



# Challenges to Managing Ecosystems Sustainably for Poverty Alleviation: Securing Well-Being in the Andes/Amazon

Final Report

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## List of Acronyms

ACTO	Amazon Cooperation Treaty Organization
AECI	Agencia Española de Cooperación Internacional
AI	Amazon Initiative Consortium
ARPA	Program for Protected Areas of the Amazon Region, Brazil
BAU	Business as usual scenario
BOLFOR	Bolivian Sustainable Forest Management Project
CAF	Corporación Andina de Fomento (Andean Development Corporation)
CAN	Andean Community of Nations
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CI	Conservation International
CIF	Certificate of Forest Incentive for Reforestation, Colombia
CRES	Compensation and rewards for environmental services
CYTED	Iberoamerican Program on Science and Technology
DFID	Department for International Development, UK
EDA	Extrapolation Domain Analysis
ENSO	El Niño-Southern Oscillation
ES	Ecosystem service
ESPA	Ecosystem Services and Poverty Alleviation Programme
ESPA-AA	Ecosystem Services and Poverty Alleviation Programme, Andes-Amazon
ESRC	Economic and Social Research Council, UK
FAO	Food and Agriculture Organization of the United Nations
FF	Fossil fuel
FONAG	Fund for the Protection of Water, Ecuador
GCM	General Circulation Models
GEF	Global Environment Facility
GIS	Geographic Information System
GTZ	German Agency of Technical Cooperation
HDI	Human Development Index
HEP	Hydroelectric power
IAI	Inter-American Institute for Global Change Research
ICMS-E	Ecological Tax on the Circulation of Goods and Services, Brazil
IDB	Inter-American Development Bank
IICA	Inter-American Institute for Cooperation on Agriculture
IIRSA	Initiative for Integration of Regional Infrastructure in South
IPAM	Instituto de Pesquisa Ambiental da Amazonia
IUCN	International Union for Conservation of Nature
LBA	Large-scale Biosphere-Atmosphere Experiment in Amazonia
MEA	Millennium Ecosystem Assessment
MO	Management option
NERC	Natural Environment Research Council, UK
NGO	Non-governmental organization

NRM	Natural resource management
NTFP	Non-timber forest products
PA	Protected area
PES	Payment for Ecosystem/Environmental Services
PROAMBIENTE	Socio-Environmental Development Program for Smallholder Production
PV	Present value
R&D	Research and development
REDD	Reduced Emissions from Deforestation and Degradation
TCO	Tierra Comunitaria de Origen (Indigenous Communal Land Holding), Bolivia
TNC	The Nature Conservancy
UBN	Unsatisfied basic needs
UN	United Nations
UNAMAZ	Association of Amazonian Universities
UNCCD	United Nations Convention to Combat Desertification
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WofE	Weights of evidence algorithm
WWF	World Wide Fund for Nature

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## Executive Summary

The Ecosystem Services and Poverty Alleviation Program (ESPA) was initiated in 2007 by the Natural Environment Research Council (NERC), the Department for International Development (DFID), and the Economic and Social Research Council (ESRC) of the UK. ESPA is a global program in its initial stages that will promote research and capacity-building to achieve sustainable ecosystem management and increased well-being in developing countries.

This report focuses on the Amazon basin and the eastern Andean slopes (herein referred to as the Andes/Amazon ecosystem or region). The Amazon is the largest fresh water system and tropical forest in the world. Large portions of the region are still covered by relatively intact primary forests that provide substantial locally and globally valuable ecosystem services (ES). Rural population densities in the region are among the lowest in the world. As such, the Andes/Amazon is a contrast to other ESPA target areas that are characterized by scarce and degraded resources used by often overwhelming numbers of the poor. Hence, in the Andes/Amazon, ESPA should focus on promoting resource conservation *before* valuable ES are irreversibly lost due to actions by resource users ranging from poor slash-and-burn farmers to large timber and commodity farming interests. A rationale for this approach is that rebuilding ecosystem services in ecologically degraded areas is generally much more costly than preventing their loss in the first place. As an agricultural colonization frontier, the Amazon has lost some 84 million ha of native forests over the last few decades – a loss accompanied by losses of locally and globally valuable ES.

A “situation analysis” of ES and poverty in the Andes/Amazon was conducted September 2007 - March 2008. Findings are intended to help guide ESPA in terms of research and capacity-building priorities. A macro-scale approach was taken to examine ES, well-being, and management needs. The work was accompanied by an extensive consultation with local, national and regional stakeholders.

The introductory chapter sets out the objectives of the situation analysis, and the approach of the study. It also briefly discusses the relationships among ES and poverty in the context of this situation analysis. The discussion settles on key findings of a recent study that has reviewed the literature on this relationship on a global scale. The situation analysis adopts existing definitions of ES, which are understood to be the “processes and conditions through which ecosystems support human life” or, more generally, the “benefits that people obtain from ecosystems”. No single poverty definition is adopted throughout the report. Depending on data availability and analytical approaches it employs different poverty concepts and explores implications if necessary. Stakeholder consultations reinforced the need to adjust standard poverty measures to better capture the ES dimensions of well-being in the Andes/Amazon. Moreover, the concept of poverty itself was challenged in favour of a well-being oriented approach.

The report focuses on key issues: Paramount ES provided by the Andes/Amazon ecosystem to local populations and to the global society, and the main threats and challenges to the provision of these services are identified (Chapter 2). The benefits that local populations derive from using ES are characterized (Chapters 2 and 5). Promising options to manage ES provision in ways that also prevent or help to alleviate poverty are identified and characterized (Chapters 3 and 4). Key results of stakeholder consultations and related priorities for research and capacity building are summarized in Chapter 5. Chapter 6 summarizes the key messages of all chapters and proposes three core areas to be addressed by research and capacity-building in the ESPA program. Prototype research projects and promising impact pathways are proposed.

Chapter 2 provides a spatial assessment of ES and poverty in the Andes/Amazon. The literature review and the stakeholder consultation allowed for the identification of the most important ES.

However, not all ES could be quantified and assessed spatially due to data limitations. Attempts to quantify services included direct measures or measures of the natural resource base for any particular service provision. Services examined were water quantity and quality, local climate regulation, carbon as an indicator for global climate regulation services, soil related services, and a set of services associated with terrestrial and aquatic biodiversity. The spatial assessment confirms that rural inhabitants are most vulnerable to changes in ES provision. Particularly traditional and indigenous populations have developed strong dependencies on locally abundant ES and goods. Hence, relative resource abundance does not mean low vulnerability. Especially, ES that are subject to natural variability and human pressures (e.g. water flow and quality, local climate, forest products) introduce an important source of uncertainty even into relatively well adapted livelihood strategies. A key contribution of Chapter 2 is to illustrate some of the spatial and long-term temporal dimensions of ES provision, which may help to better target future ESPA program activities.

Chapter 3 reviews the diverse options available to manage ES and their potential effects on the poor. Management options (MO) are classed as enabling (e.g., technologies, property rights, environmental education, public-private partnerships, credit, and insurance), incentives (e.g., payments for environmental services, subsidies, inputs, and certification or eco-labeling), and disincentives (e.g., taxes, regulations, fines, and imprisonment). It becomes clear that the MO of choice in the past have been disincentive-based. In large and sparsely populated areas, where few actors can have large impacts, the need to constantly enforce disincentive MO may make them less cost-effective than incentive-based MO. Research is needed to support the current trend in favour of such MO to determine where and under what conditions they represent true alternatives. Options to manage ES should not be understood as substitutes for social policies and basic public services. The lack of the latter is often the root cause of poverty in the Andes/Amazon. What is needed is a better understanding of how to combine enabling and incentive MO for ES management in order to allow for the poor to capture benefits.

Chapter 4 reviews factors underlying successful programmes and projects that have implemented management options in the Andes/Amazon. Lessons learned are discussed. Reviewed projects dealt with conservation and recuperation of ES and ecosystems; impacts on well-being; and innovative approaches. Project impacts are discussed in terms of economic benefits, reversal of environmental degradation or ES conservation, local added value, redistribution of benefits, empowerment of communities, and potential of resources' transfer from wealthier to poorer sectors. Again, incentive-based MO, such as certification and incentives from ecotourism, seem to have more potential to benefit the poor. Pilot experiences need to be replicated and scaled out.

Chapter 5 summarizes the main outcomes of the stakeholder consultation and discusses environmental policy approaches in the Andes/Amazon. Recommendations include: better definition, assessment, and valuation of ES; assessment of contributions of ES to well-being; development of management options that contribute to well-being; development and support of pilot studies; and improving capacities of institutions dealing with ES and poverty alleviation.

Chapter 6 recommends three core areas to be included in the ESPA Program agenda for the Andes/Amazon. The first area involves primarily biophysical, the second interdisciplinary, and the third primarily socio-economic and policy research:

1. Understanding and predicting spatial and temporal dynamics of key locally and globally valued ES (especially, forest products and fish resources, local and regional climate regulation, water quality/quantity, and carbon sequestration) with a special focus on:
  - a. Integrating traditional spatial scales of study (individual sites) to policy relevant regional scales such as the one addressed in this situation analysis. Also taking into account the important implications of geographic and environmental differences

throughout the region on the development of *locally adaptive and effective* regional policies. Recognizing the impact of trans-frontier and trans-continental linkages especially for climate and water.

- b. Identifying critical thresholds of change in the provision of ES due to human impacts (such as deforestation), climate change, and their interaction, and devising monitoring, prevention, adaptation, and mitigation measures to ensure that significant thresholds that would lead to increased poverty and vulnerability are not crossed through ecosystem mismanagement.
  - c. Developing and disseminating practical methods to monitor and document local changes in ES provision and spatial-temporal management support systems to identify the agents and processes driving such changes, as well as testing *in silico* preventative policy measures.
2. Understanding, measuring and valuing the contribution of locally important ES to generate well-being among heterogeneous local stakeholder groups, with a special focus on:
- a. Developing and testing comparative frameworks to integrate ES-related welfare into region-wide index-based poverty measures.
  - b. Identifying and mapping location and stakeholder specific vulnerability, based on indicators of the state of ES provision, and threats' assessment.
  - c. Developing and disseminating methods and tools to forecast natural and policy-induced changes in ES provision and their likely impacts for local well-being, as well as to predict the effect of alternative management options to mitigate such impacts.
  - d. Establish and institutionalize a regional knowledge management platform on ES and well-being to support prioritization of local and regional policy initiatives through interdisciplinary research for development outputs.
3. Promote innovative approaches to reduce the transaction costs and strengthen the incipient implementation of incentive based management options for enhanced ES provision (e.g. certification/ecolabelling, payments for environmental services, ecotourism; as well as other novel MO) and conduct comparative research to extract lessons learned with a special focus on:
- a. Globally and locally valued ES which are affected by externalities of local income generating activities.
  - b. How, where and for whom incentive-based management options need to be combined with enabling management options in order to maximize benefits for the poor.
  - c. Developing and disseminating decision-frame works and related tools for policy makers to decide where and under what conditions incentive-based management options will work and what can be done if minimum conditions are not in place.

Chapter 6 ends with a series of prototype projects to address key research questions in each of these areas, suggests promising impact pathways and capacity-building components.

# 1. Introduction

In 2007, the Ecosystem Services and Poverty Alleviation Programme (ESPA)<sup>1</sup> was launched by the Natural Environment Research Council (NERC), the Department for International Development (DFID), and the Economic and Social Research Council (ESRC) of the British Government. Still in its planning phase, ESPA is a global programme that intends to promote research and capacity-building to achieve sustainable ecosystem management and well-being in developing countries.

We might first ask why the Andes/Amazon ecosystems should be among the priorities of such a program. The Andes/Amazon region, defined here as the Amazon biome and the Eastern Andes slopes representing the Amazon basin catchment zones (Figure 1.1), is in many ways different from the regions and contexts studied by the other ESPA situation analyses (e.g., China, India/Hindu Kush/Himalaya, rural/urban interactions, semiarid sub-Saharan Africa, marine and coastal regions).

First, large parts of the region are still covered by relatively intact primary forests, thus providing ecosystem services much closer to natural ecosystem capacity than in most of the other ESPA pilot regions. Second, rural population densities are among the lowest in the world, and although income-based poverty prevails, rural dwellers are arguably not affected by such levels of resource scarcity as, for example, their sub-Saharan counterparts. As a consequence, more international attention has been paid to alleviating poverty and rebuilding ecosystem services in resource poor and overpopulated regions. Yet, are natural resource (and, hence, ecosystem service) scarcity in combination with high levels and density of poverty the only necessary conditions for research and capacity-building interventions? There are three reasons for answering no:

1. Continuous resource degradation and constant levels of poverty in large parts of the rural tropical world indicate that a common belief regarding rural development can be misleading. There is little reason to expect that temporarily compromising natural resources eventually leads to higher levels of rural well-being, which, in turn, stimulates increasing resource conservation *before* valuable ecosystem services are irreversibly lost.
2. Rebuilding ecosystem services in ecologically degraded areas is arguably much more costly than preventing their loss in the first place. Moreover, the rural poor often lose out in attempts to rebuild ecosystem services through conventional policy instruments.
3. The Amazon region is probably the youngest among the remaining large human colonization frontiers. As a consequence, modern technologies have contributed to its expansion at rates historically without precedence, i.e. over the last few decades, 84 million ha of natural ecosystems have been lost (Malhi et al. 2008). As an overwhelming amount of research has shown in the past three decades, this expansion is associated with losses of regionally and globally valuable ecosystem services. As such, the Amazon clearly contrasts with resource poor – high population ESPA areas in that even relatively few and poor settlers can exert considerable and increasing pressure on natural resources. That said, ecosystem service loss in the Amazon region is also driven by large-scale commercial interests that compromise livelihoods of low-income and traditional rural populations.

