitat, biological or system properties or processes of ecosystems” from which the ecosystem goods and services are derived (Costanza et al. 1997).

The anthropogenic impact on ecosystems have been rapid and extensive during the last 50 years compared to any other time period in human history, mainly due to increased demand for food, fresh water, timber, fiber and fuel. Consequences are now visible in form of significant and irreversible loss in the diversity of life on Earth (MEA, 2005). There are also clear indications that loss of biodiversity has many negative effects on ecological communities (Cardinale et al. 2012). However, this unsustainable use of our planet has contributed to increased human well-being and economic development at a cost of degradation of ecosystem services. A common cause to degradation of ecosystem services is increase of, for instance, food supply for some people, while other groups of people have been hit by exacerbated poverty. (MEA, 2005)

The term ecosystem service got its big breakthrough when the research project Millennium Ecosystem Assessment (MEA) was launched by the United Nations in 2005. The objective was to assess the consequences for human well-being of the changes in ecosystems. According to the MEA (2005), ecosystem services are defined as benefits humans obtain from ecosystems. Four interrelating categories can be identified:

- *Provisioning services* are products obtained from ecosystems (e.g. food and fibre)
- *Regulating services* are benefits obtained from regulation of ecosystem processes (e.g. climate regulation)
- *Cultural services* are non-material benefits obtained from ecosystems (e.g. recreation and ecotourism)
- *Supporting services* are services necessary for the production of all other ecosystem services (e.g. nutrient cycling)

The assessment of ecosystem services is a way of documenting changes in their nature and availability and enables an economic valuation of the services.

Ecosystem services can be classified in many ways. Various efforts have been made for classification of ecosystem services based on the MEA framework to adapt it to different environments and conditions (Busch et al. 2012). One such classification system is The Common International Classification of

Ecosystem Services (CICES). The CICES was developed to facilitate navigation between the different systems (Haines-Young and Potschin, 2016). The CICES provides a framework for classification of ecosystem services dependent on living processes. The importance of finding a classification system that is "geographically and hierarchically consistent" to be able to compare different regions has been emphasized (Busch et al. 2012). The CICES is developed around human needs and should be regarded as a means of describing ecosystem outputs contributing to human well-being enabling the assessment from different perspectives (economic, social, aesthetic and moral). Hence, abiotic outputs are not regarded as ecosystem services in this context (Haines-Young and Potschin, 2013).

The structures and processes resulting in ecosystem services are called supporting services or ecological functions, also described as "intermediate services". These are dealt with as a part of the underlying structures, processes and functions that characterize ecosystems. They are not consumed directly and can support the output of many "definitive outputs" and are treated in other ways. The aim of CICES is to evaluate the final services that people value. Consequently, the supporting services and functions are not covered in CICES (CICES, 2016). The relationship between the services is illustrated by Potschin and Haines Young (2011) using the Cascade Model (Fig. 1).

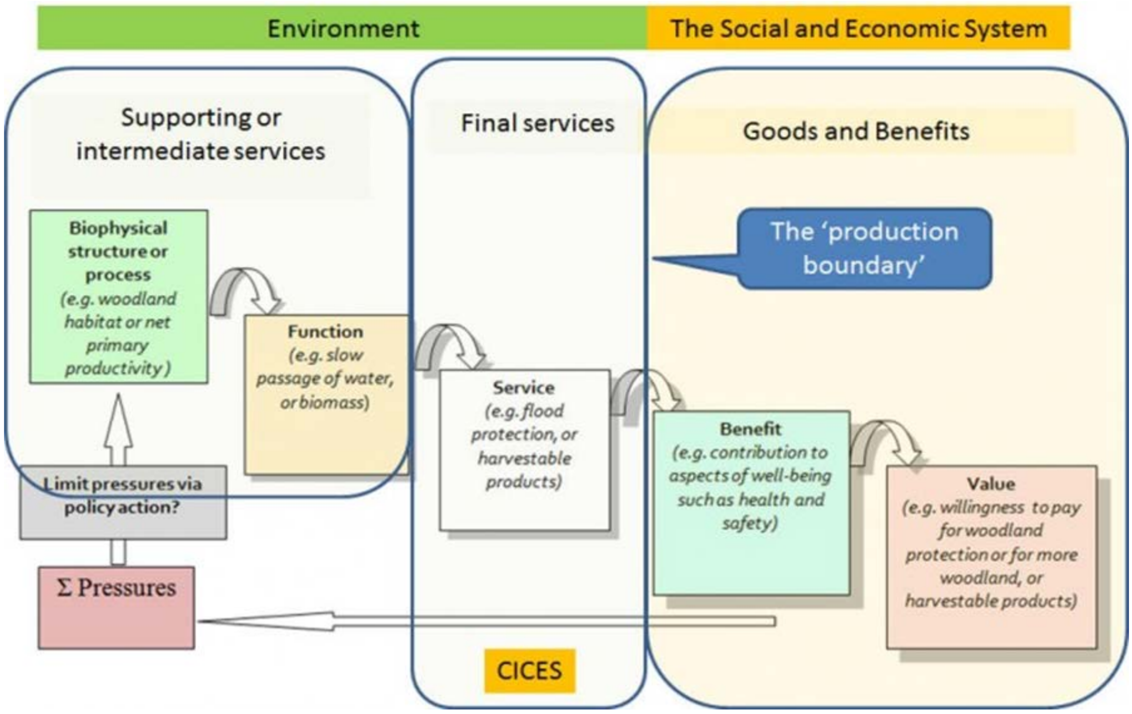


Figure 1. Showing the relationship between the different categories of ecosystem services and the emphasis on the final services in CICES. Illustration by Potschin and Haines Young (2011).

The CICES has a five-level hierarchical structure (Fig. 2) to facilitate the comparison between different thematic and spatial resolutions (Haines-Young and Potschin, 2013). The outputs according to the classification system are provisioning, regulation and maintenance, and cultural services:

- *Provisioning services* are all nutritional, material and energetic outputs from living systems. A distinction is made between outputs from biomass and water.
- *Regulation and maintenance* involves all the ways in which living organisms can mediate or moderate the ambient environment that affects human performance, e.g. degradation of wastes and toxic substances by using living processes.

- *Cultural services* include all non-material and non-consumptive outputs of ecosystems that affect the physical and mental states of people.

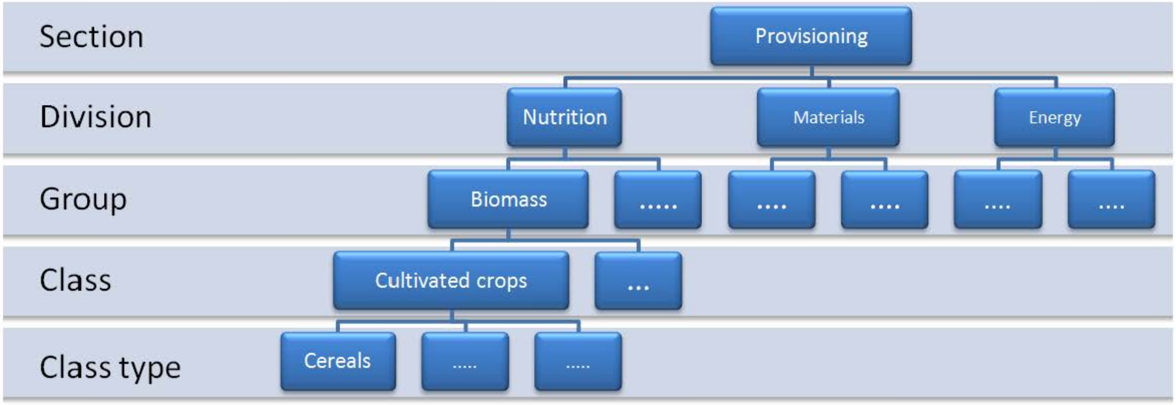


Figure 2. Showing the overall structure of CICES for the Provisioning Services.

The CICES uses the typology of ecosystem services from the MEA with some changes, for example a more hierarchical structure with ‘Divisions’, ‘Groups’ and ‘Classes’ below the ‘Sections’ that is also found in the MEA. The hierarchical structure allows the user to move between different levels and to choose the level of detail required, and moreover to adapt it to the geographical scale. (Haines-Young and Potschin, 2013). Another difference between the two systems is the distinction between ecosystem services and ecosystem benefits. The MEA consider goods and services as equal, while it has been argued that goods are things than can be valued, i.e. things ‘produced’ from the final services that affect the well-being, for example trees as a final service can generate many different types of goods.

According to the CICES, a distinction should be made between *final ecosystem services*, *ecosystem goods or products* and *ecosystem benefits*. The CICES defines *final ecosystem services* as “the contributions that ecosystem make to human well-being” and final in terms of ecosystem outputs that has direct effect on peoples’ well-being. An essential characteristic is the link they keep between the underlying ecosystem functions, processes and structures that generate them. *Ecosystem goods and benefits* are “things that people create or derive from final ecosystem services”, e.g. products or experiences without functional connection to the system from which they are derived (Haines-Young and Potschin, 2013).

The main criticism of MEA is the inclusion of the last category, *supporting services*, and that the MEA consider services and benefits to be the same (Fisher and Turner, 2008). Fisher and Turner (2008), among others, argue that there is a risk for double counting when both ecosystem functions and the subsequent ecosystem services provided by the function is counted. They also argue that the MEA systems is inappropriate to use for valuations and landscape management purposes due to this risk (Fisher and Turner, 2008).

In this thesis, the CICES is used for the assessment of ecosystem goods and services in Ecuador. The ecosystem services are categorized in the CICES classification system as shown in Fig. 2 and are assessed on the ‘Class’ level of the CICES classification. The CICES is chosen due to the exclusion of the supporting services. There is a clear distinction between ecosystem functions and ecosystem services so that double counting is avoided.

1.4 Climate change

The Intergovernmental Panel on Climate Change’s Synthesis Report (2014) states the fact that human influence on climate is clear and that anthropogenic emissions of greenhouse gases are the highest in history. The increased temperature of the climate system is unambiguous, and the observed changes are exceptional over decades to millennia. Both human and natural systems on all continents are affected by recent climate changes, and for natural systems the evidence of observed climate change is the strongest. For South America, for instance, the surface temperature is predicted to increase with 4-5 °C. The precipitation will decrease for the continent as a whole, but for high latitude areas and the equatorial Pacific it is likely to increase. The global warming will lead to very high risks of severe, widespread and irreversible impacts globally without further efforts. However, adaptation can reduce the risk of climate change impacts, but no single alternative is sufficient by itself (IPCC, 2014).

The link between forests and climate has been suggested for a long time and various methodologies exist to measure it. The research society now agree on that forests and our use of forests affect the climate and provide significant “climate forcings and feedbacks” (Bonan, 2008), i.e. the initial drivers of climate and processes that can either intensify or reduce the effects of climate forcings (NASA, 2017). There is also consensus around the fact that climate change may have negative effects on ecosystem functions (IPCC, 2014), and that forests can be managed to mitigate climate change (IPCC, 2014).

Forests provide various services to natural systems and humans: ecological, economic, social and aesthetic (Bonan, 2008). Besides the provision of ecosystem services and goods, forest and forest management activities play a key role in the context of global change and sustainable development through mitigation of climate change. However, climate change will also affect forests and their mitigation capacity may be reduced as a consequence of it (IPCC, 2007). Forests have an impact on climate through exchanges with the atmosphere of energy, water, carbon dioxide and other chemicals (Bonan, 2008). Furthermore, the world’s forests play a significant role in the global carbon cycle (IPCC, 2007). Forest ecosystem can sequester a large amount of carbon – forests store ~45% of the terrestrial carbon and contribute with ~50% of the net primary production (NPP) (Sabine et al. 2004). Moreover, forests cool the climate by sustaining the hydrological cycle through evapotranspiration.

Tropical forests hold the largest carbon pool and NPP of the terrestrial biota (Sabine et al. 2004). Through climate model simulations it has been shown that tropical forests keep high rates of evapotranspiration, decrease surface air temperature, and increase precipitation in comparison to pastureland. The Amazon-region is most studied where extensive conversion of forests to pasturelands generates a warmer and drier climate (Bonan, 2008). Tropical forests are sensitive to increased temperature and decreased humidity, and climate models predict a seasonal water deficit in eastern Amazon (Malhi, 2008). This may in turn worsen global warming through an ecosystem feedback that reduces evaporative cooling, releasing CO_2 and initiating forest dieback (Betts, 2004).

Some climate mitigation options suggested by the IPCC include reducing emissions from deforestation and forest degradation, increasing the sequestration rate in standing and new forests, substituting fossil fuels with wood fuels, and producing bioenergy from forest products. If these mitigation options are designed and implemented appropriately, they will have several co-benefits it terms of increased employment and income, conservation of biodiversity and watershed, provision of timber and fiber, as well as aesthetic and recreational values (IPCC, 2007).

1.5. Traditional Ecological Knowledge

The field of traditional ecological knowledge (hereafter TEK) has developed out of ethnoscience and human ecology. These two disciplines were eventually merged with other fields to emphasize people's perception of ecological processes and their relationships with the environment (Martin et al. 2010). The term *traditional* expresses historical and cultural continuity, nevertheless, societies are under constant change and what is considered 'traditional' is not static (Berkes et al. 2003). Several definitions of TEK have been proposed, the broadest one is from Berkes et al. (2000, p. 1252):

> *"Traditional ecological knowledge (TEK) is a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with the environment".*

The practices of TEK was developed before the era of fossil fuel dependency, and its design is adapted to using renewable energy while maintaining natural resources (Martin et al. 2010). Many disciplines have shown the contribution of TEK to improving livelihoods (McDade et al. 2007, Reyes García et al. 2008), sustaining biodiversity and ecosystem services (Gadgil et al. 1993), and building resilience in social-ecological systems (Folke, 2004, Berkes and Davidson-Hunt 2006, Gómez-Baggethun et al. 2012). In the United Nations' Convention on Biological Diversity (CBD), the potential for TEK to contribute to biodiversity has been recognized. It is stated that the knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity should be respected, preserved and maintained.

Earlier in human history, changes in the ecosystem's ability to support the social systems was buffered by resilience. However, today the human modification of ecosystems has altered the ecological resilience (Berkes et al. 2003). It has been argued that resilience is the most critical ecosystem property to be maintained, and that ecosystem resilience is promoted by biodiversity conservation. If so, long-term historical experience of certain ecosystems, such as provided by TEK, is of vital importance (Gadgil et al. 1993).

In the context of global change and environmental degradation, TEK has the potential to contribute to building resilience in social-ecological systems (MA, 2005). Communities living in close relationship with nature have developed knowledge, practices and institutions for a long time to cope with frequent disturbances to secure their livelihood (Berkes et al. 2003). When this knowledge is lost, the possibilities to respond to disturbance and global change are reduced. In many parts of the world, TEK has decreased with the increasing globalization, and the fear of its disappearance has been stressed. However, current research has found "pockets" of TEK still existing in many countries despite the globalization process, which indicates its ability to adapt to new ecological and socioeconomic conditions. The adaptive nature of TEK has increased its recognition in environmental policy for sustaining ecosystem services and biodiversity (Gómez-Baggethun et al. 2013). As a whole, the contribution of TEK in management and conservation of natural resources has been well recognized and utilized over the past few decades (Berkes et al. 2000; Gadgil et al. 2003; Lykke et al. 2004). A recent review also demonstrates that TEK can contribute to all aspects of ecological restoration, from reconstruction of the reference ecosystem and adaptive management to species selection for restoration and monitoring and evaluation of restoration outcomes (Uprety et al. 2012).

2. Objectives, Research questions and hypotheses

The main objective of this study was to generate evidence that supports the on-going effort to conserve biodiversity and restore degraded ecosystems in the face of climate change in Ecuador by examining local people's perception of changes in forest cover, ecosystem services and goods and climate. Specifically, the study presented in this thesis aimed at (i) mapping ecosystem services and goods; (ii) examining changes in supply of ecosystem services and goods; (iii) describing forest cover change qualitatively; (iv) examining awareness of climate change among local people and adaptive strategies to perceived climate change.

The specific research questions of the study were:

- Do knowledge of ecosystem goods and services and perception of their change depend on the demographic attributes of the local people and proximity to the forest remnants?
- Do local people perceive changes in forest cover? If so, is their perception of forest cover changes related to their demographic attributes?
- Do local people perceive changes in climate events? If so, to what extent does their perception depend on their demographic attributes? Are there any local adaptation mechanisms to changes in climate events?

The hypotheses of the study were

- Knowledge of ecosystem goods and services as well as perception of change depends on demographic attributes of the respondents (gender, age, educational level, household size, residence and land tenure status) and proximity to the forest resource.
- Through their daily interaction with the forest ecosystems, local people will have a better understanding of changes in forest cover, depending on their demographic attributes
- Local people are very well aware of changes in climate events in their area, and have good traditional knowledge to cope with and adapt to risks associated to climate change, but their perception of climate change depends on their demographic attributes.

3. Material and methods

3.1 Study areas

The study was conducted in two provinces of the Ecuadorean *Sierra* (Fig. 3): Pichincha and Imbabura provinces, in the surroundings of the capital of Quito. Five villages were selected for the survey about local perception of forest cover change and ecosystem service and goods: Jatumpamba (site 1, Pichincha province, north of Quito, 0°10'53.46"N, 78°27'32.02"W), Curipogio and Santa Marianitas (site 2, Pichincha province, NW of Quito, 0°09'03.03"N, 78°35'41.85"W), Santo Domingo de Ichubamba (site 3, Pichincha province, SE of Quito, 0°24'53.76"S, 78°23'20.81"W), Minas Chupa (site 4, Imbabura province, north of Quito) and Bellavista (site 5, NW of Quito). The study on climate change perception was conducted in San Augustin, Pichincha. The study areas were mainly selected based on their proximity to natural forests. This enabled to study the interaction between the community and the ecosystem and the goods and services it provides. Another selection criterion was the already established relationship between the Cambugán Foundation (non-governmental organization working with ecosystem management around the study area) and these villages. It is worth noting that conducting interviews as a third party often requires some time to build up a relationship with the community to gain trust among the respondents.

Figure 3. Map of the northern Ecuadorean Sierra with the selected study sites marked in red; 1 Jatumpamba, 2 Curipogio/Marianitas, 3 Santo Domingo de Ichupamba, 4 Minas Chupa, and 5 Bellavista (source: http://www.freeworldmaps.net/southamerica/ecuador/ecuador-geography)

In terms of altitude, the areas range from ca 1 200 to 3 000 m.a.s.l. (meters above sea level). The climatic zones range from montane cloud forest to páramo grasslands with differences in precipitation, topography and soil characteristics. In the *Sierra*, the rainy season normally starts in October and ends in March with an average precipitation of 1 500 mm per year. The variation in seasonal temperature is small in this region, but the daily fluctuations can be big (MAE, 2005). The lower montane cloud forests are typically more humid and warm compared to the drier and cooler high-altitude areas. Consequently, the landscape and forest cover (Fig. 4) as well as the main cultivated crops differ between the study areas.