These three arguments and the evidence presented in this report make a clear case in favour of a prevention-oriented research and capacity-building intervention to support integrated and sustainable management options for the Andes/Amazon ecosystems with the stated objective of

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<sup>1</sup> [www.nerc.ac.uk/research/programmes/espa/](http://www.nerc.ac.uk/research/programmes/espa/)

maintaining ecosystem service provision and prevent aspects of poverty associated with their loss.

Indeed, negative effects of land use change in the Andes/Amazon are related to convoluted political processes, clearly expressed in Amazonian socioeconomic contexts. The Amazon is home to some 380 ethnic groups that have been drastically affected by frontier expansion and biodiversity loss resulting from land use transformations. Likewise, riverine, peasant and other traditional rural populations throughout the region rely on food, fibre, fodder, fuel, and medicinal plants locally extracted. Both transitions and clashes occur between indigenous production systems and market-driven systems, jeopardizing the existence of several of these groups. Skyrocketing land prices and concentration of wealth and land ownership further exacerbate this situation, increasing rural-urban migration and augmenting social stress in the region's urban and peri-urban areas. Moreover, the regions' unique socio-cultural setting and the diverse forms in which local livelihoods depend on its ecosystem services (in both sustainable and unsustainable ways), makes it a particular valuable case for examining the nexus between ecosystem services and poverty alleviation.



*Figure 1.1 The study region as defined by the Amazonian biome and the contributing catchment in the eastern slopes of the Andes*

This report presents the results of a situation analysis of ecosystem services and poverty in the Amazon and Eastern Andes, carried out between September 2007 and March 2008. It intends to provide guidance to the ESPA program as regards the definition of research and capacity-building priorities for the Andes/Amazon. As such, the report necessarily takes a macro-scale approach to examine the state of knowledge on ecosystem services, well-being and related management needs in the region. To reduce the inherent caveats of such an approach, the situation analysis was

embedded in an extensive stakeholder consultation process, in which local, national and regional stakeholders contributed to improving and validating its outcomes.

In the remainder of this introductory chapter we lay out our general understanding of the relationship between ecosystem services and poverty, the specific objectives of the situation analysis and the methodological approaches taken.

### ***1.1. Ecosystem services and poverty in the Andes/Amazon***

“Ecosystem service” has become a widely used term in both the scientific literature and policy debates. According to the Millennium Ecosystem Assessment (MEA 2005), ecosystem services are the “benefits that people obtain from ecosystems”. Another definition separates ecosystem services, “the processes and conditions through which ecosystems support human life”, from ecosystem goods, i.e. products provided by ecosystems that generate benefits through consumption (Daily 1997).

Thinking of the benefits nature provides in terms of goods and services suggests an analogy with economic goods and services. This analogy helps to better understand the complex relationship between human well-being and the environment by breaking down the environment - well-being relationship into manageable pieces. One of the best-known, although heavily contested, global environmental valuation studies employed the ecosystem service concept to provide a first rough estimate of the value of the benefits that nature provides to human beings (Constanza et al. 1997). The study contended that tropical rainforests such as the Amazon provide high value services such as climate regulation, nutrient cycling, erosion control, waste treatment, food and raw material production, genetic resources, and recreation. Research has estimated that the amount of carbon retained in the Amazon corresponds to 1.5 decades of anthropogenic greenhouse gas emissions (Soares-Filho 2006); and that the Amazon and eastern Andes slopes together represent the world’s largest continuous area of global biodiversity priorities (Turner et al. 2007). The Amazon Basin supported by its Andean catchment zones form the largest freshwater system in the world (Muller-Karger et al. 1988) with benefits in terms of, among others, local livelihoods, transport, and electricity generation.

Given that both the provision of some types of ecosystem services and the way in which humans benefit from them are complex and not well understood, the MEA developed a qualitative conceptual framework linking categories, such as provisioning and regulating services to components of well-being, e.g. health, security, and autonomy. This qualitative conceptual framework helped to identify those dimensions of the nature - well-being relationship that are particularly hard to quantify and have therefore received less attention by both environmental regulatory policies and by the research that supports such policy formulation.

Although human well-being - environment relationships are widely recognized, the extent to which poverty is both consequence and cause of reduced ecosystem service provision remains subject to debate (Gray and Moseley 2005; Ravnborg 2003). Much of this debate relates to what actually constitutes poverty or well-being. In a component of a recent global scoping study on compensation and rewards for environmental services (CRES), Iftikhar et al. (2007) reviewed a variety of poverty concepts in terms of how they may be linked to environmental dimensions. As they point out, conventional poverty measures, such as the poverty-line and the dollar-a-day concepts, fail to incorporate non-market goods and services as well as non-material dimensions of poverty (e.g. vulnerability to shocks). This limits the usefulness of these poverty measures to analyse well-being – environment relationships. Both Vosti and Reardon (1997) and DFID’s (1999) livelihood framework highlight asset-based poverty measures, which has helped to name and measure the

contributions of ecosystems to human well-being. The CRES scoping study indicates that such broader poverty concepts also tend to emerge from self-assessment of poverty (Iftikhar et al. 2007). This notion could be confirmed in various national stakeholder consultations, especially with traditional populations in Brazil, which highlighted other than income-based dimensions of well-being. In these meetings it was not always possible to reach a consensus on what ultimately constitutes poverty in the Andes/Amazon context.

The bottom line of the debate on poverty, or lack of well-being, is that these concepts are both multidimensional and context specific. Some of the stakeholders consulted for this situation analysis even suggested that well-being may be, to some extent, a subjective experience. Although income-based measures such as one-dollar-per-day or poverty-line approaches may capture a fair range of dimensions, they often fail to capture differences between the poor in natural resource-abundant areas vs. their counterparts in resource-scarce areas. The United Nations Development Programme (UNDP) map of the Human Development Index (HDI)<sup>2</sup> in Brazil reveals that even a more comprehensive measure of well-being does not capture distinctions thought to be important by stakeholders, e.g., between tropical forest areas in the western Amazon and semi-arid savannas in north-eastern Brazilian areas. In these cases, poor health conditions, low levels of education, and limited access to other basic services clearly contribute to the incidence of poverty. Yet, humans adapt to ecosystem conditions and changes in them (e.g. through climate change, infrastructure development, or expansion of commercial agriculture) may have completely different implications for well-being in the different contexts.

First, livelihoods in tropical rainforests are possibly more dependent on (and thus more vulnerable to changes in) what nature provides at relatively low cost than those in the higher Andes. Second, abundance of a given ecosystem good or service (e.g., rapid regrowth of fallow vegetation after slash-and-burn agriculture in forest ecosystems) may be seen as a benefit by a native community; but as a cost factor by immigrants interested in extensive cattle production. Third, depending on socio-cultural background as well as economic and political settings, a given group of natural resource users may use and modify ecosystem service provision in ways that prevent other groups from reaping its benefits. Fourth, although changes in the provision of some ecosystem services may take place quickly, adaptation generally takes time and may require policy action.

Hence, understanding environment-poverty relationships requires knowledge about the spatial and temporal dimensions of ecosystem service supply and use, and the specific contexts in which benefits are derived. As a consequence, it may be that no globally comparable measure can meaningfully reflect the share that ecosystem services hold in the portfolio of factors that makeup human well-being at local scales.

Nonetheless, faced with the task of providing a regional scale overview of the situation of ecosystem services and poverty in the Andes/Amazon, we also have to rely on sources of information with consistent regional coverage. Hence, some analyses presented below employ standard poverty measures such as the dollar-a-day approach to identify and locate the incidence of low-income groups, but without necessarily proposing a causal relationship between low-income poverty and ecosystem service provision. That said, empirical evidence across the world does show that environmental degradation and consequent losses to ecosystem service provision are likely to affect low-income populations the most and thereby increase poverty because:

First, low-income households generally have little or no access to substitutes for basic goods and services they receive from particular natural resources (e.g. clean water, soil quality, forest products). And second, they also typically do not have a choice between alternative technologies

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<sup>2</sup> The HDI is a compound indicator based on income, education and life expectancy

(for improved provision or use efficiency) to offset the impact of deterioration of service provision.

A comprehensive answer with respect to which of the two reasons applies in specific contexts and to what extent this may lead to poverty is beyond the scope of this report. Nonetheless, based on a careful selection of case studies, an extensive literature review, and consultation with local stakeholders we intend to shed some light on how ecosystem services and their conservation could contribute to both preventing and alleviating poverty in the Andes/Amazon region. On this basis we define the general and specific objectives of this report in the following section.

## ***1.2. Objectives and approach of the situation analysis***

The ultimate objective of this situation analysis is to define a series of priorities for research and capacity-building to be addressed by follow-up activities in the implementation phase of the ESPA program. As such, it has to identify knowledge and capacity needs that, if properly addressed, can contribute to preventing and alleviating poverty through the maintenance of ecosystem services provision in the Andes/Amazon region. To achieve this principal objective, we defined a series of milestones to be addressed by different components of the analysis (see Figure 1.2 below):

1. Identification of the key ecosystem services provided by the Andes/Amazon ecosystem to local populations and to the global society (Chapter 2 of this report)
2. Identification of the main threats and challenges to these ecosystems and their provision of services (Chapter 2 of this report).
3. Characterization of the benefits that local populations derive from using these ecosystem services (Chapters 2 and 5 of this report).
4. Identification and characterization of promising options to manage ecosystem service provision in ways that could contribute to the prevention and alleviation of poverty in different contexts (Chapters 3 and 4 of this report).
5. Participation of local and regional stakeholders in achieving objectives 1 through 4, and defining research and capacity-building priorities related to implementing sustainable ecosystem service management options with benefits for the poor.

Figure 1.2 shows how the five components are embedded in continuous stakeholder engagement.

Five operational components of the study were defined: a spatial analysis of ecosystem services and poverty in the Andes/Amazon region (C1), a literature based analysis of options to manage ecosystem services and their impact on poverty (C2), an analysis of selected case studies of projects and programs to manage ecosystem services to alleviate poverty (C3), a review of research and capacity-building needs linked to all other components (C4), and (C5) a systematic process of stakeholder engagement feeding into all components throughout the project (yellow and orange areas in Figure 1.2).

The macro-scale spatial analysis of ecosystem services and their linkages with poverty is a key component of this situation analysis. Maps and models of ecosystem service stocks and flows are used to describe spatial and temporal characteristics of ecosystem services for which regional data are available. Component 1 integrates secondary data and spatial models of ecosystem service flows to assess some of the main drivers of ecosystem services loss, such as deforestation and climate change. Where possible, ecosystem service provision is overlaid with poverty and other socioeconomic indicators, which helps to characterize interactions between the two.

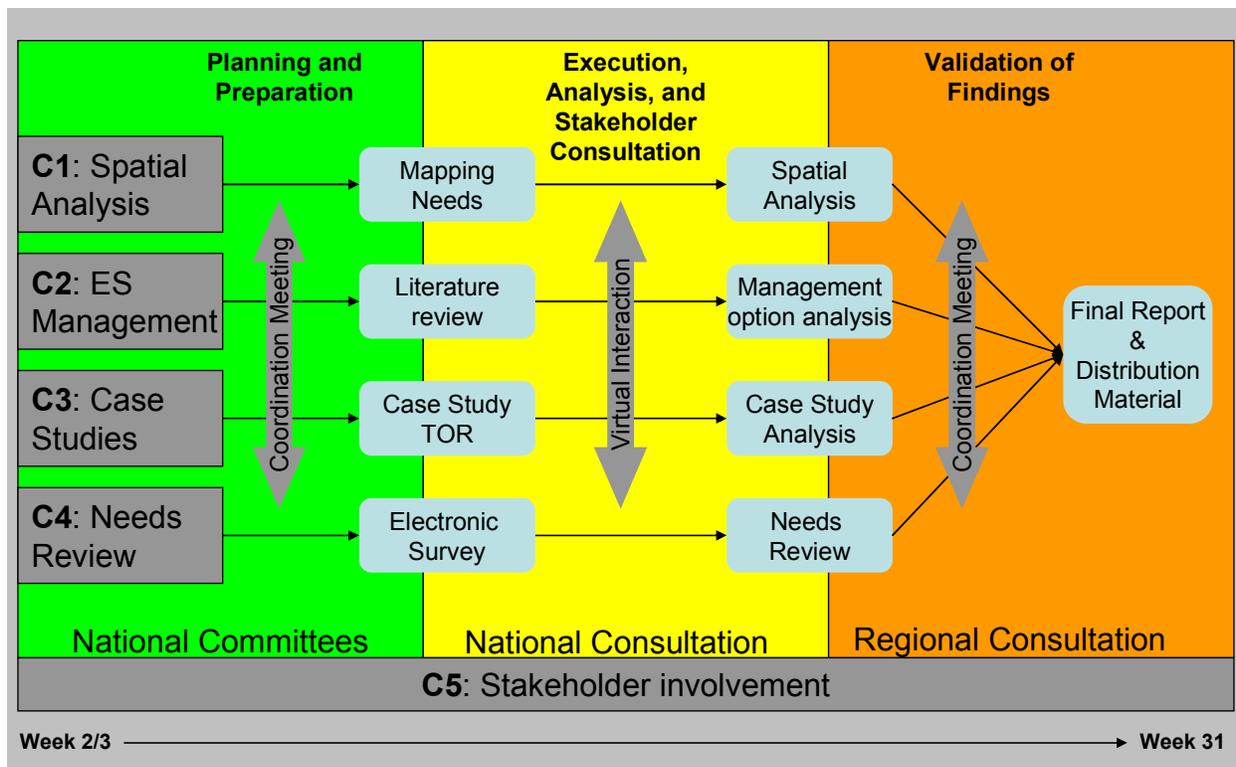


Figure 1.2 Components of the situation analysis and their linkages

Based on a review of regional and international literature, Component 2 identifies and characterizes existing and promising options to manage ecosystem service provision and their implications for poverty prevention and alleviation. Key characteristics of ecosystem services and how they are modified and/or benefits are derived from them are identified. A set of criteria to make informed choices among ecosystem service management options is proposed; and, on the basis of this, future research and capacity-building needs are proposed.