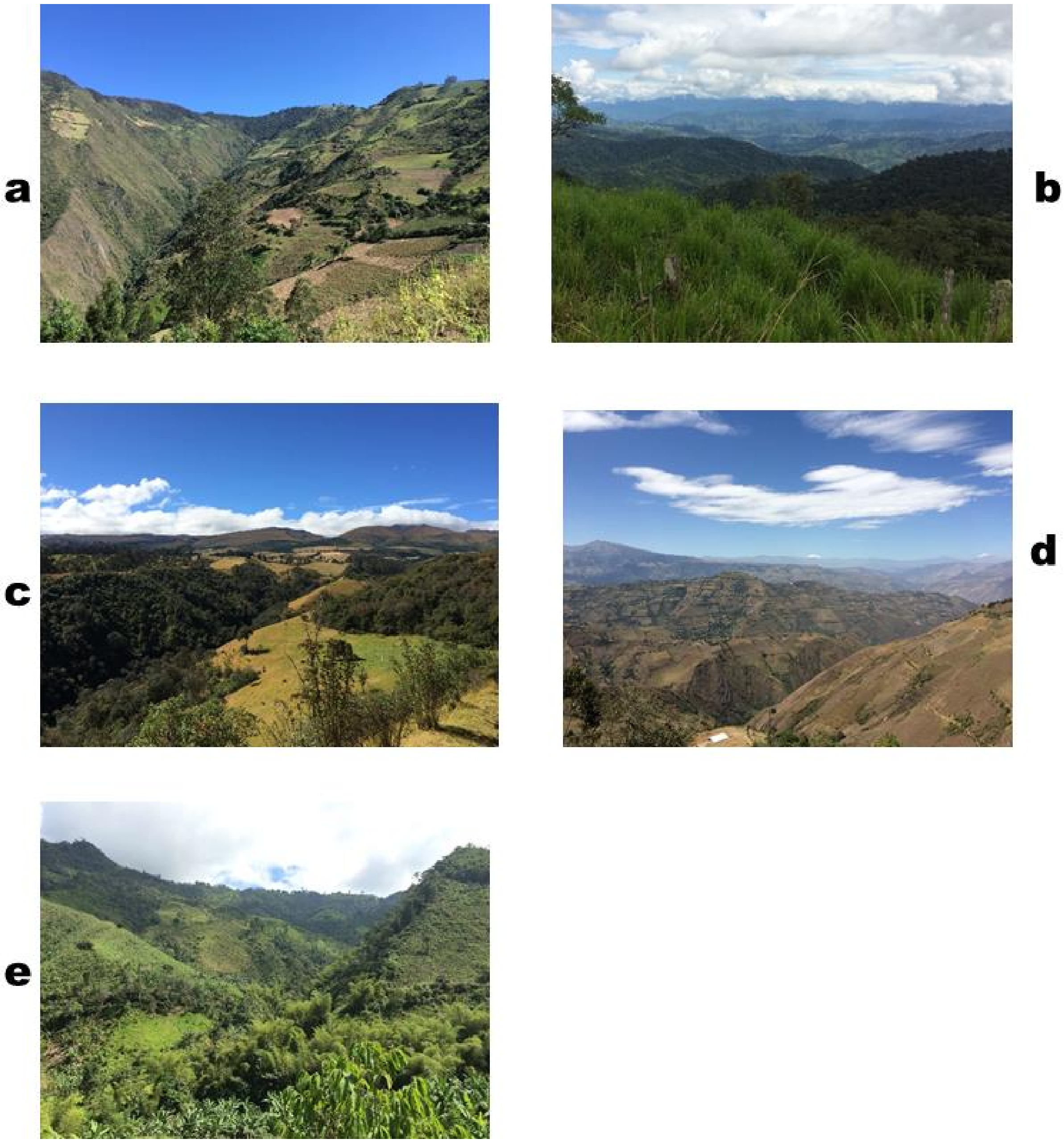


Figure 4. Overview of the different sites selected for the study: a) Jatumpamba, b) Curipogio,c) Santo Domingo de Ichupamba, d) Minas Chupa, and e) Bellavista

In the higher altitudinal zones (Jatumpamba, Santo Domingo de Ichubamba and Minas Chupa), cattle-raising dominates together with cropping of potatoes, maize, wheat and amaranth. In the mid altitude regions (Curipogio/Marianitas and Bellavista), tropical crops like sugar-cane, cassava and plantains dominate. The largest forest area per household was found in Curipogio/Marianitas (Table 1) while the smallest average forest area per household was found in Santo Domingo de Ichubamba. Curipogio/Marianitas and Bellavista had the most forest owners while Minas Chupa had the fewest. The number of residents varied slightly between the villages, and they also differed in settlement, ranging from small villages to isolated farms. In one community (Minas Chupa), Kichwa-speaking indigenous people constituted most of the population.

Table 1. The frequency of respondents per community for different land use and the average size of their land.

	Frequency						
Community	**Pasture**	**Average ha**	**Crop prod.**	**Average ha**	**Forest**	**Average ha**	**Cattle herding**
Jatumpamba	11	4.2	10	1.7	8	8.7	11
Curipogio/Marianitas	13	14	11	2.3	13	34.5	12
Santo Domingo	11	5.7	8	3.5	4	3.4	16
Minas Chupa	3	8.7	8	2.6	3	5.8	17
Bellavista	8	3.2	9	3.4	10	23.7	3

3.2 Methodology

In the study presented in this thesis, focus group discussion (community workshops), semi-structured household interviews and literature review were employed to gather relevant information. The common approach of structured quantitative interviews is carefully formulated and composed questions that come in a certain order. The questions are closed, in comparison to qualitative interviews where open questions are applied, and the respondents normally choose from predetermined answers. Questions and possible answers are the same for all respondents and the aim is to be able to make comparisons between the respondents (Ryen, 2004). The main advantage of this method is the possibility to interview numerous people in a short amount time. Also, it does not require much experience of the interviewer. Another advantage is that the results can be treated statistically. Other researchers can implement the same examination and results from different time periods can be compared. However, there are also some limitations to this method. First, it is rather inflexible not able to capture unexpected events (Jacobsen, 1993). Secondly, the outline of the questionnaire, which is the most important instrument in quantitative research (Ryen, 2004), can provide difficulties and pitfalls with leading questions as an example (Jacobsen, 1993). However, this can be complimented with focus group discussion, where participants are free to express their thoughts. Participatory processes can be applied to “link knowledge systems and to build human, social, and political capitals to strengthen adaptive capacities” (Valdivia et al. 2010). According to Lippe et al. (2011), participatory methods can integrate local knowledge and perspectives into science-based modelling methods, and together solutions for environmental problems could be developed. It is beneficial for both communities and scholars to participate in the research process through a bottom-up approach (Pretty, 1995). Some benefits recognized are: local input ensures that measured indicators are locally important and can develop over time as the surroundings change. It also increases the possibility that the project continues afterwards. Another advantage is that local participation may support the community to address future challenges, which may be of greater importance than the outcomes of the project itself (Fraser et al. 2006).

The purpose of semi-structured interviews is to generate statistically generalizable knowledge (Ryen, 2004). Consequently, a random selection of representative respondents of the population is important. Even a small sample size is appropriate for statistical generalization if the respondents are selected by random and the results quantified (Kvale & Brinkmann, 2009). A common practice in quantitative methods is to make a random selection of respondents on the basis of e.g. address or telephone number, where the questionnaire is sent out in paper form. However, since the infrastructure in Ecuador is not so well developed, the Cambugán Foundation supported with selection of villages, solving practical issues as well as assisting in conducting interviews throughout the research process. During the first two weeks of the field study, two sites not included in the study, were visited to get familiarized with the organization's work and with the cultural context. A few pilot interviews were performed to test the questionnaire and the questions were reworked and adjusted. Finally, five villages (communities) were selected to conduct the study. Each community were visited once during roughly a week due to lack of time. Similar studies are usually carried out during longer periods of time and often with several visits to the same village. A disadvantage of this method was the difficulty to obtain a deeper knowledge of site-specific relations and general trends of the community. On the other hand, using various study areas, as in the case of this thesis work, allows for a broader and comparative view and overall conclusions can be drawn.

The interviews were conducted from the 3rd of August – 9th of September 2016. In total, 84 households were involved regarding ecosystem services and goods and forest cover change. For local people's perception on climate change, 50 households were involved. This amounted to 134 households in total. The ideal would have been to conduct more interviews but due time limitations it was not possible. No sample of the population was chosen since the villages were small, but a random selection of the respondents was done. The selection of respondents was based on the aim to get a mixture of age and gender among the respondents. The intention was to include older than younger people to obtain a better view of how the forest cover has changed during the past decades. The respondents were chosen based on recommendations from the neighbourhood president of people with some knowledge about forest or who owned a bit of forest land. In general, the intention was to interview as many people as possible at each study site since the communities were small with few residents. Everybody we managed to get hold of, whether it was on the road, at their work or at home were interviewed. However, most of the interviews were conducted in the homes of the respondents. At each village, we stayed at the house of a community member. They helped to introduce and familiarize us with the community. At one village, we attended a parent meeting at the school where we introduced ourselves and the purpose of our visit; many interviews were carried out thanks to this event. All interviews were conducted in the respondent's native language (Spanish or Kichwa).

The questionnaire was developed based on similar studies on TEK, local perception of ecosystem services and goods and climate change (see Appendix 1). As a framework to identify locally important ecosystem services and goods, the CICES classification scheme was used and reworked according to the outputs from focal group discussion. The first part of the questionnaire dealt with the respondent's socio-demographic characteristics (gender, age, household size, ethnicity, education level, and source of livelihood) and form of ownership and extension of land, land-use history and current land-use. The second part of the questionnaire covered issues concerning perception of ecosystem services and goods, forest cover and climate change, forest management, TEK and recommendations for forest management in the future.

3.5 Data analysis

Ecosystem services and goods identified by respondents and during the focus group discussion were mapped following the CICES framework. Information from household interviews was translated into dummy variables for dichotomous response (yes or no) and into Likert scale (1-4) for more than two responses. Likewise, the demographic attributes of the respondents were also translated into numeric values. Descriptive analysis was performed to summarize the profile of the respondents and information related to local people's knowledge of ecosystem services, forest and climate changes. For examining the relationship between demographic attributes and knowledge of ecosystem services, perception of climate change and adaptation strategies, with dichotomous responses, stepwise binary logistic regression models were developed, using the forward elimination procedure. The model predicts the logit of the response variable (Y) from the explanatory variables (X). The logit is the natural logarithm (ln) of odds of Y, and odds are ratios of probabilities (π) of Y happening to probabilities ($1-\pi$) of Y not happening. The logistic model is specified as:

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_n x_{ni}$$

where β_0 is the intercept and β_1, β_2 … β_k are the coefficients of the demographic attributes (explanatory variables) x_1, x_2 … x_k. formed factor analysis was employed to identify latent dimensions underlying indicators that measured respondents' participation. Descriptive analysis was used to summarize the demographic characteristics of the respondents.

Multinomial regression analysis was performed to evaluate whether local people's perception of changes in ecosystem services was associated with their demographic attributes. The dependent variables (the answers) were assigned numerical values from 1 for the lowest to 4(5) to the highest expected change, which were regressed on the same explanatory variables according to the following model:

$$Y_i = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + error$$

where Yi is the response to perception of changes in ecosystem services, α is a constant and β are the coefficients of the explanatory variables, and x is demographic attributes of the respondents. During the model construction, variables with F values ≤ 0.050 and ≥ 0.100 were entered, and removed, respectively. All statistical analyses were made in Minitab (version 16; Minitab Inc., State College, PA, USA).

4. Results

4.1 Profile of respondents

The frequency and percentage of respondents falling into each category of the demographic characteristics are shown in Table 2. In five study sites visited, more than half (53.6%) of the respondents were women. Most respondents (44.0%) were between 45 and 65 years old. The two other age groups were almost similar in frequency (27.4% and 28.6% respectively). Many respondents (38.1%) had a household size equal to or above 5 family members, about a quarter (27.4%) had between 1 and 2 family members and 34.5% had between 3 and 4 family members. The respondents' ethnic composition showed a strong dominance of mestizos (77.4%) compared to indigenous people (22.6%). Only one of the communities selected for the study was dominated by indigenous people. The great majority of respondents (86.9%) were literate while a few respondents (13.1%) were illiterate. The dominating land tenure status was through purchase, gift or lease (79.8%), while 20.0% had inherited their land. Farming activities were the main source of income for 89.3% of the households, and 10.7% received their income from other activities.

Table 2. Demographic characteristics of respondents.

Characteristics	**Frequency**	**%**
Gender		
Male	39	46.4
Female	45	53.6
Age class		
20-45	23	27.4
45-65	37	44.0
>65	24	28.6
Houshold size		
1-2	23	27.4
3-4	29	34.5
≥ 5	32	38.1
Ehtnic group		
Mestizo	65	77.4
Indigenous	19	22.6
Educational level		
Illiterate	11	13.1
Litterate	73	86.9
Tenure status		
Acquired (purchased, gift, lease)	67	79.8
Inheritance	17	20.2
Livelihood		
Farming	75	89.3
Non-farming activities	9	10.7

4.2 Mapping ecosystem services and goods

Ecosystem services and goods in the study area identified by local people were mapped according to the CICES classification system. In total, 21 ecosystem services, which belonged to three major sections (provisioning, regulation and maintenance, and cultural services) were recognised (Fig. 5). The ecosystem services that were most frequently cited by respondents were plants with medicinal value (62 respondents), water (47 respondents), timber (32 respondents) and plants with symbolic or religious value (32 respondents). Other ecosystem services identified in the study area of the type *nutrition* were for instance: wild berries, honey and abstracted surface water from rivers. From the type *materials*: wood, timber and water harvesting were identified, and from the type *energy*: wood fuel. Ecosystem services identified of the type *mediation of flows* were for example: vegetation protection/stabilising of ecosystems, and of the type *maintenance of physical, chemical or biological conditions*, pollination by bees and other insects. From the type *spiritual, symbolic or other interaction with ecosystems*, willingness to preserve plants, animals and ecosystems for the experience and use of future generations was recognised.

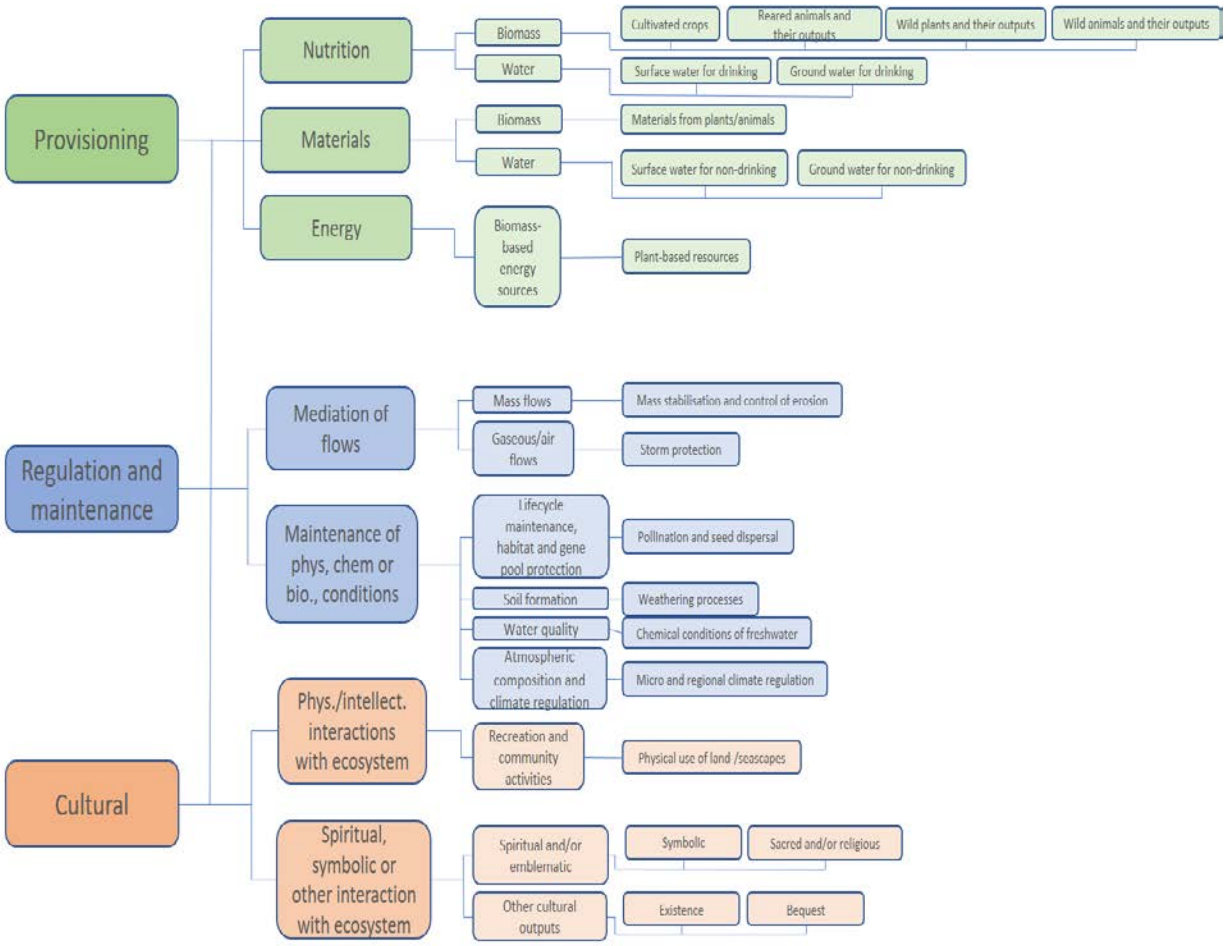


Figure 5. A map of ecosystem service sections, divisions, groups and classes identified in the study area following the Common International Classification of Ecosystem Services (CICES) scheme.

The perception of water as an ecosystem service was nearly similar between male (25 respondents) and female respondents (22 respondents), but with visible differences among age class; the highest frequency of respondents being in age class 45-65 (Fig. 6a). A difference in perception of water as an ecosystem service was also visible between communities, with highest percentage of respondents in Curipogio/Marianitas (85.7%) and Bellavista (78.6%), and lowest in Jatumpamba (23.1%). Furthermore, educational level had an impact on the perception of water as ecosystem service: many respondents among literate (44 respondents) and few respondents among illiterate (3 respondents).