Component 3--which builds on Component 2--looks at how some of these management options actually perform in different contexts in the Andes/Amazon region. Cases from the Andes/Amazon region are reviewed in which programs or projects have addressed environmental problems in different ways and with varying success, while simultaneously attempting to improve human welfare. A more comprehensive set of evaluation criteria using environmental and welfare indicators was developed to help assess the performance of management options and related implementation strategies.

Component 4 draws on the other components, contributions from local and regional stakeholders, and a review of environmental policies of the six major Andes/Amazon countries. This component was designed to extract, from all project components, key elements of a potential research and capacity-building agenda for the ESPA program.

The involvement of local and regional stakeholders throughout project execution was coordinated through Component 5 in three different stages. After a project preparation phase, key stakeholder organizations such as government and research institutions, civil society organizations, and NGOs were contacted in Brazil, Bolivia, Peru, Ecuador, Colombia, and Venezuela. This first contact involved presentation of the ESPA program and identification of key contact persons. These key

collaborators were invited to participate in national stakeholder consultation workshops to identify the most relevant ecosystem services in each country and how these services are related to the well-being of local populations. Participants also identified research and capacity building priorities for more effective ecosystem service management with positive welfare effects. Hence, this component is complementary in that it was designed to discover those ecosystem services, and their well-being implications, that Component 1 cannot cover due to data limitations.

With preliminary results available from all components, two regional stakeholder workshops were organized in the Andes and the Amazon region. Workshop participants evaluated preliminary results in order to then define key research and capacity needs at regional and local levels. Outcomes of the regional stakeholder workshops were analyzed in Component 4 and integrated into the proposed research and capacity-building agenda.

### 1.3. Concepts and Definitions

We developed a simple conceptual framework for this situation analysis based on Swallow et al. (2007) and the Millennium Ecosystem Assessment (Figure 1.3).

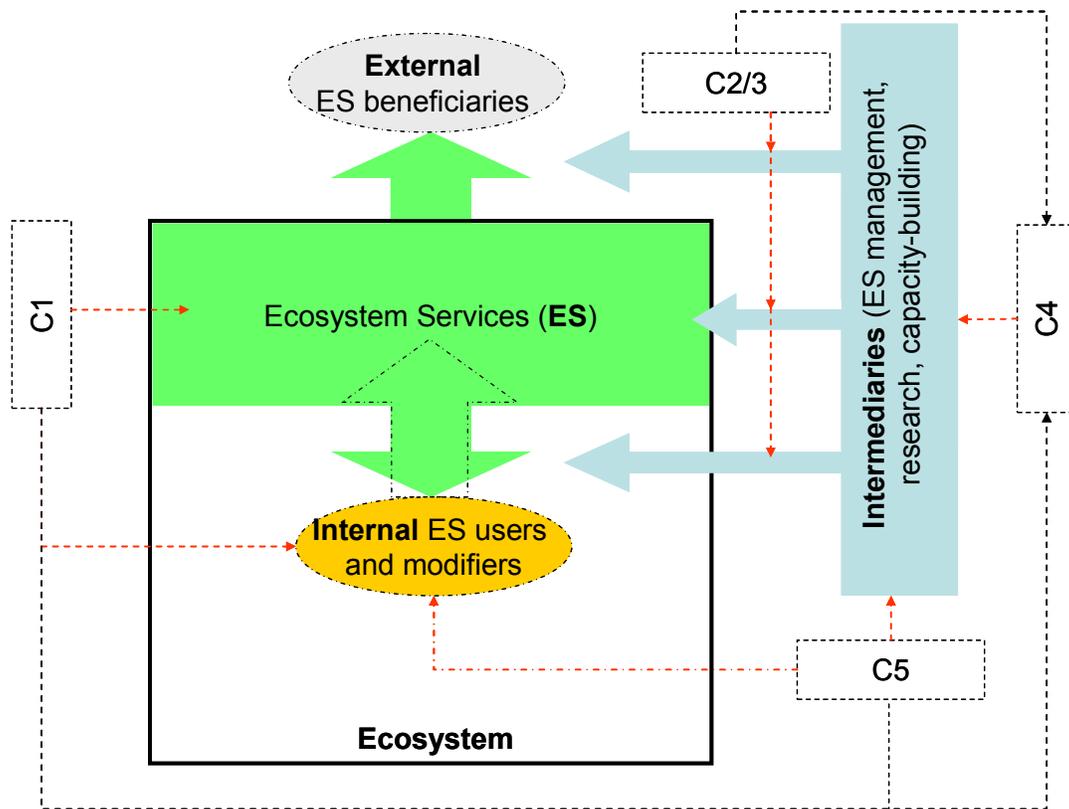


Figure 1.3 Conceptual framework of ecosystem services and stakeholders

According to Figure 1.3, a given ecosystem provides services (ES) to users and modifiers inside the ecosystem and to external ES users (e.g., global society). The conditions of ES use, access, and human driven modification are influenced by intermediaries (i.e., policy makers, local user groups,

civil society organizations, and research, education and training organizations).

Dotted lines in Figure 1.3 illustrate how the components of our analysis examine and describe this system and help to derive recommendations for the ESPA program. Component 1 analyses ES and the conditions of ES use and modification inside the ecosystem. Components 2 and 3 assess how intermediaries, ES modifiers and users can influence the performance of the system through management interventions. Component 5 interacts with ES users, modifiers, and intermediaries and, together with previous components, feeds results into Component 4, the definition of research and capacity-building priorities.

We adopt the most inclusive of definitions of ecosystems services set out at the beginning of this introduction, i.e. the benefits that people obtain from ecosystems (MEA 2005). This is because a comprehensive analysis of ES and poverty needs to account for all potentially relevant contributions of the environment to human well-being regardless of whether these are in the form of goods or services. Nonetheless, we show, for example, in Chapters 3 and 4 of this report that more restrictive definitions of ES eventually need to be adopted to evaluate ES management options or analyze specific aspects of the environment-well-being relationship.

It was not possible to adopt a single concept or definition of poverty that equally satisfied the different analytical approaches and stakeholder perceptions. Stakeholders challenged the use of the term “poverty” in the context of the Andes/Amazon region--a region in which many traditional and native communities deemed poor by most standard poverty measures actually do not consider themselves poor.

In an attempt to align stakeholder perceptions with the needs of analytical approaches, poverty could be defined as “unacceptable conditions of well-being”, where “acceptability” refers to the subjective dimension of poverty and “conditions” comprise more objective dimensions such as the lack of access to basic public services and natural resources, income and asset endowment, education, and health among others. In this report, some of these measurable dimensions of poverty are used to characterize well-being of ES users and modifiers in spatially explicit ways. Other more complex concepts of poverty, such as “conservation investment poverty” are introduced--albeit not measured--as useful tools in the evaluation of management intervention options.

Finally, ecosystem services can be managed in several ways with and without the involvement of public policy. All potentially involved stakeholders--e.g., governmental, non-governmental, and civil society organizations and local communities--can and should benefit from research and capacity-building to improve ecosystem service management and well-being. To account for all potentially relevant approaches to ecosystem service management, we introduce the term “management option”. As opposed to frequently used terms such as policy instruments or interventions, management options (MO) comprise the whole range of alternatives through which stakeholders can engage in the management of linkages between well-being and the environment--i.e., from community-based management approaches to government induced market interventions or command-and-control policies.

#### ***1.4. Structure of the report***

The report is structured as follows. Chapter 2 provides a spatial assessment of ecosystem services and poverty in the Andes/Amazon region. Data availability at the regional level constrained the services included in the spatial analysis. Considering the above assumption, we focused on the types of services that are deemed most relevant at local and global level by both the reviewed

literature and the stakeholders consulted throughout the consultation process.

We start off with the analysis of water quantity and quality, followed by local climate regulation services and carbon as an indicator for global climate regulation services. Next come soil related services and a set of ecosystem services that we group under services related to ecosystem functioning, such as those associated with terrestrial and aquatic biodiversity, e.g. fish and forest products. Note that, whenever services could not be measured directly, the natural resource basis for service provision was analysed as an indicator for service provision.

Following the spatial assessment, Chapter 3 critically reviews the diverse options available to manage ecosystem services and their potential effects on the poor based on a literature review. Chapter 4 puts this into practice by presenting a systematic review of the success factors of programmes and projects that have implemented selected management options in the Andes/Amazon region. Lessons learned are extracted.

Chapter 5 summarizes the main outcomes of the stakeholder consultation process and a review of the environmental policy settings in the Andes/Amazon countries in order to develop an agenda for research and capacity-building interventions in the ESPA programme.

At the end of each chapter key research questions are extracted that are summarized together with the main messages of this report in Chapter 6.

## 2. Spatial assessment of ecosystem services and poverty in the Andes/Amazon

### 2.1. Approach of the spatial assessment

To provide a baseline analysis of the distribution of ecosystem services in the study region, our pragmatic approach has depended on data quality and availability. The aim was to: (1) quantify environmental service provision under current conditions, (2) examine impacts of scenarios for change and management options (climate and land use impacts) to understand how the provision of services may change, and (3) identify potential impacts of these changes on the region's capacity to meet human needs for ecosystem services.

Ecosystem services selected for inclusion in the spatial assessment were:

- Provision of water quality and quantity
- Climate Regulation
- Sequestration and storage of carbon and biomass
- Provision of forest products and other terrestrial biodiversity products
- Commercial fisheries production
- Other aquatic biodiversity products
- Conservation of plant genetic resources for food and agriculture

These services do not represent all possible ecosystem services, but do represent some of the most important to the poor and potentially affected by ecosystem (mis)management. They were also selected on the basis of data availability for spatial mapping of provision, consumption, and threat. The first two services are critical services to agricultural production, hydroelectric power (HEP) generation, transport and human health in the region. Carbon and biomass are critical global services with the potential to open up new sustainable livelihoods for poor landowners, based on payments for environmental services (PES) with markets nationally and globally. The following four biodiversity related services are critical to diet (in particular the provision of protein through fisheries) and climate-change stable agriculture through the use of plant genetic resources. The relative importance of these services varies across the region with the provision of the services but also between social groups according to the need for services. Terrestrial biodiversity and forest products for example (including bush meat) are much more significant services to indigenous communities than to urban dwellers, whilst the provision of high quality and reliable water resources are more critical to urban dwellers dependent on potable supplies and HEP generation. There are other services that are also important to the poor but these are ones with such limited data that a spatial assessment was not possible, hence these are discussed further in subsequent chapters. We also map the distribution of poverty and population in order to characterise the study region for comparison with the assessment of individual ecosystem services.

We use an evidence based approach bringing together the best available datasets for analysis at the continental scale. Where analysis needs to be informed by our current understanding of processes we combine the spatial data with process based models capable of simulating the behaviour of aspects of the system. Most scientific endeavour is some form of modelling: theories are conceptual models of the real world; data are empirical models of the real world. Mathematical

models are no different: when they are used properly they are a formalization of scientific reasoning and assumptions in an experimental/exploratory form with no room for ambiguity and less room for bias and obfuscation than the traditional analytical approach. Where our work relies on a single model scenario, we use a sensitivity approach to understand the range of potential responses in the face of the uncertainty. Robust spatial modelling and remote sensing is important for the region-wide assessment of environmental services and for the development of better policy to use ecosystem management for poverty alleviation. Although an in-depth understanding of processes related to ecosystem services and well-being can only be achieved through case studies, modelling is the only tool in the scientists' toolbox that can deliver region-wide assessment in an open and transparent way and in a way that can be more scientifically robust than taking the outcomes from a limited number of case studies and assuming they hold for the entire Andes and Amazon. Whilst characterisation of this kind at the Amazon scale is a significant challenge, it has been engaged with here on the one hand to provide the regional focus required for the review and secondly to highlight the significant gaps and questions which remain as one moves from plot scale studies to studies at policy relevant scales. The accuracy of this situation analysis is strengthened by combining and comparing spatial modelling results with the analysis of case-studies (Chapter 4), as well as validating it through a broad stakeholders' consultation (Chapter 5).

These analyses are not intended to be definitive statements on the total services provided, rather they are a situation analysis of our knowledge of these services and the gaps in that knowledge: for example we have not accounted for greenhouse gases other than carbon in our analysis of services relating to global atmospheric chemistry related services. We have done this not because methane for example is unimportant but rather because the data for spatial assessment of methane is not available to us as it is for carbon and we thus conclude that further data are required by ESPA or other programmes before a more realistic assessment can be made.

## ***2.2. Population and poverty in the study region***

**Population:** The study region covers almost ten million km<sup>2</sup>, of which 92% is a part of the Amazon biome. Population was 44 million in 2000, and on average has grown over 250% since 1960 (Table 2.1). Most rapid growth has been in Colombia, French Guiana, and Venezuela, although collectively these countries represent only 8% of total population. Nearly half of the Amazon population in 2000 is found in Brazil, where the population has grown at a fairly steady 30-50% per decade since 1970. According to the data, most growth has occurred in rural areas (300-350% from 1960-2000), although this is more likely an artefact of the scale of analysis rather than a true demographic (Table 2.2). Nearly 50% of population is concentrated in moist forest ecosystems, although *várzea* (seasonally flooded forest) ecosystems and savannah are undergoing high growth rates in recent decades (Table 2.3). Detailed tables on population distribution in the study region are available in Annex 1.

Table 2.1 Population 1960 – 2000 in the study region grouped by country based on the GRUMP gridded population of the world from CIESIN (<http://sedac.ciesin.columbia.edu/gpw/>)

	1960	1970	1980	1990	2000	% Growth
Bolivia	2,254,239	2,938,516	3,791,760	5,044,365	6,551,865	291
Brazil	5,914,232	6,431,362	10,022,472	14,482,984	18,841,137	319
Colombia	250,239	485,528	683,064	1,024,494	1,429,488	571
Ecuador	1,560,097	1,441,982	1,802,324	2,329,175	2,710,316	174
French Guiana	29,349	48,398	69,456	124,368	175,263	597
Guyana	646,148	800,848	853,792	825,818	841,015	130
Peru	3,826,553	5,225,969	6,987,118	8,901,382	10,933,121	286
Surinam	295,402	380,598	636,894	419,752	459,059	155
Venezuela	423,571	436,232	884,844	1,388,211	1,750,050	413
<b>Total</b>	<b>15,199,830</b>	<b>18,189,433</b>	<b>25,458,724</b>	<b>34,540,549</b>	<b>43,691,314</b>	<b>287</b>

Table 2.2 Population in urban areas, indigenous lands and other rural areas

	1960	1970	1980	1990	2000	% Growth
Urban	3,839,136	4,393,730	5,881,405	7,887,020	10,026,922	261
Rural colonizer	10,830,045	13,210,869	18,633,130	25,252,923	31,802,582	294
Indigenous	530,649	584,834	944,189	1,400,606	1,861,810	351
<b>Total</b>	<b>15,199,830</b>	<b>18,189,433</b>	<b>25,458,724</b>	<b>34,540,549</b>	<b>43,691,314</b>	<b>287</b>

Table 2.3 Population in different major ecosystems across the study region

	1960	1970	1980	1990	2000	% Growth
Dry forest	1,756,206	2,319,276	3,128,718	4,321,858	5,738,405	327
Guayanan ecosystems	12,289	10,795	55,767	83,838	122,138	994
Mangroves	228,220	269,402	308,142	403,177	475,858	209
Moist forest	5,616,624	6,148,737	9,310,246	13,206,691	17,391,081	310
Montane Forest	2,789,888	3,533,346	4,674,768	5,862,553	7,039,474	252
Montane Grasslands	2,538,852	2,961,243	3,599,053	4,343,382	4,997,123	197
Savanna	1,511,421	2,068,081	3,094,377	4,450,590	5,478,176	362
Swamp Forest	122,041	156,944	150,307	169,103	181,705	149
Várzea	624,289	721,609	1,137,346	1,699,357	2,267,384	363
<b>Total</b>	<b>15,199,830</b>	<b>18,189,433</b>	<b>25,458,724</b>	<b>34,540,549</b>	<b>43,691,314</b>	<b>287</b>

**Poverty:** Measures of poverty such as per capita income, unsatisfied basic needs, human development index, and others are commonly used by development agencies. Stakeholders during the consultation process often pointed out that these measures of poverty say little about the conditions in which people are living, especially in the Amazon, and that any real measure in the Andes and Amazon must consider the quality of life. There is a growing field that attempts to capture more subjective measures of poverty akin to quality of life, such as life satisfaction (Abdallah et al. 2008) and happiness (NEF 2006). An astonishing 4,300 articles have been published on these topics, although adoption of such ideas in the broader development community has been slow. Future ESPA projects should contextualise poverty beyond the classic socio-economic indicators and take an approach that includes concepts of quality of life and life satisfaction, and preferably include measures of natural capital in examining the link between

ecosystem services and poverty.

Despite the stakeholder preference for a quality of life focus in the poverty analysis, the data to do this is simply not available across broad regions of the study area. Consistent sub-national level census data for the period 1993-2003 was available for 5 countries (Brazil, Bolivia, Colombia, Ecuador and Peru) and used in this assessment. We used two poverty indicators--unsatisfied basic needs (UBN--expressed as a percentage of population lacking one basic need) and infant mortality (number per 1000 population). Whilst data on the Human Development Index exists for Brazil at the municipality level, this was not available for other countries.

The poverty maps are shown in Figure 2.1, and summary tables are provided for each country (Table 2.4), for each major ecosystem (Table 2.5) and for each community type (Table 2.6). For both indices, Bolivia is highlighted as the poverty hotspot in the region with 56% of the population in the study region suffering from a lack of at least one basic need and infant mortality at 61 per 1000. Inequality in Brazil is reflected in the data for the study region, with a significant coefficient of variation in both unsatisfied basic needs and infant mortality within the country (53% and 34% respectively). Percentage population with unsatisfied basic needs in the Brazilian Amazon appears to be concentrated in the western Amazon and areas surrounding Belém, although it is important to note that there is little correlation between UBN and infant mortality across all areas. Both poverty measures appear to be fairly evenly spread across different ecosystems, although dry forests and montane grasslands have marginally higher levels of unsatisfied basic needs. There is no evidence in the data of greater poverty in lowlands (Amazon biome) versus highlands (Andean ecosystems), nor is there any evidence of differing levels of poverty in urban areas compared with rural areas (regions undergoing colonisation and indigenous lands). The latter may however be a sampling issue due to the scale of the poverty data being analysed.

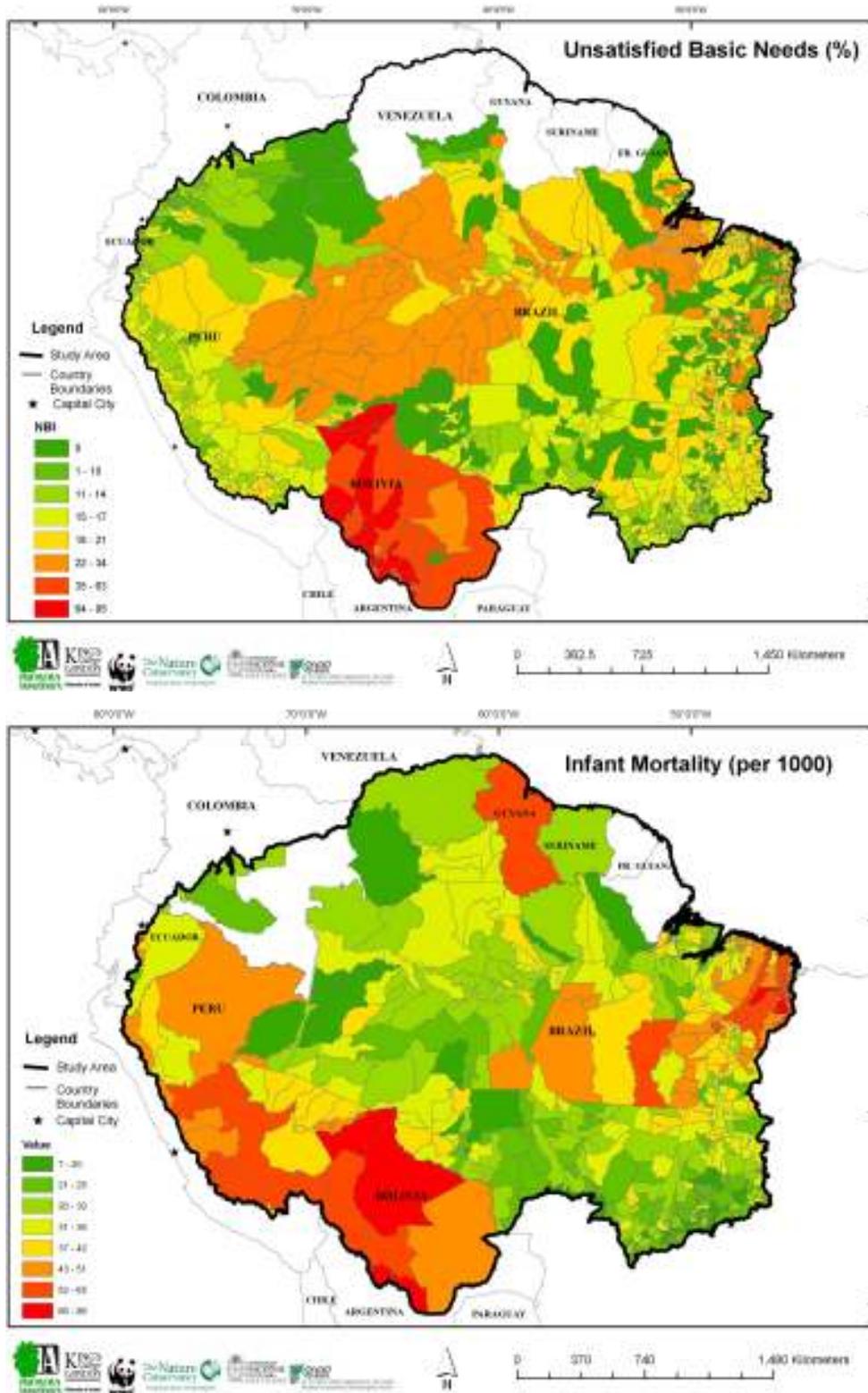


Figure 2.1 Distribution of poverty in the study region using unsatisfied basic needs (UBN) (top) and infant mortality (bottom)

Table 2.4 Average poverty indicators for each country in the study region, based on national level census data from 1995-2005.

	<b>Unsatisfied Basic Needs (%)</b>				<b>Infant Mortality (per 1000)</b>			
	Mean	Std	Min	Max	Mean	Std	Min	Max
Bolivia	56.9	23.1	0	95	61.8	10.5	36	86
Brazil	14.3	7.7	0	66	33.3	11.4	12	80
Colombia	9.6	2.8	0	18	25.3	5	18	47
Ecuador	10.9	3.8	0	18	34.8	8.2	18	52
Peru	13.9	2.9	0	88	49.4	8.7	14	67
<b>Total</b>	<b>18.1</b>	<b>15.9</b>	<b>0</b>	<b>95</b>	<b>39.9</b>	<b>14.5</b>	<b>12</b>	<b>86</b>

Table 2.5 Average poverty indicators for each ecosystem in the study region

	<b>Unsatisfied Basic Needs (%)</b>				<b>Infant Mortality (per 1000)</b>			
	Mean	Std	Min	Max	Mean	Std	Min	Max
Savanna	14.6	10.6	0	70	29.7	11.8	12	70
Dry forest	25.5	23.8	0	95	43.3	13.7	20	86
Montane grasslands	23.5	23.6	4	95	51.5	13.6	18	86
Montane forests	18.4	15.9	0	92	49.1	11.1	21	70
Mangroves	16.6	8.4	0	24	45.2	13.2	22	80
Várzea	17.9	7.2	0	66	31.8	8.5	14	57
Moist Forest	15.7	11.4	0	80	37.6	13.2	12	80
Guyanese ecosystems	4.5	5.6	0	11	33	0	33	33
<b>Total</b>	<b>18.1</b>	<b>15.9</b>	<b>0</b>	<b>95</b>	<b>39.9</b>	<b>14.5</b>	<b>12</b>	<b>86</b>

Table 2.6 Average poverty indicators for each community type (urban, rural coloniser, indigenous) in the study region

	<b>Unsatisfied Basic Needs (%)</b>				<b>Infant Mortality (per 1000)</b>			
	<b>Mean</b>	<b>Std</b>	<b>Min</b>	<b>Max</b>	<b>Mean</b>	<b>Std</b>	<b>Min</b>	<b>Max</b>
Urban	17.5	14.1	0	95	39.1	14.4	12	86
Rural	18.1	15.9	0	95	39.9	14.5	12	86
Indigenous	17.0	14.4	0	88	39.5	12.9	14	71
<b>Total</b>	<b>18.0</b>	<b>15.7</b>	<b>0</b>	<b>95</b>	<b>39.8</b>	<b>14.4</b>	<b>12</b>	<b>86</b>

Regional data generally does not allow for in-depth and formal analyses of the interrelationships of these poverty indicators with the ES described below. However, given that the livelihood conditions of many low-income groups are known from case studies, some general conclusions can be drawn on the implications of the state of knowledge about each ES category for such groups. Table 2.6 groups average poverty indicators according to three broad stakeholder groups (urban, rural, indigenous). Below we qualitatively evaluate the implications of findings on ES for these groups at the end of each section.

### 2.3. Water quality and quantity

Water is a readily quantifiable environmental service with key impacts on human health and welfare, agricultural productivity, energy generation, transport, and environmental health. Links between water poverty and human well-being are usually clear in arid and semiarid areas where water is

highly limiting: these relationships are less readily defined in areas with plenty of water such as much of the Andes and the Amazon. Nevertheless, the provision of high quality and dependable water flows is a critical environmental service provided by ecosystems in the Andes and Amazon. There is much evidence that land use change can have impacts (both positive and negative) on the provision of these services (Bonell and Bruijnzeel 2004; DFID 2005; CIFOR 2005; and Chapter 4). Available water at any point is rainfall minus evaporation plus inputs from upstream minus losses to downstream. In spite of catchment scale models and calculations of the water balance, there has been little detailed water balance modelling at the continental scale (i.e., the focus of this study). To quantify provision of water based services, we used global and regional databases for climatic and surface characteristics that determine water balance (i.e., rainfall, cloud cover, solar radiation, temperature, humidity, vegetation cover, topography, and drainage characteristics). These surfaces were used to parameterise the FIESTA water balance model (<http://www.ambiotek.com/fiesta>) at a spatial resolution of 1km and using a diurnal-within-monthly time step for the entire Amazon watershed. We present results on the water balance (rainfall – evapotranspiration) at a point and on runoff (water balance accumulated downstream). The key maps are presented in a Google Earth interface at [www.ambiotek.com/ESPA](http://www.ambiotek.com/ESPA), but Figure 2.2 shows the map of flow sensitivity to land-use change derived from the results of the FIESTA model.