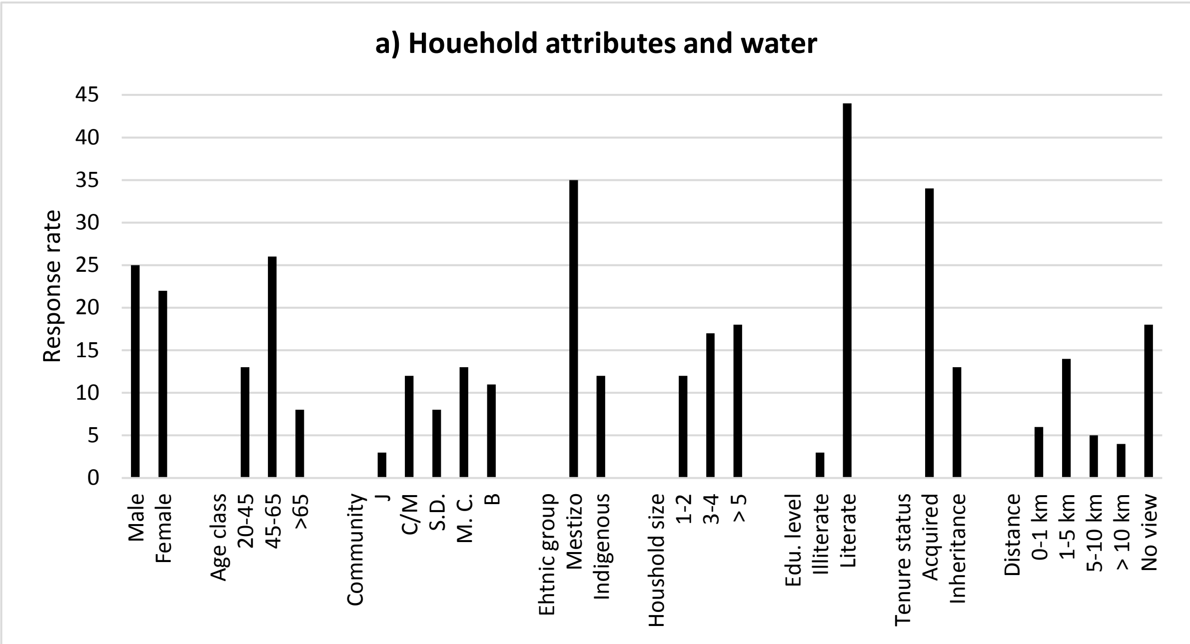


Figure 6a. Household attributes and perception of water as ecosystem service and goods.

The binary logistic regression to examine the relationship between demographic attributes of respondents and ecosystem services revealed significant relationships between water and land tenure status and distance to forest; between timber and ethnic group as well as between cultural values and age class, education level and distance to the forest (Table 3). Respondents who acquired land perceived water as ecosystem service more than those who inherited the land (Fig. 6a). Respondents who live 1-5 km away from the nearby forest were more likely to perceive water as ecosystem service than respondents living further away from the forest. The mestizos (29 respondents) perceived timber more than the indigenous people (3 respondents) as an ecosystem service (Fig. 6b). Although not statistically significant, the perception of timber as an ecosystem service tended to be more among educated than illiterate people, people who acquired land than inherited, and people who live in Santo Domingo than in other communities (Fig. 6b) while it was nearly the same between male and female respondents. The perception of ecosystem services for cultural values (like plants with symbolic or religious value) was significantly dependent on the respondent's age, educational level and distance to forest.

Table 3. Logistic regression predicting likelihood of household attributes influencing perception of ecosystem services and goods.

Variables	Coef	SE Coef	P	Odds ratio	95.0% C.I. for odds ratio Lower	Upper
Water						
Tenure status	1.445	0.778	0.049	4.241	0.924	19.468
Distance to forest	-0.553	0.203	0.004	0.575	0.387	0.856
Timber						
Ethnic group	1.751	0.810	0.020	5.758	1.178	28.154
Plants symbolic/religious value						
Age class	-1.216	0.484	0.006	0.296	0.115	0.765
Educational level	-1.969	0.701	0.010	0.183	0.046	0.724
Distance to forest	0.586	0.227	0.005	1.797	1.152	2.803

Hosmer & Lemeshow Test: Chi-square = 5.52, d.f. = 8, p = 0.700.
Hosmer & Lemeshow Test: Chi-square = 7.28, d.f. = 8, p = 0.507.
Hosmer & Lemeshow Test: Chi-square = 4.51, d.f. = 8, p = 0.809.

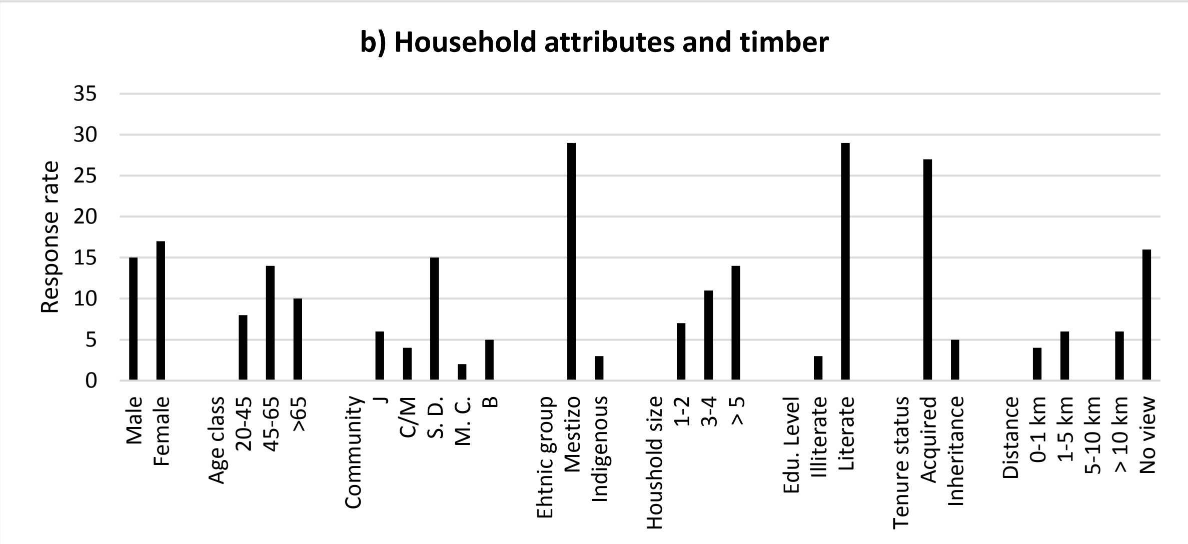


Figure 6b. Household attributes and perception of timber as ecosystem services and goods.

The knowledge of other ecosystem services (firewood, fresh air, habitat for wild flora and fauna and erosion and wind protection) showed some degree of difference among respondent's demographic attributes; albeit not statistically significant. Firewood was perceived more as service by the mestizos than indigenous people, as well as by educated than illiterate. Fresh air as an ecosystem service was perceived more by younger- and middle-age classes than the older-age class; by the mestizos than indigenous people; and by educated than illiterate people.

Habitat for flora and fauna as an ecosystem service was mentioned among few respondents in general. However, younger and middle-aged respondents had higher frequency of positive response than the older age class; mestizos than the indigenous people; educated than illiterate people, and respondents with acquired land tenure status. Perception of soil- and/or wind protection as an ecosystem service was cited by few respondents, yet a weak relationship was observable with some household attributes.

The perception of plants with symbolic or religious value (Fig. 6c) as an ecosystem service differed between genders with highest frequency among female (20 respondents) compared to male respondents (12 respondents). The frequency of responses was nearly similar among age class and distance to forest but differed between communities with highest frequency of responses in Santo Domingo (12 respondents) and lowest in Curipogio/Marianitas (3 respondents). Furthermore, educational level, ethnic group and tenure status had an impact on the perception of plants with symbolic or religious value.

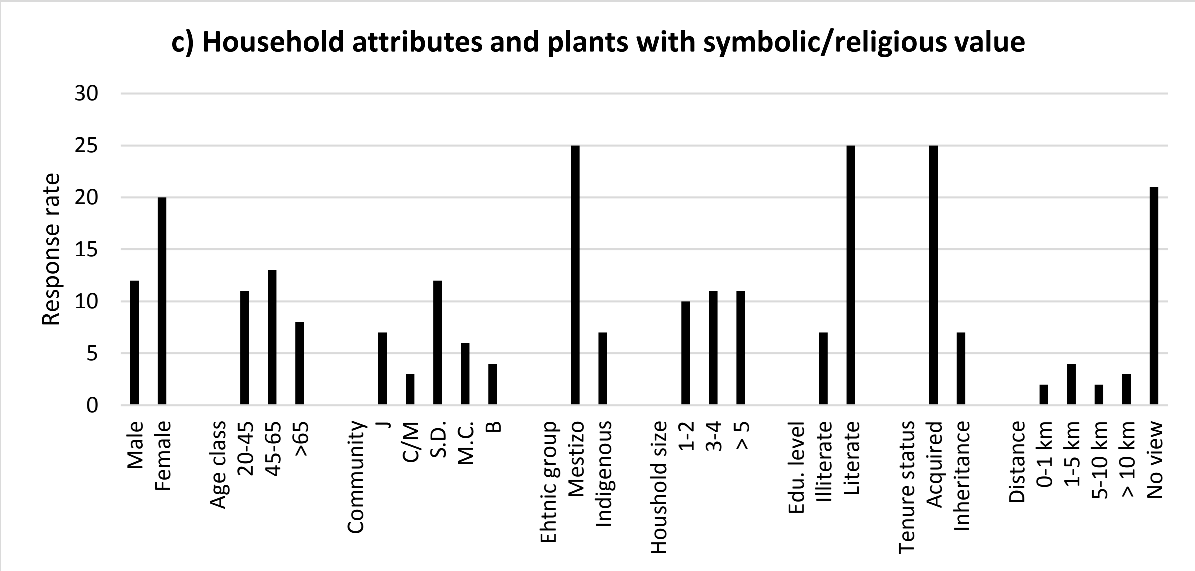


Figure 6c. Household attributes and the use of plants as symbolic or religious value.

4.3 Perception of changes in ecosystem services

Indicators of change in ecosystem services which included forest cover, tree species composition, mammal and bird abundance, and availability of forest products in relation to respondents' attributes are summarised in Appendix, S2. The perception of forest cover change differed between respondents' gender such that male respondents perceived a major change of forest cover while female respondents perceived a moderate or no change of forest cover (Fig. 7a). Moreover, there was a difference between age groups, where the middle- and the older-age classes had higher frequency of respondents, who perceived a major forest cover change, than the younger age class had the lowest frequency of respondents. The younger age class also had lower frequency of respondents perceiving moderate change and no change (Fig. 7b).

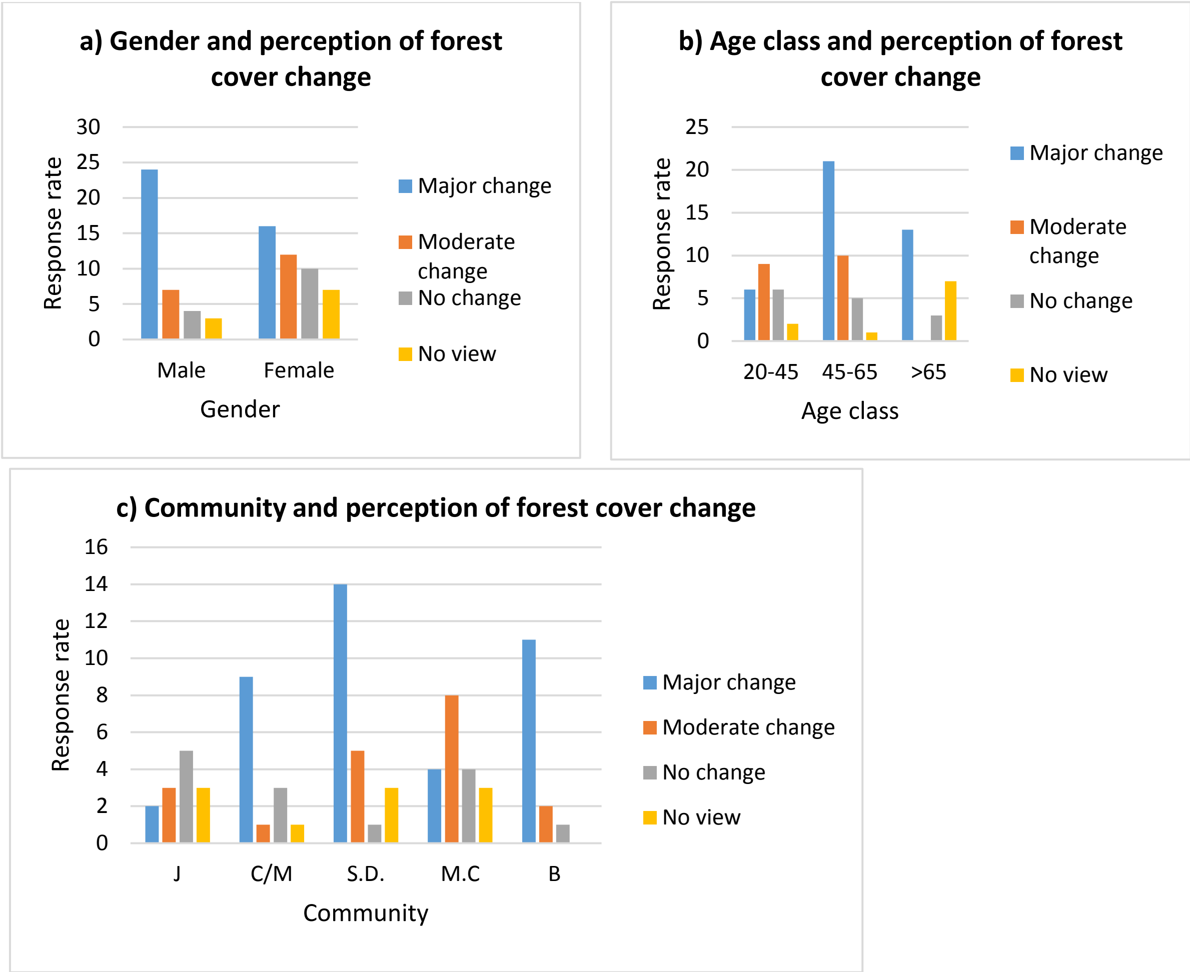


Figure 7. Perception of forest cover change by gender (a), age class (b) and communities (c).

A difference in perception of forest cover change was also visible among communities (Fig. 7c). Santo Domingo had highest frequency of respondents who perceived a major forest cover change, followed by Bellavista and Curipogio/Marianitas. Furthermore, the perception differed between ethnic groups, educational level and tenure status (Appendix, S2) The perception of trees species as decreasing or increasing differed slightly between genders (Appendix, S2). The difference was more visible among age classes. The frequency of respondents perceiving a decrease in tree spices was highest in the middle age class and lowest in the young age class. The perception also differed among communities and could be observed between ethnic groups, educational level and tenure status (Appendix, S2).

The perception of abundance and frequency of mammals as decreasing or increasing in the study area differed somewhat between respondents' gender. Female respondents perceived a decrease in abundance and frequency of mammals more than the male respondents. Moreover, the perception differed slightly between age classes where the middle-age class perceived a decrease of abundance and frequency of mammals. A small difference was also visible among communities. However, the biggest variance was found among ethnic groups, educational level and tenure status (Appendix, S2).

The perception of abundance and frequency of bird species decreasing or increasing in the study area did not differ significantly between respondents' gender (Appendix, S2). A difference was visible between age classes, where the middle-age class and the older-age class perceived a decrease in abundance and frequency of bird species more than the young age class. Moreover, the perception differed somewhat among communities. The biggest variance could be observed between ethnic groups, educational level and tenure status (Appendix, S2).

The perception of availability of forest products, as decreasing or increasing, did not differ significantly between respondents' gender and age class (Appendix, S2). However, the perception of forest products availability differed somewhat among communities (Fig. 8). Minas Chupa and Santo Domingo perceived forest products availability as decreasing more than the other communities in the study area. The perception also differed between ethnic groups and educational level (Appendix, S2).

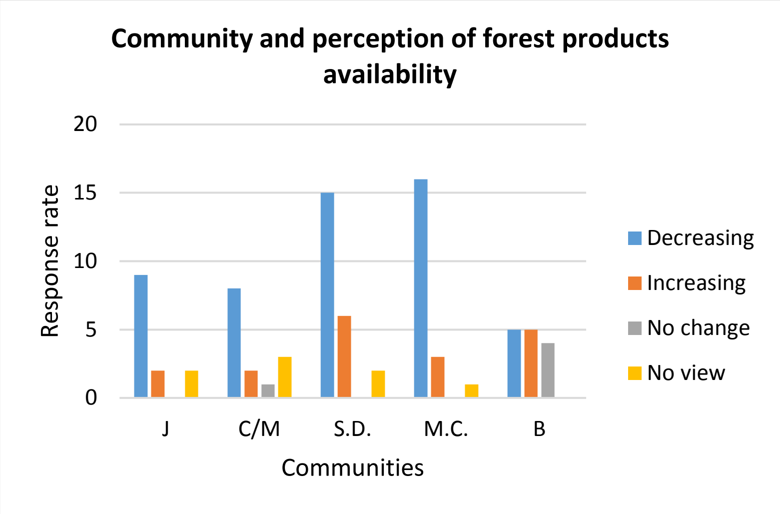


Figure 8. Perception of forest products availability in five studied communities.

Multinomial logistic regression was used to analyse the relationship between socio-demographic household attributes and the perception of changes in ecosystem services and goods. The model revealed significant relationship between perception of major change in forest cover and household attributes; namely gender, age class, ethnic group and educational level (Table 4). Educational level was most likely (9.79%) influence the perception followed by gender (7.92%). Comparing respondents' perception of "no view" with major changes in forest cover (event), the model revealed significant relationship with communities. Moreover, the model revealed significant relationship between perception of moderate change and age class and ethnic group.

Table 4. Logistic regression predicting likelihood of household attributes influencing perception of forest cover change.

Variables	**Coef**	**SE Coef**	**P**	**Odds ratio**	**95.0% C.I. for odds ratio**	
					Lower	**Upper**
Forest cover						
No change in relation to major change						
Gender	2.070	0.996	0.038	7.92	1.12	55.83
Age class	1.794	0.870	0.039	6.01	1.09	33.10
Ethnic group	-3.642	1.394	0.009	0.03	0.00	0.40
Educational level	2.281	1.152	0.048	9.79	1.02	93.60
No view in relation to major change						
Community	-0.750	0.333	0.024	0.47	0.25	0.91
Moderate change in relation to major change						
Age class	-1.169	0.575	0.042	0.31	0.10	0.96
Ethnic group	-1.753	0.864	0.042	0.17	0.03	0.94

Pearson Test: Chi-square = 195.137, d.f. = 165, p = 0.054; Log-likelihood = -81.259.