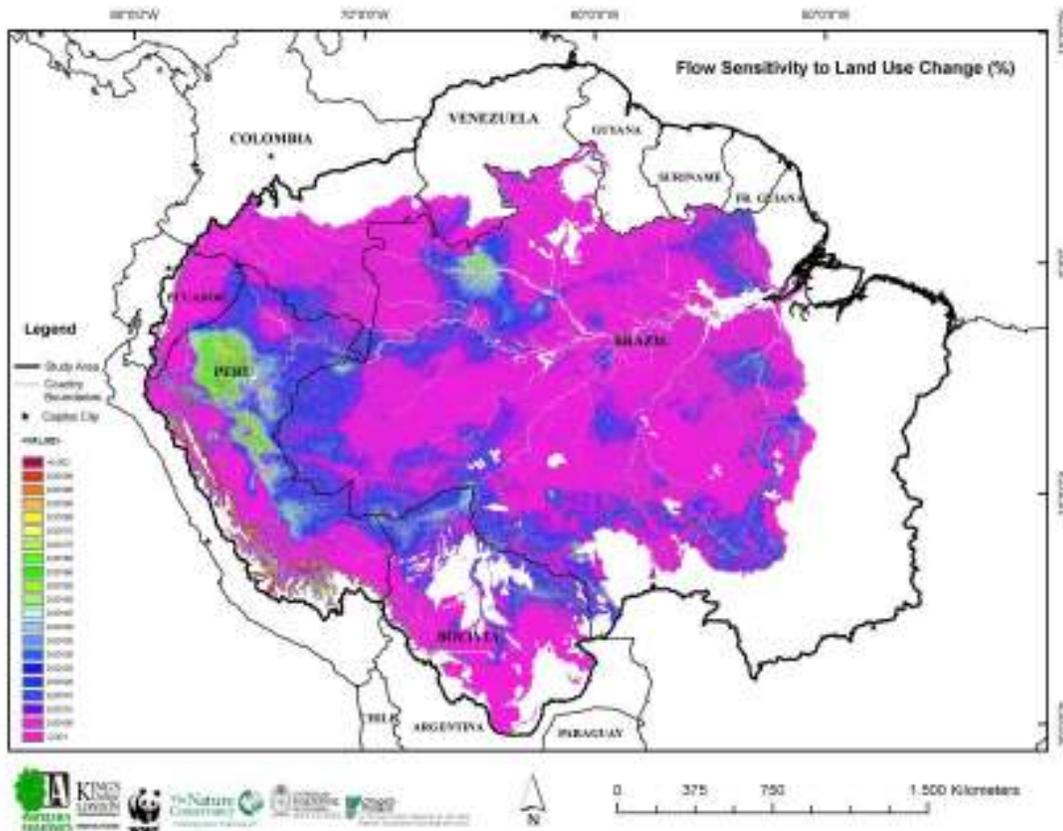


Figure 2.2 Flow sensitivity to land-use change derived from the FIESTA model

Key results indicate that:

- There is a great deal of uncertainty concerning the Amazon water balance based on the input data used (especially rainfall inputs which are still highly uncertain across the basin).

- Although the Andes may have highest water balance per unit area, their small extent means that their inputs are dwarfed by rainfall falling on the Amazon.
- The wettest catchments are in the North (N) and West (W) and the driest in the South (S) and East (E).
- Seasonal deficits in the S and E (and locally in the N+W) mean that inputs from upstream are significant to the seasonal water balance in these areas and that most of the catchment is seasonally dependent on seepage and base flow.
- Most deforestation historically has taken place along the main channel and primary tributaries of the Amazon River, along the flanks of the Andes (especially in the N and S) and throughout the “Arc of deforestation” in the S and E.
- Deforestation has had a minimum impact on water balances, with local increases in runoff of the order of a few mm/year in deforested areas.
- Runoff has led to small increases (<1%) in flow of the major rivers draining these areas. Localised responses based on historic measurements and paired catchment studies are much more complex and uncertain (see Annex 2).
- Different General Circulation Models produce broadly the same pattern but different magnitudes of temperature change for the Amazon. Different GCMs produce different patterns as well as magnitudes of rainfall change.
- Impacts of climate change on water balance are much greater than those of historic land use change. The HADCM3 GCM says that: a) evaporation increases throughout the basin but especially in the E; and b) water balance decreases throughout much of the N and central Basin; but increases throughout the Andes, N and E. These factors lead to increases in runoff over the Andes (by 100% in the south) and decreases of up to 100% in the N and central Amazon. Neighbouring rivers can show an opposite trend in terms of change in water balance. Under the ECHAM GCM, evaporation increases throughout the basin, but especially in the E; and water balance increases in the W (500mm/yr) and decreases in the E (600mm/yr). These changes lead to increased runoff in the Andes and western Amazon (30-100%) and decreased runoff in the NE (-30 to -50%) of the basin.
- Regarding hazards (high and low flows), forest loss has led to small increases in low flows especially in the N and W of the basin and small decreases in high flows especially in the E of the Basin. Climate change scenarios lead to much greater changes in minimum and maximum flows. Under the ECHAM scenario minimum flows increase especially in the W of the Basin while they decrease under HADCM3 everywhere except the extreme west.
- In summary, the Amazon basin has a generally plentiful provision of quality water that is relatively reliable seasonally and inter-annually. Although land use change effects have been minimal so far, according to the data available, climate change impacts are likely to be much more significant. There are areas of poor water accessibility (for infrastructural reasons) or for reasons of local aridity or water contamination and these are locally significant even though they do not appear at the continental scale. Better data resolution and availability along with more detailed research would improve the certainty of these analyses.

### *2.3.1. Implications for poor local stakeholders*

Dependence on water quality and quantity is generally high for all local stakeholders. The relative abundance of water in the Amazon basin does not necessarily imply low well-being impacts of changes in water related ES provision. Local economies in the Amazon are highly adapted to (and,

hence, dependent on) abundant water services, be it for transportation, energy generation, fishing or direct uses (drinking water, etc.). Seasonal water shortages are likely to especially affect fishery based livelihood strategies for traditional populations (*riberinhos*) alongside rivers. They also increase fire susceptibility on forests and may, hence, indirectly affect extractivism. Both excess rain and longer and more intense dry season are likely to negatively affect agriculture-based livelihood strategies of colonists and farmers. While waterways are of less importance for transportation in the Andes, excess rain and intensive droughts may increase erosion and runoff from steep slopes and affect downstream water users access to water quality.

*Table 2.7 Stakeholder groups and water related ES implications*

<b>Local stakeholder groups</b>	<b>Dependence on water quantity/quality</b>	<b>Well-being implications of key results</b>
<b>Urban</b>	High, but urban water distribution systems can substitute for ES. In the Amazon, some informal urban settlements may depend more on natural water related services. In the Andes, poor downstream urban settlements depend on water quality affected by upstream modifiers.	Climate change related droughts may negatively affect access to good quality water in informal urban settlements. Climate change and land use may reduce both water quality and quantity for downstream water users in the Andes.
<b>Colonists/farmers</b>	High ES dependence, for direct uses, transportation and agriculture	More extreme seasonal water shortages may reduce agricultural productivity and increase erosion and runoff. Remote communities may experience reduced mobility during dry seasons
<b>Traditional/Indigenous</b>	Same as previous	Same as previous

**Key research issues and questions for ESPA: Water quality and quantity**

1. Development and unhindered distribution of satellite-based climate datasets for improved continental scale hydrological analyses and modelling.
2. Assessment of the relative impacts of land use and climate change on water availability and flow within the Amazon Basin, including feedback processes and assessment of potential land cover or climatic thresholds that can generate significant hydrological change.
3. Assessment of the hydrological sensitivity of the basin to climate change that moves beyond the standard scenario application approach in which the results are highly dependent on the scenario used; and in which different scenarios can produce very different outcomes towards an approach that recognises sensitivity to climate change. Assessment can include use of ensemble simulations.
4. A more detailed treatment of spatial (geographical) variability across the Amazon and its implications for scaling up of site studies.
5. Better understanding of the relationships between water and poverty in water-rich environments and the extent to which these are mediated by water access and quality as much as quantity, including analysis of the issues of dams for HEP generation.

## **2.4. Local climate regulation**

Local climate regulation is a key environmental service related to land cover manifested in rainfall and cloud generation, and, thus, water balance, humidity, and temperature. Even if impacts of forest cover on runoff generation are low and positive for the terrestrial component of the hydrological cycle, it may be that feedbacks among land cover, cloud cover, and rainfall increase precipitation and reduce evaporation through generation of cloud cover. Such an effect would clearly impact on regional climates. There is evidence both for and against this (Charney 1975; Xue and Shukla 1993; D'Almeida et al. 2007; Leopoldo et al. 1995; Salati and Nobre 1991; Annex 3). Reviewing the literature dealing with the impact of land use change (ecosystem management) on climate regulation we found that:

1. Macroscale grid models suggest an overall decrease in water resources associated with deforestation at the Amazon scale attributed to reduced evapotranspiration affecting the basin's rainfall recycling.
2. Mesoscale grid models with greater detail predict changes in the intensity and distribution of precipitation and an increase in the seasonality of cloudiness in areas of high deforestation (Chu et al. 1994; Avissar and Liu 1996; D'Almeida et al. 2007). Results vary spatially, however, depending on climatic conditions and topography. Single column models (as opposed to spatial grid models) indicate greater precipitation over forested areas due to greater evapotranspiration flux from them.

Past analyses have a number of limitations including: coarse scales that are unable to resolve local and regional effects, a reliance on models rather than data, poor quality or limited period rainfall datasets, and the localised application of single column models or data based approaches that cannot resolve spatial variability across the basin, resulting in conflicting, location-dependent results.

In addition to the literature review summarised above, a GIS analysis used the best available current rainfall, cloud cover, and forest cover datasets covering the entire basin (from <http://www.kcl.ac.uk/geodata>) to better understand the role of forest cover on climate regulation. Although much was carried out before ESPA, the analysis, refocused for this purpose, calculated the difference in mean annual seasonal and diurnal cloud cover (2000-2006) and rainfall (1997-2006) between 1km pixels and their westernmost neighbour, and compared these differences with differences in tree cover (Hansen et al. 2003) between the same 1km cells (Hansen et al. 2003).

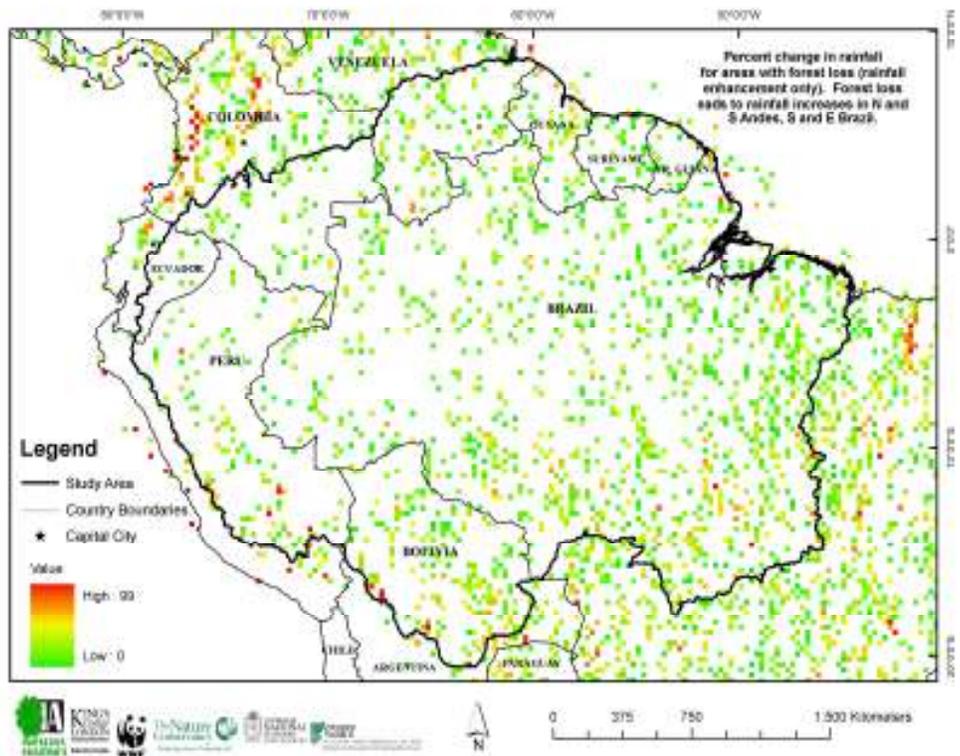
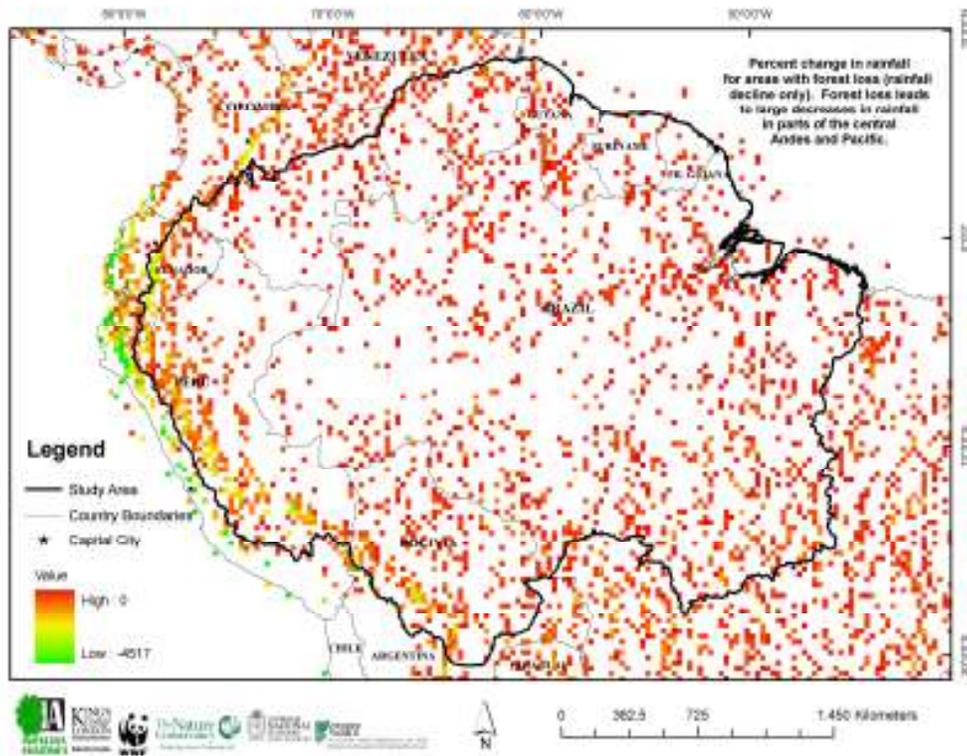


Figure 2.3 Percent change in rainfall for areas with forest loss with rainfall decline only (top) and rainfall enhancement only (bottom)

Results indicate that:

- There is no consistent relationship between difference in forest cover and rainfall of neighbouring cells. Forest loss can be associated with increases or decreases in rainfall.
- Spatial variation with forest loss led to rainfall increases of +10% in N and S Andes, S and E Brazil, but declines in rainfall in the central Andes and Pacific.
- Similarly, change in cloud frequency shows no relationship with change in forest cover.
- Spatially, cloud frequency increases significantly with forest loss in some parts of SE Amazon and E Amazon; but decreases significantly with forest loss throughout the central and S Andes and E Amazon.