Similarly, multinomial logistic regression was used to examine the relationship between household attributes and the perception of abundance and frequency of mammals and birds (Table 5). When comparing 'no view' with decrease of abundance and frequency of mammals (event), educational level was significant. For 'no change' compared to event, gender was significant. When comparing 'increase' with 'decrease' (event), ethnic group and household members were significant for the perception of abundance and frequency of bird species (Table 5). Ethnic group was the household attribute most likely (7.79%) to influence the perception of abundance and frequency of bird species followed by household members (3.56%). For all other indicators of change in ecosystem services and goods, no significant relationship was shown with the regression model.

Table 5. Logistic regression predicting likelihood of household attributes influencing perception of changes in abundance and frequency of mammals and birds.

Variables	Coef	SE Coef	P	Odds ratio	95.0% C.I. for odds ratio Lower	Upper
Mammals decrease/increase:						
No view in relation to decrease						
Educational level	-4.019	1.638	0.014	0.02	0.00	0.45
No change in relation to decrease						
Gender	-2.715	1.292	0.036	0.07	0.01	0.83
Bird populations decrease/increase:						
Increase in relation to decrease						
Ethnic group	2.052	0.916	0.025	7.79	1.29	46.93
Household mem.	1.270	0.441	0.004	3.56	1.50	8.54

Pearson Test: Chi-square for mammals = 241.312, d.f. = 174, p = 0.001; Log-likelihood = -63.083.
Pearson Test: Chi-square for birds = 197.908, d.f. = 177, p = 0.134; Log-likelihood = -71.749.

4.4 Local perception of climate change

There were no household attributes that had a strong effect on the perception of overall warming, nearly all respondents declared an overall warming, regardless of household attributes (Fig. 9).

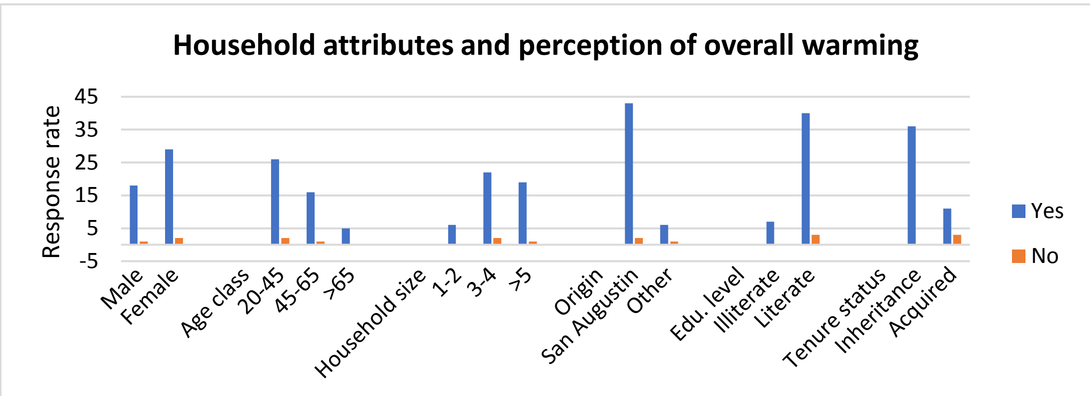


Figure 9. Household attributes and perception of overall warming in San Augustin.

Moreover, almost all respondents perceived early onset of summers and monsoons, and had observed frequent dry season fires, as well as drying up of rivers and springs irrespective of household characteristics.

There was no visible relationship between household characteristics and their perception of disappearance of wild animals that used to be common in the area (Fig. 10). The perception that wild animals had disappeared was in general high (ca 90%) among all household attributes.

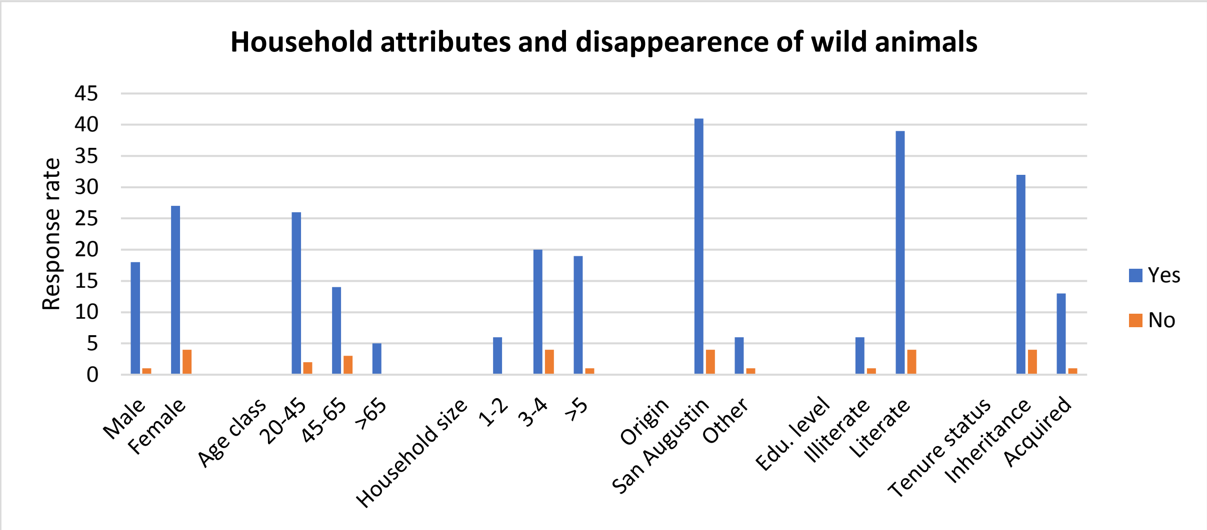


Figure 10. Household attributes and perception of disappearance of wild animals that used to be common in San Augustin

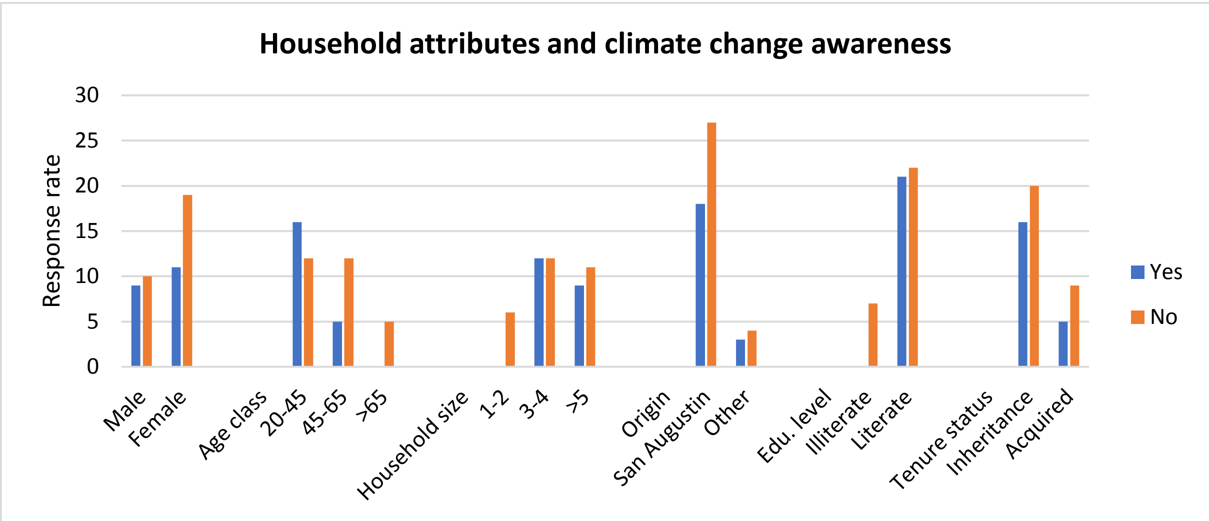


Figure 11. Household attributes and awareness of climate change in San Augustin

The perception of all other indicators of climate change is summarized in Appendix, S3. Out of the male respondents, 47.4% had heard about climate change, while among the female respondents 36.7% had heard about it. The young age class (57.1%) was more aware of climate change than the middle age class (29.4%). Among respondents older than 65 years (0%), none had heard about climate change. Moreover, there was a relationship between household size and climate change perception (Fig. 11). There was a significant relationship between educational level and climate change perception. Illiterate respondents were unaware of climate change while among literate respondents 48.8% had heard about climate change.

The respondents were asked if the climate change affects the poor (agree or disagree) and the responses differed between age classes. For the perception that climate change does affect the poor, the frequency of responses was highest among the young age class compared to the old age class where none agreed on this statement. None of the illiterate respondents agreed on the statement that climate change affects the poor, while among the literate respondents 37.2 % agreed on this statement. The relationship was similar for the statement if the climate change affects the rich. The perception that climate change affects health (agree or disagree) differed between respondents' gender. Among male respondents, 47.4% agreed on that climate change affects health while 33.3% of female respondents agreed on the statement. The perception also differed between age classes. Highest frequency of respondents was found among the young age class and none among the old age class. The statement that climate change affects food supply had the same response frequency as climate change effects on health (see above).

Climate change effects on fuelwood availability was denied by most respondents but differed somewhat between household attributes. In age class > 65, all respondents disagreed on that climate change affects fuel wood availability, in age class 45-65 (15 respondents) and in age class 20-45 (19 respondents). Moreover, educational level was related to the perception of fuelwood availability. All illiterate respondents disagreed on this statement while among the literate respondents 32 respondents disagreed. Tenure status also showed a correlation with the perception of fuelwood availability. Respondents with inherited land tenure status (26 respondents) disagreed while the respondents with acquired land tenure status 13 respondents disagreed. Climate change effect on fodder availability had the same response frequency as climate change effect on fuelwood availability (see above), where most respondents disagreed on the statement. The statement that climate change affects drinking water availability differed slightly between respondents' gender. Among male respondents 42.1% agreed while among female respondents 30.0% agreed on the statement. Furthermore, there was a correlation between age class and the perception of drinking water availability. The frequency of respondents agreeing on the statement was highest in the young age class (14 respondents) while in the old age class none agreed. Moreover, the frequency of responses agreeing on the statement differed between the household size. For the small households, none of the respondents agreed on the statement, for the middle-sized households (11 respondents) and for the large household (7 respondents) agreed. Moreover, there was a relationship between educational level and the perception of drinking water. Among illiterate respondents, none of the respondents agreed on the statement while among the literate respondents 18 individuals agreed.

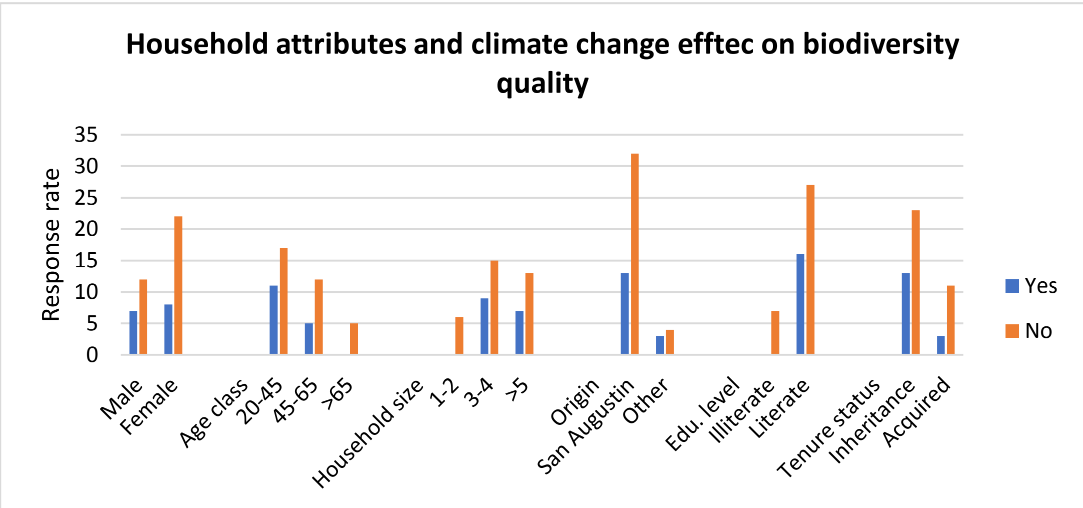


Figure 12. Household attributes and climate change effects on biodiversity quality in San Augustin.

The frequency of respondents agreeing on the statement that climate change will affect business and that climate change will cause disasters (e.g. landslide, erosion, flooding, fire) was almost equal to frequency of respondents agreeing on that climate change will affect drinking water availability (see above) and Appendix S4. The last statement concerned how climate change affects biodiversity quality (Fig. 12). There was a visible difference between respondents' gender. The frequency of responses disagreeing on the statement was higher among female than male respondents. Furthermore, there was a correlation between age class and climate change effects on biodiversity quality. The frequency of responses was higher among the young age class compared to the old age class where none agreed on the statement. Educational level was also related to this statement. Among illiterate respondents none agreed on the statement, while among literate respondents 16 respondents agreed.

Binary logistic regression was used to examine the relationship between household attributes and the perception of climate change events. The model revealed that gender, age class and education level were the key determinants influencing the perception of frequent drought because of climate changes (Table 6). Gender was the attribute most likely (5.7%) to influence this perception. For the perception of frequent storms, decrease in crop yield and new weeds as a result of climate change, age class was significant (Table 6). The household attribute influencing the perception of shortage of pastures (Table 6) was educational level according to the model. Household size was the only household attribute influencing the perception of new crop pests (Table 6) and was most likely (3.8%) to influence the perception according to the model. For all the other climate change indicators, no significant relationship with household attributes could be revealed by the model.

Table 6. Logistic regression predicting likelihood of household attributes influencing perception of climate change events.

Variables	Coef	SE Coef	P	Odds ratio	95.0% C.I. for odds ratio Lower	Upper
Perception of frequent droughts as a result of climate change						
Gender	1.742	0.885	0.035	5.706	1.007	32.352
Age class	-2.58	1.03	0.002	0.076	0.010	0.573
Education level	-3.44	1.76	0.037	0.032	0.001	26.359
Perception of frequent storms as a result of climate change						
Age class	-2.142	0.755	0.001	0.1175	0.027	0.516
Perception of shortage of pastures as a result of climate change						
Education	-2.60	1.32	0.033	0.074	0.006	0.984
Perception of decrease in crop yield as a result of climate change						
Age class	-1.658	0.692	0.010	0.191	0.491	0.740
Perception of new crop pests as a result of climate change						
Household size	1.333	0.618	0.018	3.793	1.130	12.727
Perception of new weeds as a result of climate change						
Age class	-1.322	0.679	0.035	0.267	0.070	1.009
Knowledge about climate change						
Age class	-1.592	0.585	0.002	0.204	0.065	1.641

Hosmer & Lemeshow Test: Chi-square for frequent droughts = 12.89, d.f. = 8, p = 0.116.
Hosmer & Lemeshow Test: Chi-square for storms = 3.55, d.f. = 7, p = 0.829.
Hosmer & Lemeshow Test: Chi-square for shortage of pastures = 6.21, d.f. = 7, p = 0.515.
Hosmer & Lemeshow Test: Chi-square for decrease in crop yield = 12.8, d.f. = 7, p = 0.077.
Hosmer & Lemeshow Test: Chi-square for new crop pests = 5.51, d.f. = 7, p = 0.719.
Hosmer & Lemeshow Test: Chi-square for new weeds = 2.49, d.f. = 8, p = 0.962.
Hosmer & Lemeshow Test: Chi-square = 9.67, d.f. = 8, p = 0.289

The binary logistic regression revealed significant between knowledge about climate change and age class (Table 6). Similarly, age class was related to the perception of climate change as a threat to health, food supply, and fuelwood availability (Table 7). The household attribute influencing perception of fodder availability was age class and the relationship was almost significant for ethnicity. Likewise, age class was associated with climate change effects on drinking water. Also, climate change effects on business was significantly related to age class and tenure status. Equally, age class was related the perception of climate change causing disasters (landslide, erosion, flooding, fire).

Table 7. Logistic regression predicting likelihood of household attributes influencing perception of climate change as a threat to health, food supply, fuelwood and fodder availability, drinking water, business and climate change causing disasters.

Variables	**Coef**	**SE Coef**	**P**	**Odds ratio**	**95.0% C.I. for odds ratio**	
					Lower	**Upper**
Threat to health						
Age class	-1.458	0.576	0.004	0.233	0.0753	0.719
Threat to food supply						
Age class	-1.458	0.576	0.004	0.233	0.0753	0.719
Threat to fuelwood availability						
Age class	-1.543	0.787	0.019	0.214	0.046	0.998
Threat to fodder availability						
Age class	-1.794	0.816	0.007	0.166	0.034	0.822
Origin	-2.20	1.23	0.055	0.111	0.010	1.240
Threat to drinking water						
Age class	-1.551	0.617	0.004	0.212	0.063	0.711
Threat to business						
Age class	-1.858	0.960	0.002	0.156	0.040	0.603
Tenure status	-1.973	0.918	0.017	0.139	0.023	0.840
Causing disaster						
Age class	-1.330	0.567	0.009	0.265	0.087	0.804

Hosmer & Lemeshow Test: Chi-square = 13.59, d.f. = 8, p = 0.093.
Hosmer & Lemeshow Test: Chi-square = 13.59, d.f. = 8, p = 0.093.
Hosmer & Lemeshow Test: Chi-square = 7.29, d.f. = 8, p = 0.506.
Hosmer & Lemeshow Test: Chi-square = 7.17, d.f. = 8, p = 0.519.
Hosmer & Lemeshow Test: Chi-square = 12.22, d.f. = 8, p = 0.142.
Hosmer & Lemeshow Test: Chi-square = 9.51, d.f. = 8, p = 0.301.
Hosmer & Lemeshow Test: Chi-square = 12.04, d.f. = 8, p = 0.149

4.4 Management suggestions by local people

4.4.1 Climate change adaptation

The respondents were asked what their main strategies were to adapt to climate change-related problems (Fig. 13). In general, the frequency of responses was very low. However, the strategies most frequently cited was: reintroduction of native species (6 respondents), tree planting (6 respondents) and cultivation of different crops (4 respondents). When using binary logistic regression, no significant relationship was found between household attributes and the different adaptation strategies. The only exception was for no adaptation method used, where age class (p = 0.002) was significant.