In summary, there remains a great deal of uncertainty in quantifying the provision of the regional climate regulation services by different land cover types. This reflects the complexity of mesoscale meteorological situations, which exist from the Andes to the eastern Amazon.

#### *2.4.1. Present and future need for climate regulation*

Given current climate change negotiations, the need for climate regulation services is impossible to quantify. Perhaps the need is for the maximum regulation possible because this will sustain current levels of rainfall, cloud cover, temperature, and humidity.

#### *2.4.2. Implications for poor rural stakeholders*

As with water related ES, all stakeholders are highly dependent on ES that regulate local climate. Since the direction of impact is hard to quantify based on existing data, stakeholder specific implications would be extremely speculative. Specific local climate conditions may favour (or not) vectors for infectious diseases in both rural and urban environments. Changes in rainfall, locally, are likely to have similar effects as changes caused by a globally changing climate.

### **Key research issues and questions to be addressed by ESPA: Local Climate Regulation**

1. Deeper analysis of the impacts of forest cover change on cloud and rainfall generation, and application of these feedbacks in hydrological models (that look at the impacts of forest cover on evaporation and runoff while ignoring the feedback of evaporation to cloud cover and rainfall). Although most models (as the one used here) indicate that deforestation leads to increases in runoff, deforestation may lead to decreases in runoff, with impacts on rainfall generation and recycling at the continental scale, though evidence presented in the Amazon wide precipitation analysis indicates that forest loss can lead to either increases or decreases in rainfall, depending on the context. Questions: What are the full cycle impacts of large scale land use change on water resources in the Amazon and how will these impacts interact with regional climate change and human well-being?
2. More data based analysis of rainfall recycling processes and response to land cover change at the basin scale. Question: What is the role of rainfall recycling in the provision of water at the Amazon scale and how is this mechanism sensitive to land use and climate change?
3. Need for climate regulation services is much less developed than the provision side. Although there are local needs for the maintenance of the climatic status quo, there are also global needs such as the role of the Amazon in global climate regulation. Further research should focus on questions such as: What is the resilience of Amazon livelihoods to changes in climate, and the nature of livelihood responses (positive and negative) to climate change?

## **2.5. Carbon and biomass**

The Amazon forest provides the global ecosystem service of carbon storage and sequestration. Biomass in the Amazon basin has been mapped (Brown and Lugo 1992; Fearnside 1997; Malhi et al. 2006; Saatchi et al. 2007). Coupling the Saatchi et al. 2007 map with the TNC map of ecosystem classes shows that some 92% of the Amazon biomass is tied up in forests. Assuming that carbon is 50% of biomass means that some 80 Pg (billion metric tons) of carbon are currently tied up in the Amazon basin forests (86 Pg of carbon for all Amazon ecosystems). The Amazon thus represents 21% of all carbon in the world's tropical forests. Since 1751 roughly 315 Pg of carbon have been released to the atmosphere from the consumption of fossil fuels (FF) and cement production (Marland et al. 2007). The carbon in Amazon forests is thus equivalent to some 25% of all post Industrial Revolution FF emissions. Annual average FF emissions from 1970-2004 are some 5.8 Pg. Using the modelled land cover changes of Soares-Filho et al. 2006 (business as usual--BAU scenario) and considering only deforestation (not regeneration), some 30% of the existing carbon stocks in the Amazon will be lost by 2050 (*Figure 2.4*). This loss would place a further 24 Pg of carbon into the atmosphere (equivalent to four years of total global emissions at current rates).

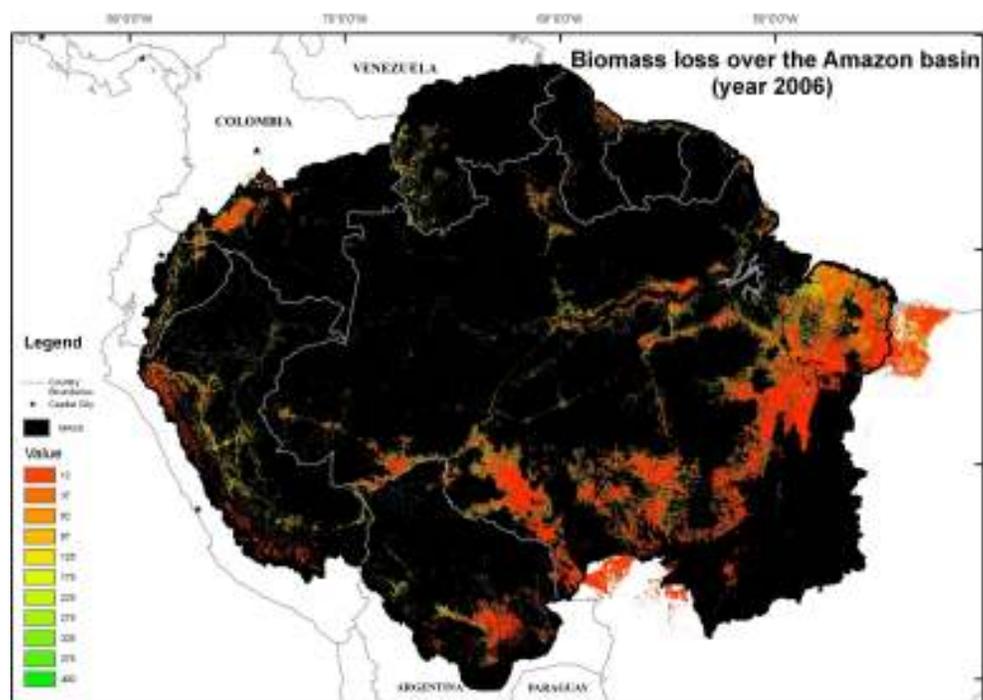
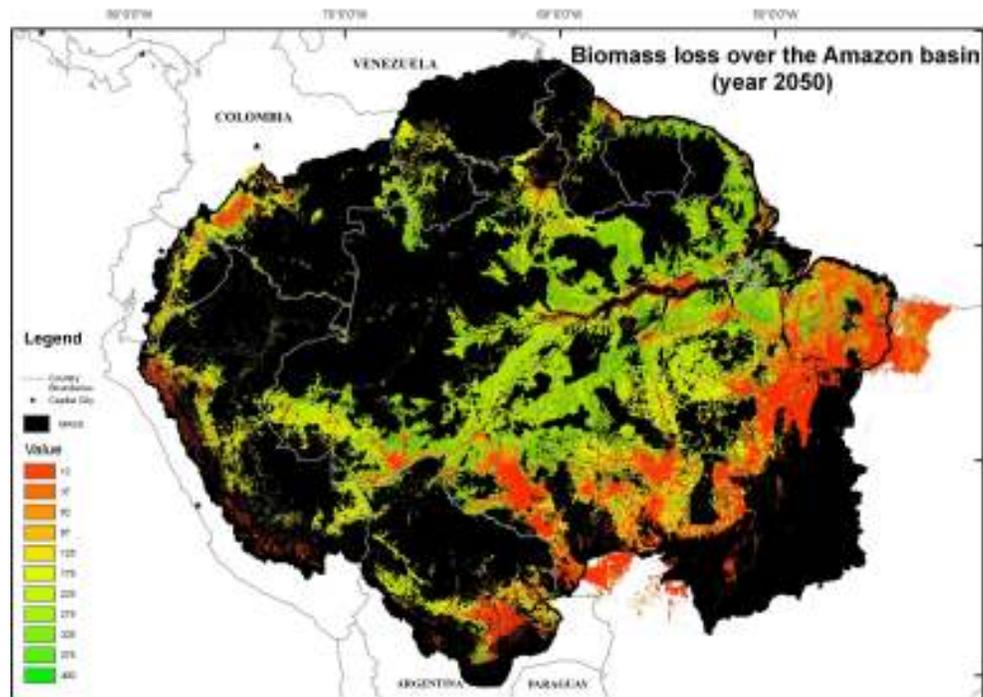


Figure 2.4 Biomass loss over the Amazon basin, year 2006 (top) and year 2050 (bottom).

Carbon sequestration rates for Amazon ecosystems vary from 1.1 to 3.7 Mg/ha/yr for *terra firme* forest (Chambers et al. 2001; Mahli et al. 2004). This produces total annual added stocks of 2.3 Pg for the Amazon, most of which (2.2) is from the forest ecosystem. This total would be reduced by 30% by 2050 under the Soares-Filho business as usual scenario. The Amazon thus currently sequesters the equivalent of 40% of current annual FF emissions. Combining the loss in Amazon carbon stocks (in addition to the atmospheric carbon stocks) with the loss of sequestration under the BAU scenario gives an overall net contribution to atmospheric carbon dioxide of 24 Pg (stock losses) plus 116.5 Pg (loss of sequestration potential over the 50 years--assuming that forest replacement crops do not grow significant standing biomass as secondary forest does, but rather have most of their biomass returned to the atmosphere through annual burns or decomposition). This represents an additional 48% on current annual FF emissions as a result of deforestation. Carbon sequestration by the Amazon is clearly a significant global environmental service.

### *2.5.1. Present and future need for carbon and biomass*

How much additional carbon could be sequestered in the Amazon if the objective was to maximize its contribution to climate change? The literature indicates that greatest sequestration rates are obtained under forest plantation (6.6 Mg/ha/yr), *várzea* forest (5.4 Mg/ha/yr) and particularly forest regeneration (9.3 Mg/ha/yr). In terms of maximising carbon sequestration, the replacement of old growth forest (which sequesters 2.2 Mg/ha/yr on average) with plantation or regenerating forest would increase the sequestration rate, but if much of the old growth forest carbon were returned to the atmosphere in the process, the 7 Mg/ha/yr of extra sequestration under regenerating forest would take 20 years of sequestration to offset the carbon released into the atmosphere on conversion from old growth forest to regenerating. Over those 20 years, sequestration rates of the regenerating forest will have fallen closer to the levels for old growth forest. The net long-term carbon gains from regenerating forest are thus low if the carbon stocks have been released for the purpose of replacement with regenerating forest: avoiding deforestation in the first place is a more effective approach, especially because of the positive benefits for other environmental services (especially the hydrological and biodiversity related ones).

### *2.5.2. Implications for poor local stakeholders*

ES related to carbon and biomass in both the Andes and the Amazon are clearly global. Local stakeholders derive little or no benefits from the carbon content in vegetation and soils, if not in the form of other local ES that are examined (e.g. soil productivity, forest products). What remains is the perspective of deriving benefits from the increasing international demand for reduced carbon emissions through direct transfers to local ES modifiers. Such benefits depend on the design of new mechanisms to make such transfers happen, e.g. through payments for environmental services (PES) schemes. Even if such mechanisms were in place, benefits are likely to accrue only to those local stakeholders that can demonstrate additionality (of ES) on land with secure property rights. Stakeholders living in remote areas with little or no pressure on forests are unlikely to benefit.

Table 2.8 Stakeholder groups and carbon related ES implications

Local stakeholder groups	Well-being implications of key results
<b>Urban</b>	Few or no opportunities to participate in carbon markets exist for urban poor.
<b>Colonists/farmers</b>	Landowners and communities with use rights living on public land can sell carbon related ES in the areas threatened by deforestation with high carbon content (see green areas in right panel of <i>Figure 2.4</i> ) or in areas where additional carbon can be sequestered at competitive costs.
<b>Traditional/Indigenous</b>	Indigenous people living in demarcated indigenous territories have sufficient property rights to sell carbon related ES. Yet, few indigenous territories are located in high pressure areas.

**Key research issues and questions to be addressed by ESPA: Carbon and biomass**

1. Most studies of the impact of land use change do not consider the impact of changes in sequestration, only of carbon stock losses. There is still much debate as to the role of the Amazon as a global carbon sink (Houghton et al. 2000; Clark 2002; Laurance et al. 2001). More research is needed to scale up the plot and tower scale studies to Amazon-wide estimates capable of tackling the issue of the overall contribution of the basin. Question: How will the carbon budget of the entire Amazon respond to environmental change and what are the implications for reduced emissions from deforestation and degradation (REDD) in developing countries?
2. Given the potential incorporation of avoided deforestation in the post Kyoto climate change treaty through REDD, a mechanism now exists for payments for carbon services. Key questions concerning how to ensure that this mechanism works for the poor include: how much carbon is sequestered by different ecosystems; and how does this vary spatially, seasonally and inter-annually? How can areas at risk of deforestation be assessed? And how could PES (payments for environmental services) schemes contribute?
3. The global need for carbon sequestration services is apparent; but there remains a great deal of uncertainty as to the long-term carbon balance implications of particular carbon management strategies (avoided deforestation, plantation forest, protection, conservation, regeneration, tree planting and biofuel cultivation). Critical questions include full cycle impacts (i.e., all aspects considered from production through consumption). Moreover these studies need to take into account the changing ecology of Amazon forests under climate change and CO<sub>2</sub> fertilisation effects and must be carried out at the Amazon scale.