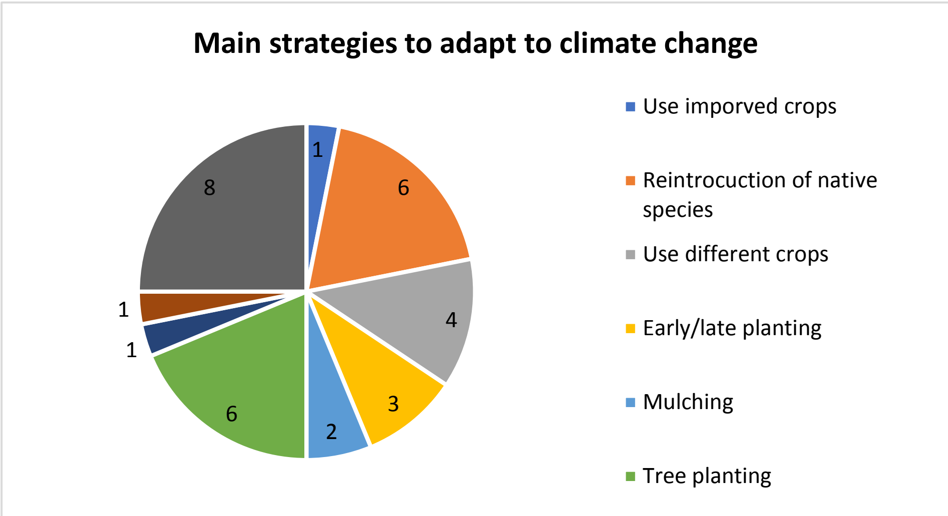


Figure 13. Strategies to adapt to climate change in San Augustin.

4.4.2 Problems with climate change adaptation

The respondents were asked what the main problems were for climate change adaptation (Fig. 14), and the frequency of responses was low. Yet, the problems most frequently cited was lack of knowledge on adaptation methods (17 respondents), inadequate information regarding climate change (14 respondents) and lack of funding to acquire modern techniques (11 respondents). Binary logistic regression showed a significant relationship between lack of adaptation methods and age class (p = 0.032). Similarly, age class (p = 0.002) was significantly related to the statement that inadequate information regarding climate change is a problem.

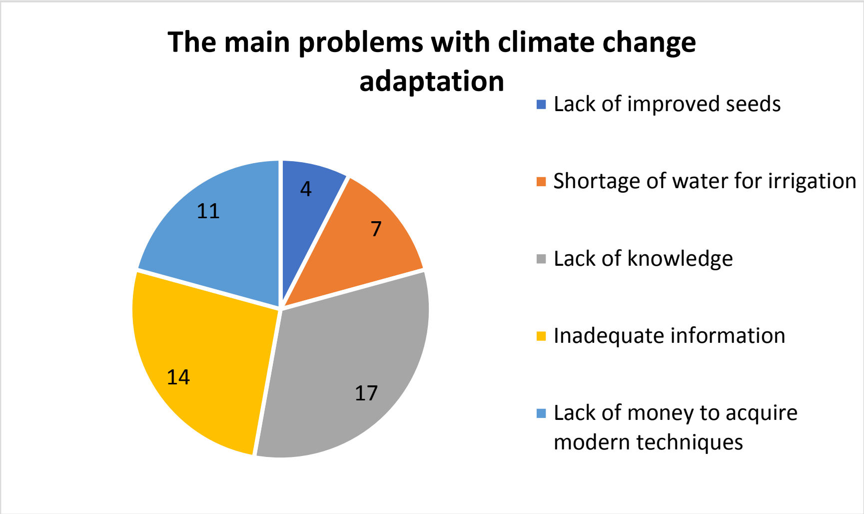


Figure 14. Main problems with climate change adaptation in San Augustin

4.4.3 Solutions to climate change adaptations

The respondents were asked how the mentioned problems could be solved (Fig. 15). The most frequently cited method (15 respondents) was active collaboration of the three given alternatives; establishment of a village development body, local NGOs in collaboration with the villagers and collaboration with local and central government. Willingness to participate in the village development strategy was higher among male (47.4%) compared to female respondents (35.5%). Moreover, there was a relationship between age class and willingness to participate. The young age class were more willing to participate than the middle age class, and in the old age class none were willing to participate. For household size, the willingness to participate was highest among middle sized household followed by large households while among the small households none were willing to participate. A relationship was also visible between educational level and willingness to participate in the development strategy. The literate respondents were more willing to participate compared to the illiterate respondents where none were willing to participate. When using binary logistic regression, the relationship was significant between age class ($p = 0.030$) and active collaboration of the three mentioned alternatives.

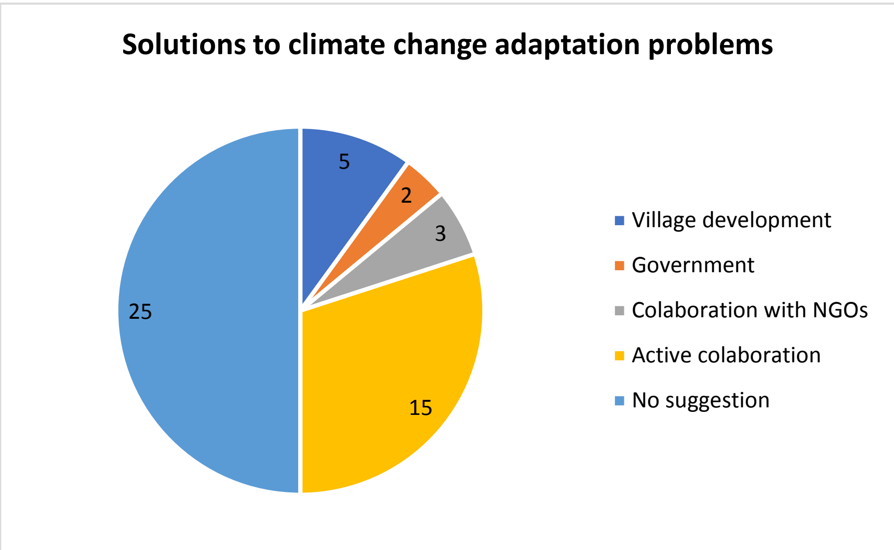


Figure 15. Solutions to climate change adaptation problems in San Augustin.

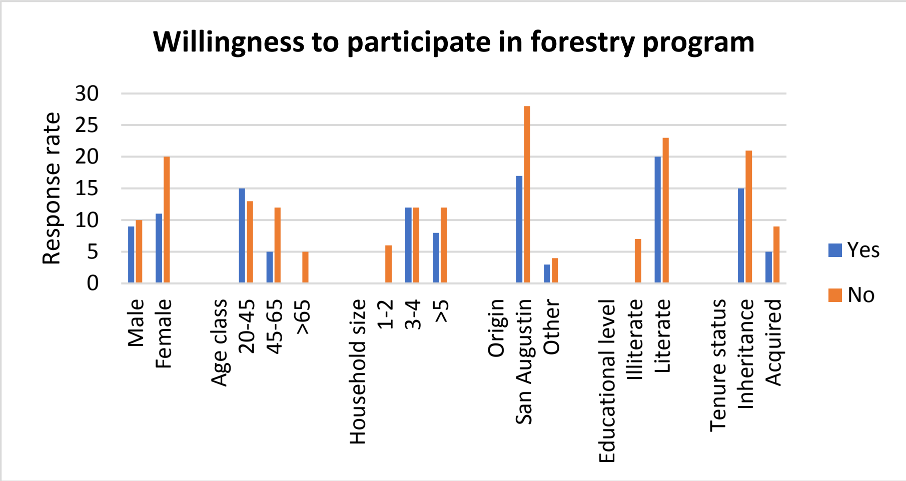


Figure 16. Household attributes and willingness to participate in forestry programs in San Augustin.

4.4.4 Participation in forestry program

To examine the respondents' interest in participating in an afforestation program, they were asked to share the amount of money and time they were willing to spend. Out of the 50 respondents, 21 were willing to participate in the program (Fig. 16). The interest differed somewhat between gender: male respondents (47.4%) were more willing to participate than female respondents (38.7%). Moreover, the interest was related to age class and household size. The young age class were more willing to participate than the middle age class while none in the old age class were interested in participating. For household size, the interest was higher among middle-size households than large households while in the small households none were willing to participate. Furthermore, educational level was related to willingness to participate. Among illiterate respondents none were willing to participate while all literate respondents wanted to participate. However, the binary logistic regression revealed significant relationship between age class and the willingness to participate in in an afforestation program (p = 0,002) and village development strategies (p = 0.004). Similarly, age class was the only significant (p = 0.002) household attribute related to the question if elected members of the village should be responsible in managing climate change adaptation strategies in the village.

Most of the respondents (18 respondents) were willing to pay between 1.0 and 5.0 US$, two respondents were willing to pay between 6.0 and 10 US$ and one respondent was willing to pay more than 20 US$. There was a correlation between age class and willingness to pay (1 to 5 US$) for participation. The willingness was higher among the young age class than the middle age class, while none among the old age class were willing to pay. Educational level was also related to the amount of money (1 to 5 US$) the respondents were willing to pay. Among illiterate respondents none were willing to pay 1 to 5 US$, while the literate respondents (18 respondents) were willing to contribute with the same amount.

The respondents were also asked how many times they were willing to pay the given amount of money. Most of the respondents (12 respondents) were willing to pay one time, eight respondents were willing to pay five times and one respondent were willing to pay 10 times. Moreover, they were asked for how long they were willing to pay. Most of the respondents were willing to pay one year (19 respondents) and two respondents were willing to pay more than one year for the afforestation program.

4.4.5 Recommended measures for conservation of flora and fauna

The respondents were asked if they take any measures to conserve the plant species of the forest. Most respondents (52 respondents) answered that no actions were taken. 27 respondents said that they let the forest recover and 3 respondents said that they plant trees for biodiversity conservation. Moreover, the respondents were asked if they take any measures to preserve wild mammals. Similarly, most respondents (40 respondents) said that no measures were taken. Conserving the forest was the strategy for 21 respondents, and some respondents (17 respondents) said that prohibit hunting is a good method. Furthermore, they were asked if they take any measures to preserve bird species. Again, most respondents (37 individuals) said that no actions were taken. Prohibition of hunting (22 respondents) was the second most frequent response and thereafter conserving the forest (16 respondents).

Many respondents (27 respondents) considered biodiversity conservation as important in general. Some respondents (15 respondents) considered biodiversity conservation important for the fauna. Others said that protection of the forest is important (7 respondents), and a few considered forest products as the most important thing to preserve. Some respondents (5 respondents) considered that animals cannot be conserved.

4.4.6 Forest management and methods used

The respondents were asked how they manage their forest land (Fig. 17), and 55% of the respondents stated that they have forest land. Among them, the most frequently used management methods was to cut some trees or tree species (13 respondents), to conserve the forest without any management (12 respondents), or to cut everything (8 respondents).They were also asked how they transmit the knowledge of forest management between generations. The most frequently used method was through both oral and practical ways (10 respondents) followed by practical ways (9 respondents).

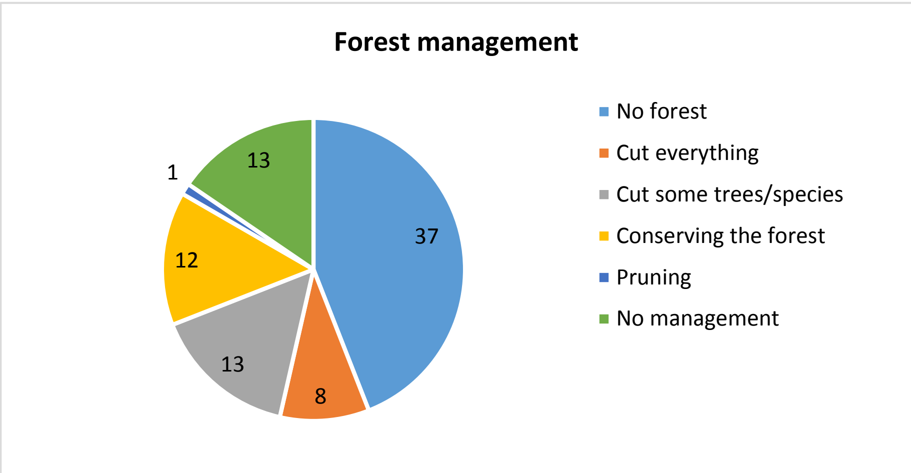


Figure 17. Most frequently used forest management methods

4.4.7 Tree species for future plantation

The respondents were asked to recommend tree species for future plantation to conserve biodiversity. For all communities, the most frequently cited tree species was alder, followed by cedrus and puma maqui (Table 8).

Table 8. Most frequently mentioned tree species recommended for future plantation for all communities.

Tree species (common name)	**Frequency**
Alder	38
Cedrus	26
Puma maqui	13
Eucalyptus	12
Laurel	10
Teme	8
Avocado	8
Quijoar	8
Guayacán	7
Roble	7
Arrayán	7
Motilón	6
Pagchi	5
Pine	5
Cypress	5
Yalomán	5

5. Discussion

5.1 Overview of ecosystem services and goods

The results from the field study show that several ecosystem services and goods can be found within the study sites. All communities recognize the provisioning services: nutrition, materials and energy, e.g. cultivated crops, drinking water and different types of biomass. Regulation and maintenance, such as mediation of flows and maintenance of physical and biological conditions, were recognized in most communities to some extent. Moreover, cultural services, such as physical and symbolic interaction with biotic ecosystems, were found in all communities. The number of indicators differed among the study sites. Nevertheless, respondents in all communities have good knowledge of some or all ecosystem services assessed. A similar study from Nepal regarding assessment and mapping of ecosystem services, showed priority ecosystem services in line with the results from this study (Paudyal et al. 2014). The priority ecosystem services identified were timber, firewood, freshwater, carbon sequestration, water regulation, soil protection, landscape beauty and biodiversity. The study also revealed strong divergences in the valuation of ecosystem services between local people and experts, between gender and between different status and income classes in the studied communities. Another study from the Ecuadoran Amazon concluded that the perception of ecosystem services varies in relation to socioeconomic characteristics, cultural background, lifestyle and benefits obtained from the forest (Caballero-Serrano et al. 2017). Many respondents in the mentioned study stated that ecosystems provide many services and nearly all respondents stated that ecosystem services contributed to their well-being. In correspondence with the results from the present study, most of the ecosystem services identified were in the provisioning section, such as water, wood and medicinal plants. The study highlighted the importance of identifying social groups within a population and understanding their specific characteristics before developing conservation and land use planning policies (Caballero-Serrano et al. 2017). Mapping and assessment of ecosystem services and goods is important for policy development concerning water, climate, agriculture, forest and regional planning. It is also relevant for planning and implementation of individual projects to have access to reliable and comparable data (EC, 2014). Increased biodiversity can lead to an increase of several ecosystem services and greater resilience in forest ecosystems. Hence, vital ecosystems will improve or preserve the flow of ecosystem goods and services that the system is capable of producing (Thompson et al. 2011).

From the mapping of ecosystem services and goods, some ecosystem services were chosen to examine local peoples' perception of their importance in relation to household attributes. No big differences could be observed for most ecosystem services. However, the statistical model revealed variations in the perception of some ecosystem services depending on household attributes. The most frequently cited ecosystem services were water, timber and plants with symbolic or religious and medicinal value. The perception of water as an ecosystem differed between age classes with age class 45-65 showing the highest frequency of response. The distance to the forest also influenced the perception of water as an ecosystem service and was statistically significant. People living close to the forest (1-5) km perceived water as an ecosystem service more than those living further away from the forest. The perception of water as an ecosystem service also differed between the communities. Communities with good access to water (Curipogio and Bellavista) had the highest percentage of respondents perceiving water as an ecosystem service compared to communities where water scarcity was an issue. Communities with good access to water also had more forest in the surroundings which shows the direct consequences of forest felling. It is also worth mentioning that there is a tendency for the respondents to answer what they see in their surroundings. If the access to water is good in a certain community, the respondents will most probably spontaneously think of water as an important factor. The subjectivity of the respondents is something that should be kept in mind when interpreting the results from the survey.

Cultural services, such as plants with symbolic or religious values, were more frequently used among female (50.0%) than male (30.8%) respondents. The statistical model also revealed that age class, education level and distance to forest influenced the perception of plants with symbolic or religious values as an ecosystem service. The pattern was the same for plants with medicinal value, where female respondents (87.5%) used medicinal plants to a greater degree than male respondents (69.2%). The visible difference between respondents' gender could be due to the strong gender roles in these rural communities. The women often stay at home taking care of children and household activities while the men are working on the farmland or outside the village.

5.2 Perception of changes in forest cover and ecosystem services and goods

To examine local people's perception of forest cover change, the respondents were asked "How much of the land had forest since you were a child?". The question was explained as how much the forest cover has changed during this period. A forest cover decrease of 100-50% is considered a major change, while a decrease of 50-0% is considered a moderate change. Although the question may be difficult to interpret, the estimation of how much the forest cover has changed is a subjective assessment and could be complicated for an untrained eye, it still provides an idea of a major or moderate change within the area. It would have been interesting to compare the respondents' perception of forest cover change with remote sensing analyses of forest cover change to make the interpretation of forest cover patterns more robust, but that is beyond the limitations of this study. The perception of forest cover change differed somewhat between male and female respondents. Male respondents (63.2%) perceived a major forest cover change compared to female respondents (35.6%). Moreover, there was a visible difference between age classes. This was also shown in the logistic regression analysis where age class showed a significant relation with forest cover change when comparing no change with major change, and moderate change with major change. The young age class perceived a moderate change or no change to a greater degree than the other two age classes. This divergence could be interpreted as that the greatest deforestation in these areas took place a few decades ago and that deforestation rates has decreased in recent years. Nevertheless, deforestation rates in Ecuador are still high – the forest cover declined from 49.9 to 38.9 percent between 1990 and 2011 (FAO, 1014) – but deforestation is currently taking place mostly along the coast and in the Amazon region. The perception that the forest cover has changed greatly is therefore lower among younger respondents. Furthermore, the perception of forest cover change differed between communities where the perception of a major change was highest in Santo Domingo, thereafter in Bellavista and Curipogio/Marianitas. However, the standing forest was much higher in the two last mentioned communities than in Minas Chupa and Jatumpamba where the perception of forest cover change was lower. The forest cover has most probably declined since far back in time which could explain why the change was perceived as less dramatic. In a study from Uganda regarding livelihood typologies influence on local perceptions of forest cover change, a significant relation between forest cover change and livelihood typologies was found (Twongyirwe et al. 2017). Most respondents perceived a decline in forest cover. However, in contrary to the results from this study, younger people were more likely to think of the forest as declining compared to the older age classes. The conclusion was that other factors, such as education level and wealth status, are important in shaping perceptions and knowledge on forest cover change (Twongyirwe et al. 2017).