Further information: Baseline datasets in Google Earth ([www.ambiotek.com/ESPA](http://www.ambiotek.com/ESPA)); project presentations ([www.ambiotek.com/ESPA](http://www.ambiotek.com/ESPA)); Forest and climate interactions: a bibliography (<http://www.ambiotek.com/ESPA>); Literature review on water quality and quantity provision in the face of climate and land use change in the Amazon ([www.ambiotek.com/ESPA](http://www.ambiotek.com/ESPA)), Annex 4.

## ***2.6. Status of erosion and soils productivity losses in the Amazon Basin***

Soil is an environmental resource critical to hydrological and ecological systems and the basis of agriculture. There are a number of important soil-related ecosystem services, including soil quality, soil biodiversity and soil carbon. However, consistent spatial data on soil-related services is scarce, hence this analysis focuses only on soil erosion, and acknowledges that other important services are missing. This analysis has made an initial effort at mapping soil erosion and the likelihood of soil productivity losses, but it should be noted that this is only an initial approach to generating spatial maps of soil-related ES, and further work in this area is merited.

Soil erosion can lead to local reductions in soil fertility and productivity and to contamination and sedimentation of rivers. Soils have very different origins, forms, and processes in the Andes and the Amazon - with erosion risk being greatest on the steep slopes of the Andes. Although soil erosion in the Andes and Amazon is widely documented, there is no systematic Amazon-wide assessment. We conducted a spatial assessment using available geospatial data and a literature-based database of known erosion events. The erosion data used for the model are related to natural processes and human activities. Natural processes include high runoff over large slopes, low infiltration capacity, and poor vegetative cover. Human causes include deforestation, inappropriate land use, livestock, and agriculture. These latter activities result in losses in terms of soil profiles, structure, and organic matter. Problems such as compaction, reduction in biological activity, and loss of infiltration capacity are also reported. For natural processes, long and intensive periods of precipitation produce losses of surface soils and sedimentation of valleys and flatter zones.

Existing evidence and Extrapolation Domain Analysis (EDA) were used to assess the status of soil erosion and productivity losses in the Amazon Basin (Otero et al. 2006). The method identifies areas that exhibit high or low probabilities for the occurrence of similar processes as those reported in the documented cases. Key environmental conditions within extrapolation domains are estimated by cross-referencing against population and/or ecosystems maps. Areas expected to suffer similar degradation are identified, highlighting where actions need to be taken both for protection or restoration. This approach helps in identifying the environmental service offered by the land in each individual pixel in terms of probability of environmental degradation.

EDA uses a combination of Bayesian and statistical modelling to determine the potential of a site to suffer erosion or losses in productivity. Bayesian modelling uses the weights of evidence (WofE) algorithm (Bonham Carter et al. 1989; Bonham Carter 2002) to determine the probability that target sites exhibit socioeconomic and other landscape attributes deemed to be critical to degradation. Similarities of climatic attributes with areas where the project originates are determined using Homologue (Jones et al. 2005). Homologue uses a time series of temperature, rainfall and evapotranspiration to produce some 32 different variables relevant to soil erosion that are analysed statistically against the spatial occurrence of known erosion problems. The two estimates are combined in a single estimate for each grid cell of 1 km<sup>2</sup> within the tropics.

### ***2.6.1. Probability of erosion occurrence***

Figure 2.5 shows the zones susceptible to erosion based on the EDA analysis. The 105 reported cases of erosion presented in the map (black points) were used for the Homologue model as well as for WofE modelling to obtain zones that present similar physical characteristics (Table 2.9).

Table 2.9 Variables included in the WofE and Homologue models

WofE modelling variables
1 km resolution SRTM elevation model
1 km resolution derived slope
1 km resolution accessibility model (Nelson 2007)
Vegetation cover (GLCF 2008)
Cation Exchange Capacity (for analysis of productivity losses)

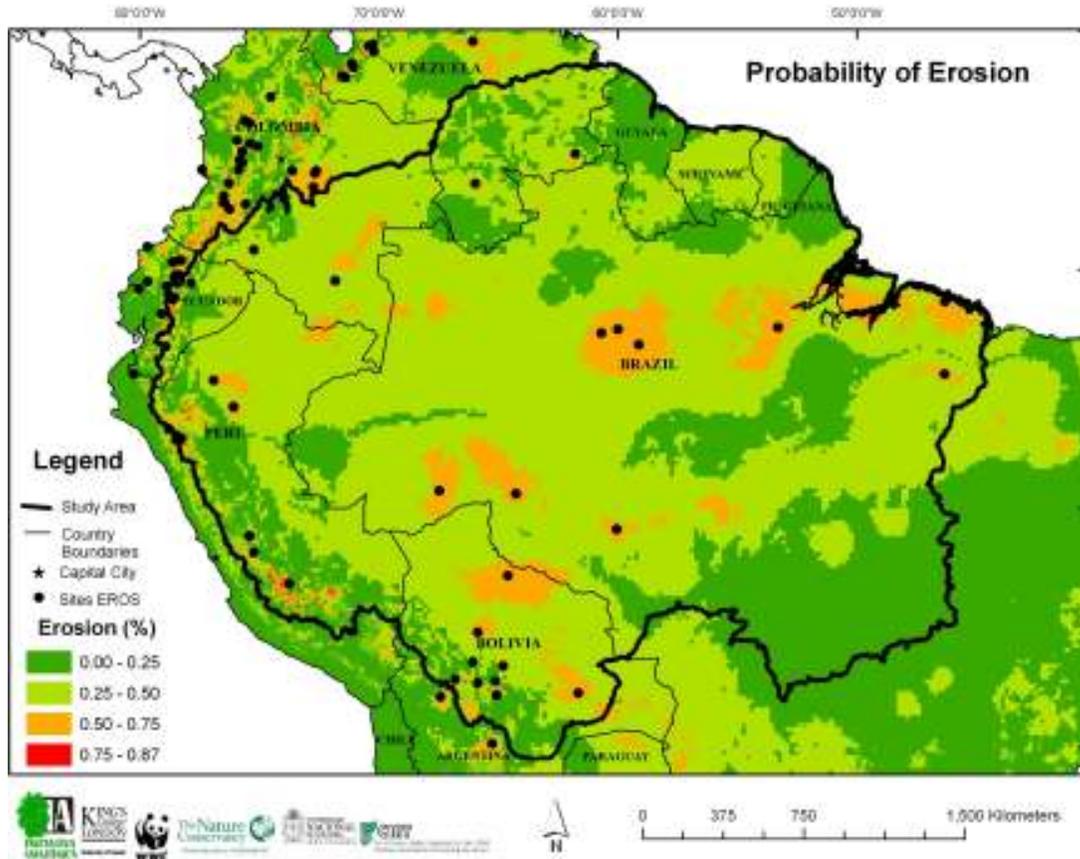


Figure 2.5 Probability of erosion in the Amazon basin

Distribution of erosion probabilities over the Amazon Basin was analyzed. Table 2.10 and table 2.11 summarize these distributions related in ten different probability classes:

Table 2.10 Distribution of population and areas over ten erosion probability classes.

Class	Interval of probability (%)	Occurrence in area (%)	Cumulative area (%)	Population distribution (%)	Cumulative population (%)
1	0 – 10	11.07	100	11.51	99.89
2	10 – 20	9.27	88.93	8.22	88.38
3	20 – 30	15.12	79.66	13.22	80.16
4	30 – 40	18.55	64.54	16.16	66.94
5	40 – 50	37.91	45.99	30.53	50.78
6	50 – 60	7.66	8.08	14.70	20.25
7	60 – 70	0.25	0.42	2.89	5.55
8	70 – 80	0.10	0.17	1.49	2.66
9	80 – 90	0.07	0.07	1.17	1.17
10	90 – 100	0	0	0	0

Figure 2.5 shows a probability of erosion higher than 50% over about 8% of area inhabited by 20% of the regional population. In terms of need and provision, 8% of the area is a potential producer of erosion; and 20% of the population is potential demander of actions to avoid it.

Table 2.11 Distribution of ecosystems (cumulative area in %) over ten erosion probability classes.

Class	Ecosystem								
	Dry forest	Guayanan ecosystems	Mangroves	Moist forest	Montane Forest	Montane Grasslands	Savanna	Swamp Forest	Várzea
0-10	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
10-20	92.2	86.2	80.8	96.1	74.1	76.9	58.7	100.0	99.1
20-30	73.9	74.2	76.6	88.0	55.7	50.0	48.3	83.4	96.7
30-40	51.9	60.0	75.3	72.5	40.1	37.8	37.6	45.8	91.8
40-50	34.2	25.2	70.1	52.7	25.2	22.2	24.9	27.3	78.1
50-60	3.6	1.3	30.9	6.0	11.5	14.6	4.3	0.0	13.5
60-70	0.4	0.0	0.0	0.0	5.4	8.1	0.0	0.0	0.0
70-80	0.1	0.0	0.0	0.0	2.2	3.0	0.0	0.0	0.0
80-90	0.0	0.0	0.0	0.0	1.0	1.4	0.0	0.0	0.0
90-100	0	0	0	0	0	0	0	0	0

Table 2.11 shows that 31% of mangroves, 15% of montane grasslands, 14% of the várzea, 12% of montane forest, 6% of moist forest, 4% of savanna, 4% of dry forest and 1% of Guayanan ecosystems are subject to more than 50% chance of soil erosion.

### 2.6.2. Probability of productivity losses

The EDA allows inference of zones susceptible to losses in productivity based on the combination of WofE and Homologue models. Sixty-three cases of productivity loss were found (the black points in Figure 2.6). The variables used for the models are reported in

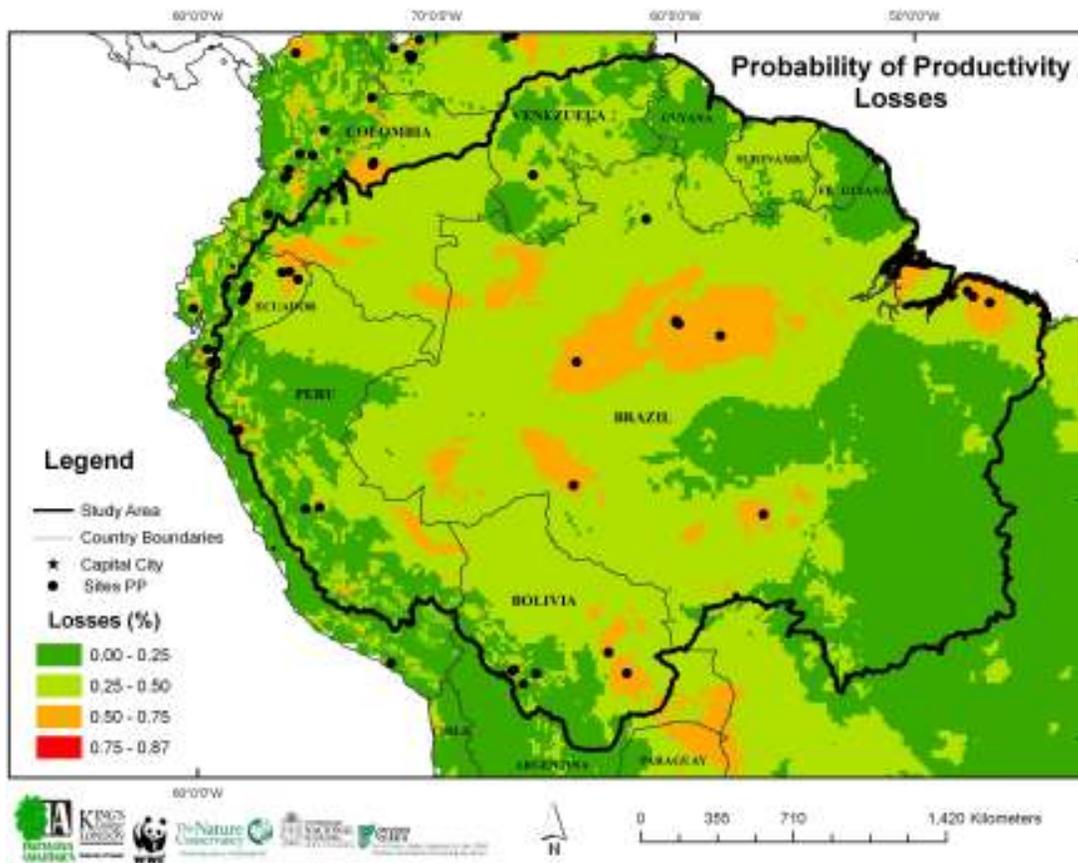


Figure 2.6 Probability of productivity losses in the Amazon basin

Following the same processes used for the erosion analyses, population and areas were quantified for each probability of productivity loss classes.

Table 2.12 and Table 2.13 summarize these distributions in ten different classes.

Table 2.12. Distribution of probability of productivity losses into ecosystems, population and total area.