The respondents were also asked about how the flora and fauna had changed. Most respondents perceived a decrease in tree species. The middle age class perceived a change more than the young age class which, again, could be interpreted as that the tree species disappeared further back in time when the greatest deforestation took place. More than half of the respondents perceived a decrease in abundance and frequency of mammal and bird species. The middle age and the older age class also perceived a decrease in abundance and frequency of bird species more than the young age class.

However, the biggest difference of changes in flora and fauna was observable among ethnic groups, educational level and tenure status. The statistical model revealed that the household attributes most likely to influence the perception of change in abundance and frequency of mammals was educational level and gender. For the perception of change in abundance and frequency of birds, ethnic group and household members were significant according to the model. Many respondents also perceived a decrease in forest products availability. Respondents from Santo Domingo and Minas Chupa perceived a decrease in forest products availability more than respondents from the other communities. Correspondingly, Santo Domingo was the community with most respondents perceiving a major forest cover change.

5.3 Perception of climate change

Almost all respondents in San Augustin perceived an overall warming, irrespective of household characteristics. All respondents also perceived drying up of rivers and springs, regardless of household attributes. Other climate change indicators that had a high frequency of responses was early onset of summer and monsoons and frequent dry season fires, irrespective of household characteristics. Nevertheless, when the respondents were asked if they had heard about climate change, the response frequency was lower. The male respondents (74.4%) were more aware of climate change compared to female respondents (36.7%). It is predicted that climate change will affect gender differently depending on their roles and responsibilities in the household and community (UNDP, 2010). Climate change will have greater effect on women than men since women are often poorer and less educated and often excluded from political and household decision-making processes. It is thus important to incorporate a gender perspective into climate change adaptation efforts (UNDP, 2010). The results also revealed a clear distinction between age classes with regard to awareness of climate change. A majority of young respondents (57.1%) had heard about climate change compared to none in age class >65. This may be related to educational level, where none of the illiterate respondents had heard about climate change while literate respondents (48.8%) was more aware of climate change. Most illiterate respondents are found in the middle age and old age classes. One explanation could be that older and illiterate respondents perceive an overall warming, but are not aware of what it means in a broader context due to lack of education and information. A study on local perception of climate change and adaptation in mangrove areas of the Cameroon Coast concluded that almost all respondents (>90%) had heard about climate change (Din et al. 2016). However, there was a big difference between gender, only 17.8 percent of the women perceived climate change in their area compared to 82.2 percent of the men. Similar to the results of this study, the young age class were more aware of climate change than the older age classes (Din et al. 2016).

Most respondents did not believe that climate change will affect their livelihood, e.g. food supply, availability of fuelwood, fodder or drinking water nor that it will cause disasters such as flooding and fires, or affect biodiversity. However, when they were asked about their perception of changes in climate most respondents had experienced that type of events. It may seem contradictory that they experience extreme weather events, but do not associate it with climate change. It has been shown that local people’s perception of climate change can be shaped by personal experiences of short-term weather fluctuations (e.g. actual outdoor temperature), rather than long-term climate changes (Reyes-García et al. 2016). Consequently, they may not perceive these weather events as an effect of climate change, but rather as fluctuations in weather, and therefore do not believe that climate change will affect their livelihood. Furthermore, there is a risk that local observations of climate change reflect unusual rather than average patterns and occurrences (Reyes-García et al. 2016). Yet, regional projections of climate change are a prerequisite for local adaptation strategies to be developed and implemented (Marengo et al. 2009).

5.4 Management suggestions by local people

Many respondents did not take any measure to adapt to climate change. However, the most frequently used methods were reintroduction of native species, cultivation of different crops and tree planting. The absence of adaptation measures may be due to the fact that lack of knowledge about adaptation methods together with inadequate information regarding climate change, which were mentioned as main problems with climate change adaptation according to the respondents. To solve these problems most respondents (15 individuals) believed that active collaboration of a village development body, with villagers, local NGOs, and local and central government were the best solutions.

The respondents were also asked if they were willing to participate in a forestry program and how much money and time they were willing to spend on the program. Less than half of the respondents (42%) were willing to participate. The interest was bigger among male than female respondents, and the interest was also significantly greater among young respondents. Most respondents wanted to pay the lowest proposed amount of money and time. One important factor that influences the respondents' adaptive capacity is their socioeconomic situation. Their main concern is not biodiversity conservation or climate change issues but rather subsistence, and their interest in conservation programs may be limited. However, the 'Social Forest Programme' (Socio Bosque) developed by the Ecuadorian government provides monetary incentives to participate in the programme. Nevertheless, the economic condition of the state is tough, and the lack of funds will most probably affect the work with biodiversity conservation. The latest information on the 'Social Forest Programme' is that the payments to forest landowners have been suspended due lack of government funds.

Regarding management suggestions by local people to conserve flora and fauna, most respondents stated that no measures were taken. However, among the respondents who actively contributed to conservation efforts, conserve the forest or let the forest recover were the most frequently used approach. Many respondents also stated that the fauna will be conserved by prohibiting hunting. Again, lack of knowledge and information about management measures to conserve biodiversity is probably a reason to why few measures are taken. The three most recommended tree species for future plantation were similar for all five communities: alder (38 individuals), cedrus (26 individuals) and puma maqui (13 individuals). Biodiversity conservation conventionally focuses on protecting threatened rare species. However, the respondents highlighted the wish to conserve the most common and useful trees that had decreased in the area. This is somehow in line with results from other studies stressing that local conservation priorities concern species of practical use (Lykke et al. 2004; Stave et al. 2017). In general, there was a great interest for planting trees among the communities; about 91 percent stated that they would like to plant trees in the future given assistance and advice concerning plantations is available. Some of the communities had received assistance from the government in terms of advice and plant material but the plantations had failed. They required more expert advice, especially about how to preserve ground water by planting trees, since lack of water is a great issue in some communities.

5.5 Traditional ecological knowledge

The TEK systems are comprised of local knowledge of species and the environment, resource management practices, and beliefs about how humans relate to ecosystems. Local people have the capacity to observe changes in ecosystems due to their proximity to nature (Berkes, 2000). The respondents recognised a relatively high number of tree and plant species, mammals and birds which indicates a fairly high level of local biodiversity knowledge. Many respondents were also aware of the importance of biodiversity and biodiversity conservation. However, the results of the study indicate that knowledge of resource management was somewhat limited. It is difficult to determine if the communities suffer loss of traditional knowledge, or if this knowledge never has been particularly strong historically in these communities. A review by Tang and Gavin (2016) compiled the evident threats to TEK, e.g. loss of traditional language, believes and land use. Some of their examples are also visible in the study areas selected for this thesis, for example younger generations' migration to the cities, dependence on modern products and/or technologies and the use of westernised primary production systems such as cattle ranching. Loss or perceived changes in TEK is a global phenomenon and there are numerous studies from various academic disciplines showing degradation of TEK (Tang and Gavin, 2016). The drivers of change in TEK were not studied in the present study, but it is a subject that would have been interesting to look deeper into. However, a study by Harisha et al (2015) examined TEK and its importance in India and the reasons behind changes in TEK. The study revealed that modernization is one of the major drivers of change in TEK, e.g. infrastructure, communication technologies, lifestyle change and change in food habit and that the use of wild plants is associated with shame and poverty (Harisha et al. 2015). Most of these changes could probably be applied to the Ecuadorian context as well, above all modernization and migration and occupation change. Many people move into the cities to find better living conditions and employment or education opportunities.

The importance of integrating TEK into forest biodiversity conservation has been stressed (Charnely et al., 2007). For this to be successful, the knowledge holders, together with scientists and forest managers, should be actively involved in these efforts. The joint efforts are considered to provide a greater understanding of the natural environment and the conservation of biodiversity. The integration of TEK into forest biodiversity is also dependent on the perseverance and flourishing of this knowledge (Charnley et al. 2007). Even though the results from the study indicates that the use of TEK may be limited within the study areas, local people are good observants of changes in local ecosystems and have knowledge of local species, information that should not be underestimated.

5.6 Limitations of the study

The ecosystem services found within the studied communities are based on subjective assessments on the basis of the CICES scheme. This means that the research includes personal assessment which increases the risk of bias in the results. The results are also based on the respondents' spontaneous answers and their associations to ecosystem services and goods of what they find in their surroundings. Furthermore, each of the area were visited just once. Several visits to each study site gives the opportunity to strengthen the results and to account for seasonal variations in flora and fauna, weather fluctuations etc.

No focus groups discussions with forest managers or environmental experts were held which is common practice in this type of studies. It would have been valuable to consolidate the results from the surveys and the assessment with CICES of ecosystem services and goods. Another limitation is language difficulties. One of the areas (Minas Chupa) is dominated by indigenous people whose native language is Kichwa. This required an interpreter during some of the interviews, which in turn may have affected the responses. There were some problems with the interpretation in some cases.

However, the method used, a questionnaire with possible answers, is a good method when the study requires many respondents in a shorter time period, as in this case. It gives an indication of people's perception and allows for comparisons to be made between different communities and household characteristics. The sample may be considered small, a bigger number of respondents is desirable for this type surveys to be able to make statistical analysis of the material with reliable outcomes. However, the number of respondents in the study still gives an insight into the overall trend of local people's perception. The results would probably not change that much with a bigger sample size, though the results should be interpreted carefully. The residents in the studied villages were too small to make sampling, everyone that were willing to participate were interviewed. Although no population sampling was made, in the end, a relatively good range of diverse respondents regarding gender and age class was achieved. At the same time, a trade-off is necessary between the number of questions posed, and the time the respondent is willing to spare and still keep concentration and provide useful answers. The interviews were not recorded, which in retrospect would have been a good idea. Most of the interviews were carried out by two persons, one person asking the questions and one person taking notes. Even if the questions were closed, some respondents gave further information about how, for example, the community had developed over time, causes of land use change and other information that would have been valuable.

6. Conclusion

In this thesis, local people's perception of changes in forest cover, ecosystem services and goods and climate were examined with the objective of generating evidence that supports efforts to conserve biodiversity and restore degraded ecosystems in the face of climate change in Ecuador. The study revealed that most of the ecosystem services mapped using the CICES scheme can be found within the study sites. However, the supply of ecosystem services and goods seems to be diminishing. Forest products availability and the abundance and frequency of plant species, mammals and birds is decreasing according to the local people's perception. The study also revealed that knowledge of ecosystem services and goods and perception of their change depends on demographic attributes and proximity to the forest to some extent. Furthermore, local people perceive changes in forest cover and the perception depends on their demographic attributes. The perception of change is most visible among the middle age and old age class and less observable among the young age class which indicates that the greatest forest degradation took places a few decades ago. Additionally, local people perceive changes in climate events. Almost all respondents perceive an overall warming, regardless of demographic attributes. Likewise, there was consensus around some of the other climate change indicators, nearly all respondents perceive early onset of summers and monsoons, frequent dry season fires and drying up of rivers and springs. However, regarding climate change awareness and the effects of climate change, demographic attributes had an impact on the perception. Furthermore, the study showed that there are some local adaptation mechanisms to climate change events. Though, the adaptation mechanisms are not widespread and only used by a few respondents. The most frequently used methods are reintroduction of native species and tree planting. Lack of knowledge and information was stated as the reason for not taking any measures. Moreover, the interest to participate in a forestry program was weak. Most respondents do not take any measures to conserve the flora and fauna of the forest. Out of the respondents who owned a bit of forest land, most of them do not manage their forest or cut just a few trees/species. Yet, many respondents leave the forest for conservation.

To conclude, demographic attributes do affect how local people perceive forest ecosystems, the services and goods it provides and the perception of climate change. The respondents are aware of changes in forest cover and climate events in their area. Nevertheless, regarding traditional knowledge to cope with and adapt to risks associated to climate change, the results indicate that respondents' knowledge is limited. However, the study does not reveal the historical use of TEK; consequently it is difficult to assess its status. TEK systems hold long-term memoires of ecological adaptations to changes in the environment. In Ecuador, as in many parts of the world, 'pockets' of TEK have lost its influence in land-use management. If this knowledge completely vanishes, we may also loss adaptation options for the future since TEK is an important complement to science and technique in forming management systems adapted to local conditions and for building long-term social ecological resilience. Further studies are needed to get a better understanding of the degradation of TEK in the study areas. Still, this thesis is a step forward to better understand what support efforts that are needed in order to conserve biodiversity and restore degraded ecosystems. A recommendation for the future is that when planning conservation and adaptation programs, consideration should be given to the local population's understanding of ecosystems and local adaptation strategies.

Acknowledgements

I would like to thank my supervisor Mulualem Tigabu for his knowledge and guidance during the lengthy process of this thesis, and for establishing contacts in Ecuador to conduct my master thesis. I would also like to thank my other supervisor, Eric Agestam for his support.

Thanks also to the Cambugán Foundation for their support in the field work in Ecuador. Finally, I would like to thank Sida for the MFS scholarship and the Faculty of Forest Science for their financial support of this study.

References

Asamblea Constituyente. 2008. Constitución de la República del Ecuador. Capítulo Séptimo – Derechos de la naturaleza, Art. 71-74. (Registro Oficial No. 449)

Berkes, F. 1993. Traditional Ecological Knowledge in Perspective. In: Inglis, J.T. (eds), Traditional Ecological Knowledge: Concepts and cases. Ottawa: International Development Research Center, pp 1-9. Available: Ebook Central [2017-02-14]

Berkes, F., Colding, J., Folke, C. 2000 Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications 10 (5): 1251-1262.

Berkes, F., Colding, J., Folke, C. 2003. Navigating social ecological systems: Building resilience for complexity and change. Cambridge University Press. Available: Ebook Central [2017-02-14]

Berkes,F., and Davidson-Hunt, I. 2006. Biodiversity, traditional management system, and cultural landscapes: Examples from the boreal forest of Canada. International Social Science Journal, 58 (187): 35-47.

Betts, R.A., Cox, P.M., Collins, M., Harris, P.P., Huntingford, C., Jones, C.D. 2004. The role of ecosystem-atmosphere interactions in simulated Amazonian precipitation decrease and forest dieback under global climate warming. Theoretical and Applied Climatology, 78 (1): 157-175.

Bonan, G.B. 2008. Forests and climate change: forcings, feedbacks, and the climate benefits of forests. Science 320: 1444-1449.

Bremer, L.L., Farley, K.A., Lopez-Carr, D., Romero, J. 2014. Conservation and livelihood outcomes of payment for ecosystem services in the Ecuadorian Andes: What is the potential for ‘win-win’? Ecosystem Services 8: 148-165.

Busch, M., La Notte, A., Laporte, V., Erhard, M. 2012. Potentials of quantitative and qualitative approaches to assessing ecosystem services. Ecological Indicators 21: 89-103.

Caballero-Serrano, V., Alday, J.G., Amigo, J., Caballero, D., Carrasco, J.C., McLaren, B., Onaindia, M. 2017. Social Perceptions of Biodiversity and Ecosystem Services in the Ecuadorian Amazon. Human Ecology 45: 475-486.

Cardinale, B.J., Duffy, E., Gonzales, A., Hopper, D.U., Perrings, C., Venail, P., Narwani, A., Mace, G.M., Tilman, D., Wardle, D.A., Kinzing, A.P., Daily, G.C., Loreau, M., Grace, J.B., Larugaderie, A., Srivastava, D.S., Naeem, S. 2012. Biodiversity loss and its impacts on humanity. Nature 486 (7401): 59-67.

Charnley, S., Fischer, A.P., Jones, E.T. 2007. Integrating traditional and local ecological knowledge into forest biodiversity conservation in the Pacific Northwest. Forest Ecology and Management 246: 14-28.

Chase, T.N., Pielke, R.A, Kittel, T.G.F., Nemani, R.R., Running, S.W. 1999. Simulated impacts of historical land cover changes on global climate in northern winter. Climate Dynamics 16: 93-105.

Convention on Biological Diversity[1]. Forest biodiversity. Available: https://www.cbd.int/forest/problem.shtml [2017-12-07]

Convention on Biological Diversity[2]. Forest biodiversity. Available: https://www.cbd.int/forest/importance.shtml [2017-12-07]

Convention on Biological Diversity [3]. Forest biodiversity. Available: https://www.cbd.int/traditional/intro.shtml [2017-12-07]

CICES. 2016. Structure of CICES. Available: http://cices.eu/cices-structure/ [2017-12-07]

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'neil, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. Nature 387 (6630): 253-260.

Din, N., Ngo-Massou, V.M., Essomè-Koum, G.L., Kottè-Mapoko, E., Emane, J.M., Akongnwi, A.D., Tchoffo, R. 2016. Local Perception of Climate Change and Adaptation in Mangrove Areas of the Cameroon Coast. Journal of Water Resource and Protection 8: 606-618.

Gadgil, M., Olsson, P., Berkes, F. & Folke, C. 2003. Exploring the role of local ecological knowledge in ecosystem management: three case studies. Navigating social-ecological systems: building resilience for complexity and change, 189-209.

Gadgil, M., Berkes, F., Folke, C. 1993. Indigenous knowledge for biodiversity conservation. Biodiversity: Ecology, Economics, Policy 22 (2/3): 151-156.

European Commission. 2014. Mapping and Assessment of Ecosystems and their Services. 2nd Report. European Union. (Technical Report – 2014-080). Available: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf [2017-12-07]

FAO (Food and Agriculture Organization of the United Nations). 2003. Available: http://www.fao.org/forestry/country/57478/en/ecu/ [2017-12-07]

FAO (Food and Agriculture Organization of the United Nations). 2010. Global Forest Resources Assessment 2010. Terms and definitions. Working paper 144/E. Rome; 2010.

FAO (Food and Agriculture Organization of the United Nations). State of the World's forests 2011. Rome; 2011.

FAO. 2014. FAO Statistical Yearbook 2014: Latin America and the Caribbean Food and Agriculture. Santiago. Available: http://www.fao.org/docrep/019/i3592e/i3592e.pdf [2017-12-07]

Farley, K. 2007. Grasslands to tree plantations: Forest in transition in the Andes of Ecuador. Annals of the Association of American Geographers, 97 (4): 755-771

Fisher, B., and Turner, B.K. 2008. Ecosystem services: Classification for valuation. Biological Conservation 41: 1167-1169.

Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe., M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty, N., Snyder, P.K. 2005. Global consequences of Land Use. Science. 309 (5734): 570-574.

Folke, C. 2004. Traditional knowledge in social-ecological systems. Ecology and Society, 9 (3): 7.

Fraser, E.D.G., Dougill, A.J., Mabee, W.E., Reed, M., McAlpine, P. 2006. Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. Journal of Environmental Management 78: 114-127.

Gadgil, M., Berkes, F., Folke, C. 1993. Indigenous knowledge for biodiversity conservation. Ambio, 22 (2): 151-156.

Gómez-Baggethun, E., Reyes-García, V., Olsson, P., Montes, C. 2012. Traditional ecological knowledge and community resilience to environmental extremes: A case study in Doñana, SW Spain. Global Environmental Change 22: 640-650.

Gómez-Baggethun, E., Corbera, E., Reyes-García. 2013. Traditional ecological knowledge and global environmental change: Research findings and policy implications. Ecology and Society 18 (4): 72.

Hansen, M., Islar, M., Krause, T. 2015. The politics of natural resource enclosure in South Africa and Ecuador. Conservation and Society 13 (3): 287-298.

Haines-Young, R., and Potschin, M. 2013. Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012. EEA Framework Contract No EEA/IEA/09/003.

Haines-Young, R., and Potschin, M. 2016. Hugin OpenNESS - Classifying Ecosystem Services. Available: http://openness.hugin.com/example/cices [2017-12-07]

Harisha, R.P., Padmavathy, S., Nagaraja, B.C. 2015. Traditional ecological knowledge (TEK) and its importance in South India: Perspectives from local communities. Applied ecology and environmental research 14 (1): 311-326.

IPCC (Intergovernmental Panel on Climate Change). 2007. Climate Change 2007: Mitigation of Climate Change. Cambridge University Press. (Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007). Available: http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4_wg3_full_report.pdf [2017-12-07]

IPCC. 2014. Climate Change 2014: Synthesis Report. Summary for Policymakers. Contribution of Working Groups I, II and III to the fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

IPCC[1]. 2014. Summary for policymakers. In: Climate Change 2014: Synthesis Report. Available: http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf [2017-12-07]

IPCC[2]. 2014. Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32

IPCC[3], 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jacobsen, J.K. 1993. Intervju: konsten att lyssna och fråga. 1:16. ed. Lund: Studentlitteratur.

de Koning, F., Aguiñaga, M., Bravo, M., Chiu, M., Lascano, M., Lozada, T., Suarez, L. 2011. Bridging the gap between forest conservation and poverty alleviation: the Ecuadorian Socio Bosque program. Environmental Science and Policy, 14: 531-542.

Kvale, S. & Brinkmann, S. 2009. InterViews: learning the craft of qualitative research interviewing. 2. ed. Los Angeles: Sage Publications.

Lippe, M., Minh, T.T., Neef, A., Hilger, T., Hoffmann, V., Lam, N.T., Cadisch, G. 2011. Building on qualitative datasets and participatory processes to simulate land use change in a mountain watershed of Northwest Vietnam. Environmental Modelling & Software 26: 1454-1466.

Lykke, A.M., Kristensen, M.K. and Ganaba, S. 2004. Valuation of local use and dynamics of 56 woody species in the Sahel. Biodiversity and conservation, 13: 1961-1990.

Malhi, Y., Roberts, T., Betts, R.A., Killeen, T.J., Li, Wenhong., Nobre, C.A. 2008. Climate change, deforestation and the fate of the Amazon. Science, 319 (11): 169-172.

Marengo, J.A., Ambrizzi, T., da Rocha, R.P., Alves, L.M., Cuadra, S.V., Valverde, M.C., Torres, R.R., Santos, D.C., Ferraz, S.E.T. 2009. Future change of climate in South America in the late twenty-first century: intercomparison of scenarios from three regional climate models. Climate Dynamics, 35 (6): 1073-1097.

Mariscal Chavez, A.G. 2016. Local baseline knowledge for conservation and restoration of degraded ecosystems in Ecuador. Swedish University of Agricultural Science. Southern Swedish Forest Research Centre. (Doctoral Thesis 2016:69).

Martin, J.F., Roy, E.D., Diemont, A.W., Ferguson, B.G. 2010. Traditional Ecological Knowledge (TEK): Ideas, inspiration and designs for ecological engineering. Ecological Engineering 36: 839-849.

McDade, T.W., Reyes-García V., Blackinton, P., Tanner, S., Huacana, T., Leonard, W.R. 2007. Ethnobotanical knowledge is associated with multiple measures of child in health in the Bolivian Amazon. PNAS, 194 (15): 6143-6139.

Millenium Ecosystem Assessment. 2005. Ecosystems and human well-being: Synthesis. Island Press, Washington, DC.

Ministerio del Ambiente de Ecuador. 2010. Cuarto Informe Nacional para el Convenio sobre la Diversidad Biológica. Quito.

Mohebalian, P.M. and Aguilar, F.X. 2015. Additionality and design of forest conservation programs: Insights from Ecuador's Socio Bosque Program. Forest Policy and Economics, 71: 103-114.

Myers N., Mittermeier, R. A., Mittermeier C. G., da Fonseca G. A. B., Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

NASA Earth Observatory. 2012. Seeing forest for the trees and the carbon: mapping the worlds forest in three dimensions. Available: http://earthobservatory.nasa.gov/Features/ForestCarbon/ [2017-02-11]

NASA Science. 2017. Global climate change: Vital signs of the planet. Available: http://climate.nasa.gov/nasa_science/science/ [2017-12-07]

Paudyal, K., Baral, H., Burkhard, B., Bhandari, S.P., Keenan, R.J. 2015. Participatory assessment and mapping of ecosystem services in a data-poor region: Case study of community-managed forests in central Nepal. Ecosystem Services 13: 81-92.

Perz, S. G., and D. L. Skole. 2003. Secondary forest expansion in the Brazilian Amazon and the refinement of forest transition theory. Society and Natural Resources 16:277–94.

Poorter, L., van der Sande, M.T., Thompson, J., Arets, E.J.M.M., Alarcón, A., Álvarez-Sánchez, J., Ascarrunz, N., Balvanera, P., Barajas-Guzmán, G., Boit, A., Bongers, F., Carvalho, F.A., Casanoves, F., Cornejo-Tenorio, G., Costa, F.R.C., de Castilho, C.V., Duivenvoorden, J.F., Dutrieux, L.P., Enquist, B.J., Fernández-Méndez, F., Finegan, B., Gormley, L.H.L., Healey, J.R., Hoosbeek, M.R., Ibarra-Manríquez, G., Junqueira, A.B., Levis, C., Licona, J.C., Lisboa, L.S., Magnusson, W.E., Martínez-Ramos, M., Martínez-Yrizar, A., Martorano, L.G., Maskell, L.C., Mazzei, L., Meave, J.A., Mora, F., Muñoz, R., Nytch, C., Pansonato, M.P., Parr, T.W., Paz, H., Pérez-García, E.A., Rentería, L.Y., Rodríguez-Velazquez, J., Rozendaal, D.M.A., Ruschel, A.R., Sakschewski, B., Salgado-Negret, B., Schietti, J., Simões, M., Sinclair, F.L., Souza, P.F., Souza, F.C., Stropp, J., ter Steege, H., Swenson, N.G., Thonicke, K., Toledo, M., Uriarte, M., van der Hout, P., Walker, P., Zamora, N., Peña-Claros, M. 2015. Diversity enhances carbon storage in tropical forests. Global Ecology and Biogeography, 24 (11): 1314-1328.

Pretty, J.N. 1995. Participatory learning for sustainable agriculture. World Development 23 (8): 1247-1263.

Reyes-García, V., McDade, T., Vadez, V., Huanca, T., Leonard, W.R., Tanner, S., Godoy, R. 2008. Non-market returns to traditional human capital: Nutritional status and traditional knowledge in native Amazonian society. The Journal of Development Studies, 44 (2): 217-232.

Reyes-García, V., Salpetur, M., Calvet-Mir, L., Serrano-Tovar, T., Gómez-Baggethun, E. 2013. Coupling technology with traditional knowledge and local institutions to deal with change in rural households: A focus on the semi-arid tropics. Serchesse, 24: 340-349.

Reyes-García, V., Fernández-Llamazares, A., Guèze. M., Garcés, A., Mallo, M., Vila-Gómez, M. and Vilaseca, M. 2016. Local indicators of climate change: the potential contribution of local knowledge to climate research. WIREs Climate Change, 7:109-124.

Rudel, T. K., D. Bates, and R. Machinguiashi. 2002. A tropical forest transition? Agricultural change, out-migration, and secondary forests in the Ecuadorian Amazon. Annals of the Association of American Geographers 92 (1): 87–102.

Ryen, A. 2004. Kvalitativ intervju – från vetenskapsteori till fältstudier. 1. ed. Malmö: Liber Ekonomi.

Sabine. C.L., Heimann, M., Artaxo, P., Bakker, D.C.E., Chen, C-T.A., Field, C.B., Gruber, N., Le Quéré, C., Prinn, R.G., Richey, J.E., Romero Lankao, P., Sathaye, J.A., Valentini., R. 2004. Current status and past trends of the global carbon cycle. In: Field, C.B., & Raupach, M.R. (eds), The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World. Washington, DC: Island Press, pp. 17-44. Available: Ebook Central [2017-02-11]

Stave, J., Oba, G., Nordal, I., Stenseth, N.C. 2007. Traditional ecological knowledge of a riverine forest in Tukana, Kenya: implications for research and management. Biodiversity and Conservation 16 (5): 1471-1489.

Tang, R. and Gavin, M.C. 2016. A classification of threats to traditional ecological knowledge and conservation responses. Conservation and Society 14 (1): 57-70.

Thompson, I.D., Okabe, K., Tylianakis, J.M., Kumar, P., Brockerhoff, E.G., Schellhorn, N.A., Parrotta, J.A., Nasi, R. 2011. Forest biodiversity and the delivery of ecosystem good and services: translating science into politics. BioScience 6 (12): 972-981.

Twongyirwe, R., Bithell, M., Richards, K.S., Rees, W.G. 2017. Do livelihood typologies influence local perceptions of forest cover change? Evidence from a tropical forested and non-forested rural landscape in western Uganda. Journal of Rural Studies 50: 12-29.

UNDP (United Nations Development Programme). 2010. Gender, Climate Change and Community-Based Adaptation. New York: UNDP. Available: http://www.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/climate-change/gender-climate-change-and-community-based-adaptation-guidebook-/Gender%20Climate%20Change%20and%20Community%20Based%20Adaptation%20(2).pdf [2017-12-07]

Uprety, Y., Asselin, H., Bergeron, Y., Doyon, F., Boucher, J-F. 2012. Contribution of Traditional Knowledge to Ecological Restoration: Practices and Applications. Ecoscience 19 (3): 225-237.

Utrikespolitiska Institutet. 2014. Landguiden. Available: http://www.landguiden.se/Lander/Sydamerika/Ecuador?p=1 [2017-02-14]

Valdivia, C., Seth, A., Gilles, J.L., García, M., Jiménez, E., Cusicanqui, J., Navia, F., Yucra, E. 2010. Adapting to climate change in Andean ecosystems: landscapes, capitals, and perceptions shaping rural livelihood strategies and linking knowledge systems. Annals of the Association of American Geographers, 100 (4): 818-834.

Wunder, S. 2000. The Economics of Deforestation: The example of Ecuador. London: Palgrave McMillan. Available: Ebook Central. [2017-02-14]

Appendixes

Survey of rural villages

Land use and remnants of native forests

Number of the interviewee ______

Gender Female (F) / Male ______

Age ______

Date: 2016 ______ - ______

Location ______

Origin: Indigenous / Mestizo / Afro-Ecuadorian / other ______

Prudence ______

Occupation: Agriculture / Other / No job ______

We inform you that for the development of the present interview it is not necessary to know the name of the person interviewed, additionally, the information to be generated will be treated as part of a master thesis and will be treated with strict confidentiality.

Student, Southern Swedish Forest Research Centre, The Swedish University of Agricultural Science, SLU, Alnarp, Sweden.

History of land use

Relatives	**Place of birth**	**Education** No education (N) Primary (P) Secondary (S) University (U)	**Number of children** Women (M) Men (H)	**Education** No education (N) Primary (P) Secondary (S) University (U)	**Number of farms acquired**	**Approximate extension including all farms in (ha)**	**Main form of domain** Possession (P), legal document (E)	**From of acquisition** Purchase (C), heritage (H), gift (R)	**Slope in % of total land** Very steep (ME), steep (E), flat (P)	**(Ha) of pastures**	**(Ha) of crops**	**(Ha) of forest**	**(Ha) of primary forest**	**(Ha) of forest plantations**	**(Ha) other uses**
Great grand-parents															
Grand-parents															
Parents															
Current family boss															

Questionnaire for interviews, part II

1. Do you or your family belong to a community, association, or other type of organization?
   - Yes
   - No
   - If yes, what?

2. Do you and your family participate in conservation projects in your area? If not, why?
   - There are no projects

3. How close do you live to a conservation area?
   - I don't know
   - The protective forest of… is … km away
   - Does that benefit you and your family in any way?

4. Does your family obtain any social or economic help for keeping your farm?
   - Yes
   - No
   - If yes, what?
     - Education
     - Economic support
     - Infrastructure support

5. Do you believe that forests are beneficial?
   - Yes
   - No
   - If yes, what type of benefits?

6. How much of your land had forest since you were a child?
   - 100% - all of the land
   - 50% - half of the land
   - 0% of the land
   - I don't know

7. If you have crops on your farm, what kind of crops?
   - Crop plants – how much?
   - Vegetables – how much?
   - Fruits – how much?

8. How long has this area been cultivated?
   - Always
   - More than 20 years
   - The last 20 years
   - The last 10 years
   - I don't know

9. Do you and your family have animals? What kind of animals?
   - Cows
   - Chickens
   - Pigs
   - Others

10. What kind of products do you obtain from them?
    - Meat

- Dairy products such as milk, cheese
- Honey
- Eggs
- Other

11. Do these products contribute to the economy of your family?
    - Yes
    - No

12. Do you have access to a market where you can sell your products?
    - Yes
    - No

13. If there are any forest plantations on your farm, how many ha and what kind of tree species?

14. Why did your family decide to plant this species? When did you establish the plantations?
    - For wood use
    - For firewood use
    - To sell

15. Are there any tree species that are decreasing or increasing?
    - Yes
    - No
    - If yes, what kind of tree species?

16. Are there any tree species that you think should be planted in the future to maintain the biodiversity?
    - Yes
    - No
    - If yes, what kind of tree species?

17. How do you manage your forest area?
    - I cut everything
    - I just cut some trees/tree species
    - I conserve the forest
    - Other

18. Do you use fertilizers or pesticides?
    - Yes
    - No
    - If yes, what kind?

19. What do you do to maintain the tree species that are important for you and your family considering different ages of tree?
    - I cut and will plant in the future
    - I cut and help the timber trees to be maintained
    - Nothing
    - Other

20. How is this knowledge of managing the forest transmitted between parent and child?
    - Orally
    - Written

- Practical knowledge
- Other method

21. How are you planning to work on you farm during the next five years? Do you want more forest, crops, pasture or other?
    - Forest
    - Crops
    - Pastures
    - Other

22. What work expectations do you have for the future?
    - Continue as today
    - Work on other farms
    - Work with other crops
    - Work in the city

CICES – *provisional services*

23. How do you collect the drinking water?
    - Rain water
    - Piped water
    - Drinking water from tank

24. Do you collect any products from the forest for direct use that are not processed?
    - Firewood
    - Wood
    - Flowers
    - Plants
    - Grass for fodder

25. Does the availability of these products decrease or increase?
    - Increase
    - Decrease
    - I don’t know

Regulation and maintenance

26. Are there any problems with erosion around here?
    - Yes
    - No
    - If yes, do you do anything to control it?

27. Are there any problems with storms around here?
    - Yes
    - No
    - If yes, do you do anything to control it?

Climate change – have you noticed any changes in the climate?

- Yes
- No
- If yes, what kind of changes?

Cultural services

28. Do you use plant or animal species from the forest that has spiritual or symbolic value?
    - Yes
    - No

- If yes, what kind of species?

29. Do you use plant or animal species from the forest that has medicinal value?
    - Yes
    - No
    - If yes, what kind of species?

TEK used for conservation of biodiversity

30. Are there any plant species in the forest that are decreasing or increasing?
    - Yes
    - No
    - If yes, what kind of species?

31. Do you take any measures to maintain them?
    - Yes
    - No
    - If yes, what kind of measures?

32. What kind of wild animals do you have on your land?
    -

33. Are there any wild animals that are decreasing or increasing?
    - Yes
    - No
    - If yes, what kind of animals?

34. Do you take any measures to maintain them?
    - Yes
    - No
    - If yes, what kind of measures?

35. Are there any bird species that are decreasing or increasing?
    - Yes
    - No
    - If yes, what bird species?

36. Do you take any measures to maintain them?
    - Yes
    - No
    - If yes, what kind of measures?

37. Do you want to add anything, or anything that is important for biodiversity conservation?

Questionnaire for interviews, part III – Climate change

1. Do you perceive an overall warming?
   - Yes
   - No
2. Do you perceive early onset of summers?
   - Yes
   - No
3. Do you perceive early onset of monsoons?
   - Yes
   - No
4. Do you perceive frequent droughts?
   - Yes
   - No
5. Do you perceive drying up of rivers and springs?
   - Yes
   - No
6. Do you perceive frequent flooding during rainy season?
   - Yes
   - No
7. Do you perceive frequent storms?
   - Yes
   - No
8. Do you perceive frequent dry season fires?
   - Yes
   - No
9. Do you perceive shortage of pastures?
   - Yes
   - No
10. Do you perceive shortage of drinking water?
    - Yes
    - No
11. Do you perceive early crop maturity?
    - Yes
    - No
12. Do you perceive decrease in crop yield?
    - Yes
    - No
13. Do you perceive new crop pests?
    - Yes
    - No
14. Do you perceive new weeds?
    - Yes
    - No
15. Do you perceive an increased frequency of livestock diseases?
    - Yes
    - No
16. Do you perceive disappearance of wild animals?
    - Yes
    - No
17. Have you heard about climate change?

- Yes
- No

18. Do you believe that climate change will affect the poor?
    - Yes
    - No
19. Do you believe that climate change will affect the rich?
    - Yes
    - No
20. Do you believe that climate change will affect health?
    - Yes
    - No
21. Do you believe that climate change will affect food supply?
    - Yes
    - No
22. Do you believe that climate change will affect fuelwood availability?
    - Yes
    - No
23. Do you believe that climate change will affect fodder availability?
    - Yes
    - No
24. Do you believe that climate change will affect drinking water availability?
    - Yes
    - No
25. Do you believe that climate change will affect business availability?
    - Yes
    - No
26. Do you believe that climate change may cause disasters?
    - Yes
    - No
27. Do you believe that climate change will affect biodiversity quality?
    - Yes
    - No

Adaptation measures to climate change

28. Do you plant improved crops?
    - Yes
    - No
29. Have you reintroduced native species?
    - Yes
    - No
30. Are you using different crops?
    - Yes
    - No
31. Are you planting the seed early or late?
    - Yes
    - No
32. Are you using irrigation on your farm?
    - Yes
    - No
33. Are you using fertilizers?
    - Yes

- No

34. Are you using mulching?
    - Yes
    - No
35. Are you plating trees?
    - Yes
    - No
36. Are you harvesting and storing fodder?
    - Yes
    - No
37. Are you using alternative energy sources?
    - Yes
    - No
38. No adaptation method used
    - Yes
    - No

What is the main problem with climate change adaptation?

39. Lack of improved seed
    - Yes
    - No
40. Shortage of water for irrigation
    - Yes
    - No
41. Lack of knowledge regarding adaptation methods
    - Yes
    - No
42. Inadequate information regarding climate change
    - Yes
    - No
43. Lack of money to acquire modern techniques
    - Yes
    - No

How can the problems with climate change adaptation be solved?

44. Through a village development body
    - Yes
    - No
45. By the local and central government
    - Yes
    - No
46. By local NGO:s in collaboration with the villagers
    - Yes
    - No
47. Active collaboration of the three mentioned alternatives
    - Yes
    - No

Participation in a forestry program

48. Are you willing to participate in a forestry program?
    - Yes
    - No

49. How much money are you willing to spend on a forestry program?
    - 1 – 5 $
    - 6 – 10 $
    - 11 – 15 $
    - 16 – 20 $
    - > 20 $
    -
50. How many times are you willing to pay for a forestry program?
    - 0 times
    - 1 time
    - 5 times
    - 10 times
51. For how long are you willing to pay for a forestry program?
    - For one year
    - For more than one year

S1. Description and summary statistics of the variables used in the binary logistic model for examining relations between perception of ecosystem services and goods and respondents' attributes.

Attributes	**Water**		**Timber**		**Firewood**		**Fresh air**		**Habitat (flora & fauna)**		**Soil- and wind-protection**		**Plants symb./ religious value**		**Plants medi-cinal value**	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Gender																
Male	25	14	15	24	8	31	7	32	9	30	3	36	12	27	27	12
Female	22	23	17	28	13	32	10	35	9	36	2	43	20	20	35	7
Age class																
20-45	13	10	8	15	6	17	8	15	6	17	1	22	11	11	19	4
45-65	26	11	14	23	9	28	7	30	8	29	2	35	13	20	29	5
>65	8	16	10	14	6	18	2	22	4	20	2	22	8	16	14	10
Community																
Jatumpamba	3	10	6	7	2	11	2	11	2	11	1	12	7	5	11	1
Curipogio/Marianitas	12	2	4	10	3	11	2	12	6	8	1	13	3	11	10	4
Santo Domingo	8	15	15	8	8	15	5	18	4	19	3	20	12	9	17	4
Minas Chupa	13	7	2	18	3	17	4	16	4	16	0	20	6	12	12	8
Bellavista	11	3	5	9	5	9	4	10	2	12	0	14	4	10	12	2
Ethnic group																
Mestizo	35	30	29	36	18	47	15	50	13	52	5	60	25	37	51	11
Indigenous	12	7	3	16	3	16	2	17	5	14	0	19	7	10	11	8
Household size																
1-2	12	11	7	16	5	18	1	22	6	17	2	21	10	13	14	9
3-4	17	12	11	18	9	20	8	21	7	22	0	29	11	17	21	6
>5	18	14	14	18	7	25	8	24	5	27	3	29	11	17	27	4
Educational level																
Illiterate	3	8	3	8	3	8	1	10	2	9	0	11	7	3	8	3
Literate	44	29	29	44	18	55	16	57	16	57	5	68	25	44	54	16
Tenure status																
Acquired	34	33	27	40	18	49	13	54	15	52	5	62	25	39	48	16
Inheritance	13	3	5	12	3	14	4	13	3	14	0	17	7	8	14	3
Distance to protected area																
0-1 km	6	4	4	6	4	6	2	8	2	8	0	10	2	8	9	1
1-5 km	14	3	6	11	5	12	2	15	5	12	2	15	4	13	14	3
5-10 km	5	0	0	5	1	4	3	2	1	4	0	5	2	3	3	2
>10 km	4	4	6	2	4	4	4	4	2	6	0	8	3	5	7	1
Don't know/there is no	18	26	16	28	7	37	6	38	8	36	3	41	21	18	29	12

S2. Description and summary statistics of the variables used in the binary logistic model for examining relations between perception of changes ecosystem in services and goods and respondents' attributes.

Attributes	**Forest cover change**				**Tree species decreasing/increasing**				**Mammals decreasing/increasing**				**Birds decreasing/increasing**				**Forest products availability**			
	Major change	Mod. change	No change	No view	Dec	Inc	No change	No view	Dec	Inc	No change	No view	Dec	Inc	No change	No view	Dec	Inc	No change	No view
Gender																				
Male	24	7	4	3	25	5	9	0	20	9	7	1	19	13	3	2	24	9	4	2
Female	16	12	10	7	25	7	4	6	28	5	1	6	22	12	3	4	29	9	1	6
Age class																				
20-45	6	9	6	2	13	4	5	1	14	4	1	2	8	10	1	3	14	5	2	2
45-65	21	10	5	1	21	6	4	3	18	8	4	4	17	10	4	3	24	6	3	4
>65	13	0	3	7	16	2	4	2	16	2	3	1	16	5	1	0	15	7	0	2
Community																				
Jatumpamba	2	3	5	3	6	2	3	2	7	1	1	3	4	3	2	1	9	2	0	2
Curipogio/Marianitas	9	1	3	1	9	1	3	0	8	4	2	0	10	4	0	0	8	2	1	3
Santo Domingo	14	5	1	3	15	3	1	2	15	3	0	1	11	6	1	2	15	6	0	2
Minas Chupa	4	8	4	3	16	3	0	1	14	0	2	2	13	5	1	1	16	3	0	1
Bellavista	11	2	1	0	4	3	6	1	4	6	3	1	3	7	2	2	5	5	4	0
Ehtnic group																				
Mestizo	35	12	11	7	34	10	13	5	35	13	6	6	28	21	5	5	38	15	5	7
Indigenous	5	7	3	3	16	2	0	1	13	1	2	1	13	4	1	1	15	3	0	1
Household size																				
1-2	14	2	5	1	15	3	4	0	17	1	2	2	19	1	1	1	16	5	0	2
3-4	14	6	3	6	15	4	5	4	15	6	3	2	11	10	4	3	16	8	4	1
>5	12	11	6	3	20	5	4	2	16	7	3	3	11	14	1	2	21	5	1	5
Educational level																				
Illiterate	4	1	4	1	8	2	0	1	6	0	1	3	7	3	0	1	9	2	0	0
Literate	36	18	10	9	42	10	13	5	42	14	7	4	34	22	6	5	39	15	5	8
Tenure status																				
Acquired	35	13	8	10	40	10	10	4	39	12	6	4	33	20	4	4	43	13	3	8
Inheritance	5	6	6	0	10	2	3	2	9	2	2	3	8	5	2	2	10	5	2	0
Distance to protected area																				
0-1 km	6	1	1	2	7	1	2	0	6	3	0	0	5	3	1	0	7	2	0	1
1-5 km	12	2	3	0	7	4	5	0	7	5	3	2	8	6	1	2	8	3	4	2
5-10 km	1	3	1	0	4	0	1	0	3	0	1	1	3	2	0	0	4	0	0	1
>10 km	5	1	1	1	3	2	2	1	3	2	1	1	2	4	2	0	4	3	1	0
Don't know/ there is no	16	12	8	7	29	5	3	5	29	4	3	3	23	10	2	4	30	10	0	4

S3. Description and summary statistics of the variables used in the binary logistic model for examining relations between climate change indicators and respondents' attributes in San Augustin.

Attributes	**Overall warming**		**Early onset of summer**		**Early onset of monsoon**		**Frequent droughts**		**Drying up of river, springs etc.**		**Frequent flooding during rainy season**		**Frequent storms**		**Frequent dry seasons fires**		**Shortage of pastures**		**Shortage of drinking water**		**Early crop maturity**		**Decrease in crop yield**		**New crop pests**	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Gender																										
Male	18	1	19	0	18	1	18	1	19	0	7	12	12	7	19	0	19	0	10	9	19	0	14	5	13	6
Female	29	2	30	1	31	0	27	4	31	0	8	23	19	12	30	1	29	2	12	19	28	3	23	8	21	10
Age class																										
20-45	26	2	27	1	27	1	23	5	28	0	12	16	22	6	28	0	26	2	13	15	25	3	24	3	18	10
45-65	16	1	17	0	17	0	17	0	17	0	2	15	8	9	16	1	17	0	7	10	17	0	11	6	15	2
>65	5	0	5	0	5	0	5	0	5	0	1	4	1	4	5	0	5	0	2	3	5	0	2	3	1	4
Household size																										
1-2	6	0	6	0	6	0	6	0	6	0	1	5	2	4	6	0	6	0	2	4	6	0	3	3	2	4
3-4	22	2	23	1	23	1	21	3	24	0	9	15	17	7	24	0	23	1	12	12	23	1	20	4	15	9
≥5	19	1	20	0	20	0	18	2	20	0	5	15	12	8	19	1	19	1	8	12	18	2	14	6	17	3
Origin																										
San Augustin	43	2	45	0	44	1	41	4	45	0	14	31	29	16	44	1	44	1	19	26	42	3	33	12	31	14
Other	6	1	6	1	7	0	6	1	7	0	2	5	4	3	7	0	6	1	5	2	7	0	6	1	5	2
Educational level																										
Illiterate	7	0	7	0	7	0	7	0	7	0	3	4	4	3	7	0	7	0	5	2	7	0	5	2	4	3
Literate	40	3	42	1	42	1	38	5	43	0	12	31	27	16	42	1	41	2	17	26	40	3	32	11	30	13
Tenure status																										
Acquired	36	0	36	0	35	1	31	5	36	0	11	25	21	15	35	1	36	0	16	20	35	1	28	8	25	11
Inheritance	11	3	13	1	14	0	14	0	14	0	4	10	10	4	14	0	12	2	6	8	12	2	9	5	9	5

Continuation of S3

Attributes	New weeds		Increase frequency of livestock diseases		Disappearance of wild animals	
	Yes	No	Yes	No	Yes	No
Gender						
Male	12	7	16	3	18	1
Female	16	15	27	4	27	4
Age class						
20-45	18	10	24	4	26	2
45-65	9	8	14	3	14	3
>65	1	4	5	0	5	0
Household size						
1-2	2	4	6	0	6	0
3-4	14	10	21	3	20	4
≥5	12	8	16	4	19	1
Origin						
San Augustin	26	19	38	7	41	4
Other	3	4	6	1	6	1
Educational level						
Illiterate	4	3	7	0	6	1
Literate	24	19	36	7	39	4
Tenure status						
Acquired	23	13	31	5	5	4
Inheritance	5	9	12	2	13	1

S4. Description and summary statistics of the perception of climate change and its affects in relation to respondents' attributes in San Augustin.

Attributes	**Climate change awareness**		**Climate change affects the poor**		**Climate change affects the rich**		**Climate change affects the health**		**Climate change affects food supply**		**Climate change affects fuelwood availability**		**Climate change affects fodder availability**		**Climate change affects drinking water availability**		**Climate change affects business availability**		**Climate change may cause disasters**		**Climate change affects biodiversity quality**	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Gender																						
Male	9	10	7	12	4	15	9	10	9	10	4	15	4	15	8	11	8	11	9	10	7	12
Female	11	19	8	22	4	26	10	20	10	20	7	23	8	22	9	21	9	21	10	20	8	22
Age class																						
20-45	16	12	11	17	4	24	15	13	15	13	9	19	10	18	14	14	14	14	14	14	11	17
45-65	5	12	5	12	4	13	5	12	5	12	2	15	2	15	4	13	4	13	5	12	5	12
>65	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5
Household size																						
1-2	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6
3-4	12	12	8	16	4	20	12	12	12	12	8	16	9	15	11	13	10	14	12	12	9	15
≥5	9	11	8	12	4	16	8	12	8	12	3	17	3	17	7	13	8	12	7	13	7	13
Origin																						
San Augustin	18	27	14	31	7	38	17	28	17	28	9	36	9	36	15	30	15	30	16	29	13	32
Other	3	4	2	5	1	6	3	4	3	4	2	5	3	4	3	4	3	4	3	4	3	4
Educational level																						
Illiterate	0	7	0	7	0	7	0	7	0	7	0	7	0	7	0	7	0	7	0	7	0	7
Literate	21	22	16	27	8	35	20	23	20	23	11	32	12	31	18	25	18	25	19	24	16	27
Tenure status																						
Acquired	16	20	14	22	6	30	16	20	16	20	10	26	10	26	14	22	16	20	15	21	13	23
Inheritance	5	9	2	12	2	12	4	10	4	10	1	13	2	12	4	10	2	12	4	10	3	11

S5. Description and summary statistics of adaptation measures used to cope with climate change in relation to respondents' attributes in San Augustin.

Attributes	**Planting improved crop**		**Reintroduction of native species**		**Use different crop**		**Early/late planting of seeds**		**Irrigation farming**		**Use of fertilizer**		**Mulching**		**Tree planting**		**Harvesting and storing of fodder**		**Alternative energy source**		**No adaptation method used**	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Gender																						
Male	0	19	4	15	3	16	1	18	0	19	0	19	1	18	3	16	1	18	0	19	3	16
Female	1	30	2	29	1	31	2	29	0	30	0	31	1	30	3	28	0	31	1	30	5	26
Age class																						
20-45	1	27	4	24	2	26	3	25	0	28	0	28	2	26	3	25	1	27	1	27	7	21
45-65	0	17	2	15	2	15	0	17	0	17	0	17	0	17	3	14	0	17	0	17	1	16
>65	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5
Household size																						
1-2	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6
3-4	1	23	4	20	2	22	3	21	0	24	0	24	2	22	0	24	1	23	0	24	6	18
≥5	0	20	2	18	2	18	0	20	0	20	0	20	0	20	6	14	0	20	1	19	2	18
Origin																						
San Augustin	1	42	5	38	4	39	2	41	0	43	0	43	1	42	6	37	1	42	1	42	6	37
Other	0	7	1	6	0	7	1	6	0	7	0	7	1	6	0	7	0	7	0	7	2	5
Educational level																						
Illiterate	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6
Literate	1	36	5	32	4	33	2	35	0	37	0	37	1	36	6	31	1	36	1	36	1	36
Tenure status																						
Acquired	0	32	3	29	3	29	1	31	0	32	0	32	1	31	4	28	1	31	0	32	6	26
Inheritance	1	10	2	9	1	10	1	10	0	11	0	11	0	11	2	9	0	11	1	10	0	11

S6. Description and summary statistics of the perception of the main problems with climate change in relation to respondents' attributes in San Augustin.

Attributes	**Lack of improved seed**		**Shortage of water for irrigation**		**Lack of knowledge**		**Inadequate information**		**Lack of money to acquire modern techniques**	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Gender										
Male	2	17	4	15	8	11	6	13	4	15
Female	2	29	3	28	9	22	8	23	7	24
Age class										
20-45	4	24	5	23	12	16	12	16	7	21
45-65	0	17	2	15	5	12	2	15	4	13
>65	0	5	0	5	0	5	0	5	0	5
Household size										
1-2	0	6	0	6	0	6	0	6	0	6
3-4	4	20	3	21	9	15	6	18	5	19
≥5	0	20	4	16	8	12	8	12	6	14
Origin										
San Augustin	3	42	7	38	15	30	13	32	10	35
Other	1	6	0	6	2	5	1	6	1	6
Educational level										
Illiterate	0	7	0	7	0	7	0	7	0	7
Literate	4	39	7	36	17	26	14	29	11	32
Tenure status										
Acquired	3	33	5	31	13	23	12	24	9	27
Inheritance	1	13	2	12	4	10	2	12	2	12

S7. Description and summary statistics of adaptation to climate change in relation to respondents' attributes in San Augustin.

Attributes	**Village development body**		**By local and central government**		**By local NGOs in collaboration with villagers**		**Active collaboration of the three alternatives**	
	Yes	No	Yes	No	Yes	No	Yes	No
Gender								
Male	2	17	2	17	1	18	6	13
Female	3	28	0	31	2	29	9	22
Age class								
20-45	5	23	2	26	2	26	11	17
45-65	0	17	0	17	1	16	4	13
>65	0	5	0	5	0	5	0	5
Household size								
1-2	0	6	0	6	0	6	0	6
3-4	5	19	2	22	2	22	7	17
≥5	0	20	0	20	1	19	8	12
Origin								
San Augustin	3	42	2	43	2	43	14	31
Other	2	5	0	7	1	6	1	6
Educational level								
Illiterate	0	7	0	7	0	7	0	7
Literate	5	38	2	41	3	40	15	28
Tenure status								
Acquired	3	33	2	34	2	34	12	24
Inheritance	2	12	0	14	1	13	3	11

S8. Description and summary statistics of respondents' willingness to participate in forestry program in San Augustin.

Attributes	**Participation in forestry program**	
	Yes	No
Gender		
Male	9	10
Female	12	19
Age class		
20-45	16	12
45-65	5	12
>65	0	5
Household size		
1-2	0	6
3-4	12	12
≥5	9	11
Origin		
San Augustin	18	27
Other	3	4
Educational level		
Illiterate	0	7
Literate	21	22
Tenure status		
Acquired	16	20
Inheritance	5	9

S9. Description and summary statistics of money and time respondents are willing to spend on forestry program in San Augustin.

Attributes	**Money**					**Amount**				**Time – 1 year**	**Time – > year**
	1-5 $	6 -10 $	11-15 $	16-20 $	>20 $	0	1	5	10		
Gender											
Male	7	1	0	0	1	9	6	3	0	7	2
Female	11	1	0	0	0	14	6	5	1	12	0
Age class											
20-45	14	2	0	0	0	9	7	8	1	16	0
45-65	4	0	0	0	1	9	5	0	0	3	2
>65	0	0	0	0	0	5	0	0	0	0	0
Household size											
1-2	0	0	0	0	0	5	0	0	0	0	0
3-4	11	1	0	0	0	11	4	7	1	11	1
≥5	7	1	0	0	1	7	8	1	0	8	1
Origin											
San Augustin	16	1	0	0	1	21	12	6	0	16	2
Other	2	1	0	0	0	4	0	2	1	3	0
Educational level											
Illiterate	0	0	0	0	0	7	0	0	0	0	0
Literate	18	2	0	0	1	16	12	8	1	19	2
Tenure status											
Acquired	15	0	0	0	1	18	9	7	0	15	1
Inheritance	3	2	0	0	0	5	3	1	1	4	1