Class	Interval of probability (%)	Occurrence in area (%)	Cumulative area (%)	Population distribution (%)	Cumulative population (%)
1	0 – 10	12.20	100	16.23	99.89
2	10 – 20	14.47	87.88	22.60	83.66
3	20 – 30	12.01	73.41	10.85	61.06
4	30 – 40	16.36	61.40	15.60	50.21
5	40 – 50	35.54	45.04	20.72	34.61
6	50 – 60	9.40	9.50	13.63	13.89
7	60 – 70	0.07	0.10	0.25	0.246
8	70 – 80	0.02	0.03	0.10	0.014
9	80 – 90	0.01	0.01	0.04	0.04
10	90 – 100	0	0	0	0

Table 2.12 shows that there is an erosion probability greater than 50% over about 10% of the region. This probability could eventually affect about 14% of the area's population.

*Table 2.13 Distribution of ecosystems (cumulative area in %) over ten productivity loss probability classes.*

Class	Ecosystem								
	Dry forest	Guayanan ecosystems	Mangroves	Moist forest	Montane Forest	Montane Grasslands	Savanna	Swamp Forest	Várzea
0-10	100	100	100	100	100	100	100	100	100
10-20	89.2	85.1	82.3	93.1	73.4	73.0	68.9	100.0	93.6
20-30	61.2	76.3	81.1	82.6	42.7	33.3	50.4	94.0	86.4
30-40	45.5	62.9	80.5	70.9	29.9	24.6	36.2	78.1	81.7
40-50	35.8	30.9	76.4	53.3	13.5	6.0	23.0	42.3	70.7
50-60	8.7	1.2	42.8	9.9	4.0	2.3	1.1	1.0	19.9
60-70	0.2	0.0	0.0	0.0	1.2	0.8	0.0	0.0	0.0
70-80	0.1	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0
80-90	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
90-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Potential productivity loss with probabilities higher than 50% were in 43% of mangroves, 20% of the várzea, 10% of moist forest, 9% of dry forest, 4% of montane forest, 2% of montane grasslands, 1% of Guayanan ecosystems, 1% of savanna, and 1% of swamp forest ecosystems.

### *2.6.3. Implications for poor local stakeholders*

ES affecting soil productivity are clearly important for all rural dwellers (and some urban or peri-urban), but particularly for agriculture based livelihood strategies. Figure 2.6 suggests that productivity losses are most likely in areas dominated by small and large scale farmers in the Andes/Amazon. Small-scale farmers, often depending on slash-and-burn techniques, have typically few means to substitute natural soil fertility by improved technology and external nutrient sources. Hence, they are more vulnerable to soil productivity losses. Also traditional/indigenous people rely on agriculture. However, at least those living in specially designated areas, such as indigenous territories and extractive reserves (see also Chapters 3 and 4) often have more land at their disposal, which contributes to maintaining natural soil fertility.

Table 2.14 Stakeholders and soil related ES

Local stakeholder groups	Dependence on natural soil productivity	Well-being implications of key results
Urban	Generally low, but locally important	Reduced soil quality can affect urban and peri-urban agriculture based livelihood strategies, but access to substitutes is more likely than in rural areas.
Colonists/farmers	High dependence on natural soil productivity in widespread slash –and-burn production systems.	Reduced soil productivity means less staple food availability and income from sales. Staple food substitutes can be bought, but at relatively high prices.
Traditional/Indigenous	Moderate to high dependence on natural soil productivity. Especially for staple food crop production.	Results generally indicate low probability of soil productivity losses on land occupied by traditional/indigenous people. Exceptions to the rule can be landless traditional populations on illegally occupied lands and people living in indigenous territories or extractive reserves under both internal and external pressure (e.g. Southern and Northwestern Brazilian Amazon)

**Key research questions to be addressed by ESPA: Soil erosion and productivity losses**

1. Where and under what conditions is soil erosion poverty relevant on and off-site?
2. Identify best practices and economically, culturally, and agronomically feasible technologies to reduce soil erosion.
3. What factors constrain farmers in adopting practices and technologies that minimize soil erosion?
4. What is the economic loss associated with soil erosion on-site? Where is it high, where negligible?
5. Measure the downstream costs of soil erosion and evaluate whether they could cover opportunity costs of preventing it upstream. Evaluate tradeoffs and identify cost-effective management options (Chapter 3)

## **2.7. Ecosystem functioning**

### **2.7.1. Services related to terrestrial biodiversity**

Biodiversity provides people with services from food to timber to less tangible services such as pollination and nutrient cycling. Most rural Amazon communities depend in some way on biodiversity related ecosystem services. People in the Basin consume an estimated 148,171 tones per year of wild mammal meat (Fa et al. 2002). Timber and non-timber forest products provide food, fiber, construction materials, and market products that contribute to subsistence and income of local people. Research suggests that biodiversity may be important in reducing the risk of certain animal diseases such as Cutaneous *leishmaniasis* or Chagas disease (Ostfeld and Keesing 2000), though this is a matter of debate.

Terrestrial biodiversity in the Andes/Amazon also provides global benefits. Both the Andean and Amazonian regions harbour an array of biological resources, parts of which have been identified as global priorities for biodiversity conservation (Myers et al. 2000).

Although one of the most significant ecosystem services, the provision of biodiversity is notoriously difficult to quantify due to the great diversity in provisions (from genes to ecological processes) and the multiple beneficiaries at multiple scales. Given this diversity of provisions and of uses, we use the quality of the habitat as a proxy for the provision of the range of ecosystem services (including pollination, nutrient cycling, ecosystem stability, reducing disease risk and other ecological processes). This approach fits with the Millennium Ecosystem Assessment (2005) recommendations to ensure acceptable and resilient levels of biodiversity related ecosystem services in the long term, variation of genes, populations, and species and the variety of structure, function, and composition of ecosystems must be conserved.

We divided the provisioning of terrestrial biodiversity services into three elements; biodiversity provision as a source of biological resources and ecosystem services; timber and non-timber forest products; and ecotourism in protected areas.

#### **2.7.1.1. Biodiversity provision**

In order to assess the spatial distribution of biodiversity provision, two factors were mapped: 1. habitat quality, and 2. habitat and species diversity.

**Habitat quality** was used as a proxy of all the goods and services provided by biodiversity at a given place. The index was based on the analysis of biodiversity threats in South America (Jarvis et al. 2008). The immediate threat to a specific site in an ecosystem was considered to be a function of the magnitude of the threat and the sensitivity of the ecosystem to that threat. Seven threats were considered: grazing pressure, recent conversion, accessible population, infrastructure, conversion to agriculture, fire, and oil and gas exploration. The threat analysis represents the degree of degradation, but here the reverse was used as a proxy for habitat quality (Figure 2.7).

Future scenarios for the provision of biodiversity ES were generated based on two main sources of data: 1) a deforestation scenario developed by Instituto de Pesquisa Ambiental da Amazônia (IPAM) for the year 2020, and 2) data regarding road development in the Amazon region (based on the Initiative for Integration of Regional Infrastructure in South--IIRSA). These two data sources lead to the generation of habitat quality in the year 2020 through recalculation of the projected threat layers of accessibility and areas of recent conversion (left image in Figure 2.7).

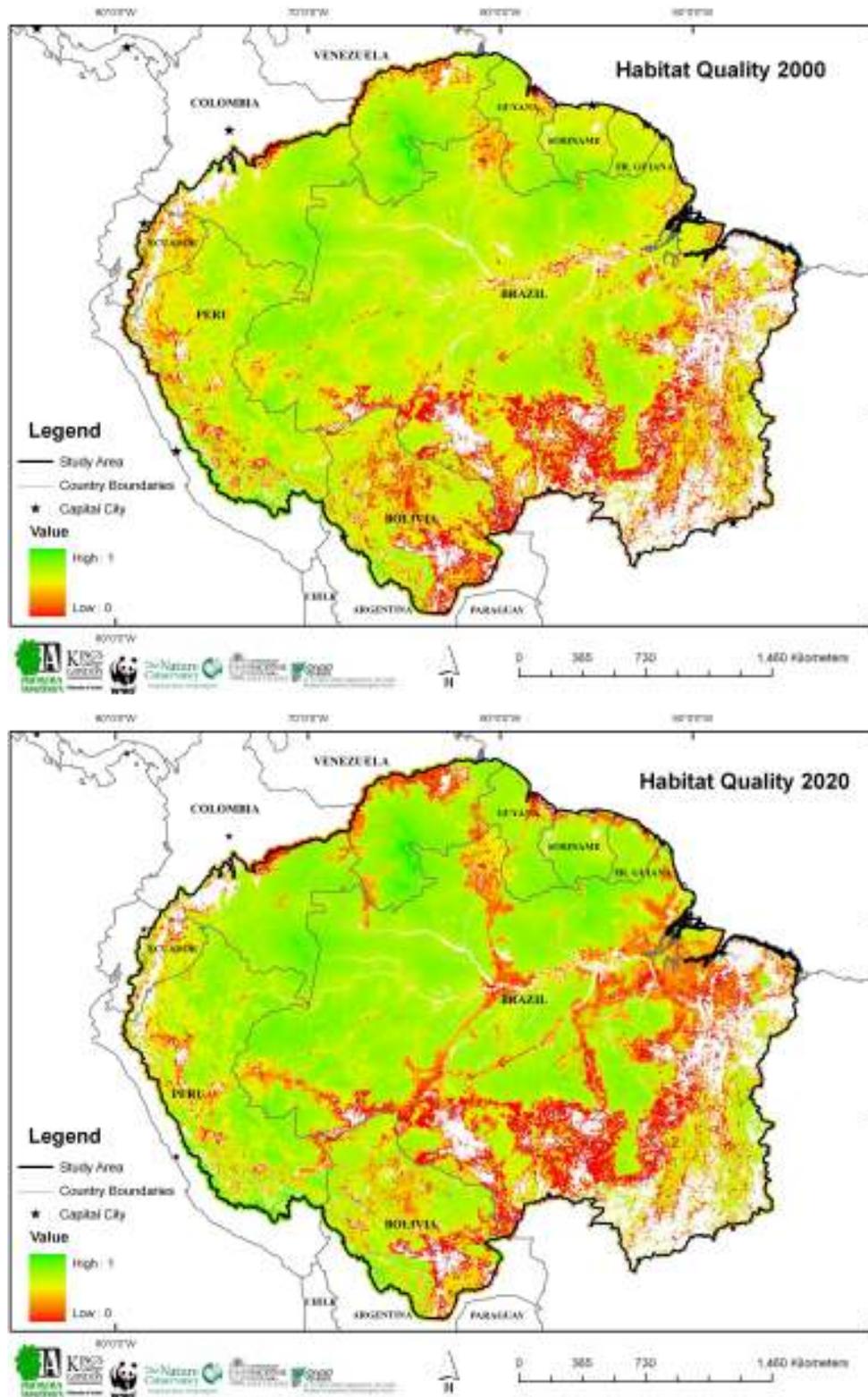


Figure 2.7 Habitat quality of terrestrial ecosystems in 2000 (top) and projected for 2020 (bottom)

Large areas of the study region are still natural ecosystems without evidence of degradation. Areas in the Andes as well as S and SE Amazon, however, have been highly degraded. Indigenous lands and protected areas show higher values of habitat quality. Moist forests and Guayanan ecosystems have the greatest habitat quality (0.81 and 0.84 respectively), whilst dry forests have the least habitat quality (0.66).

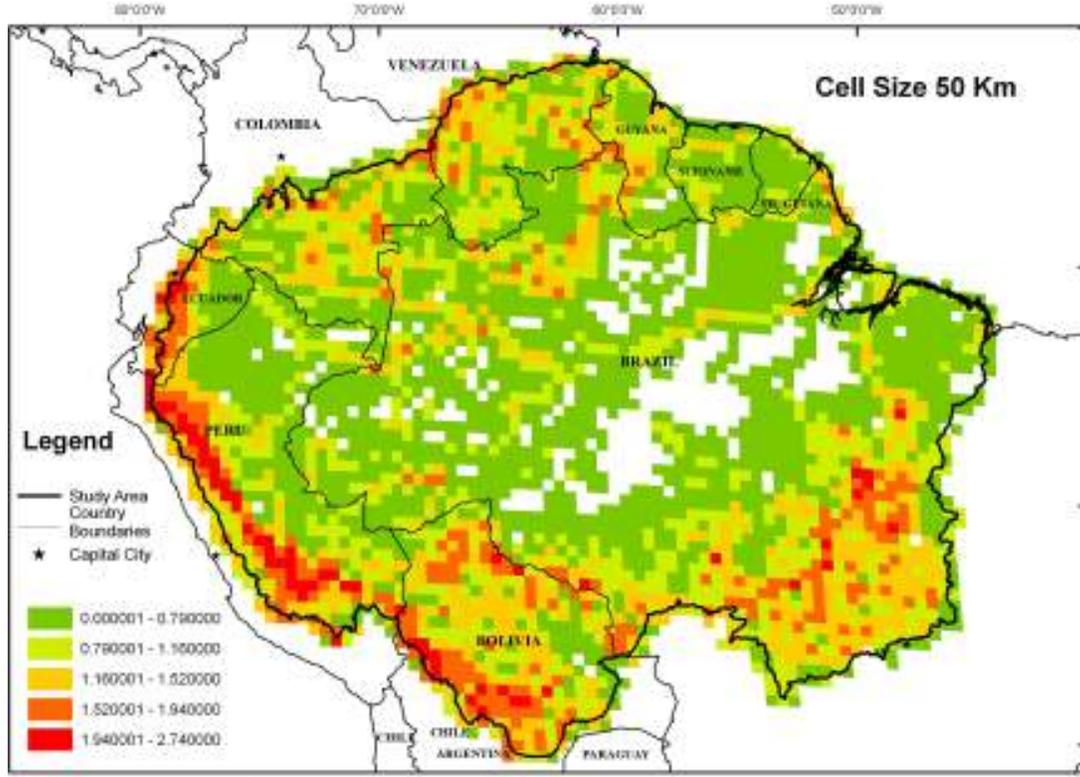
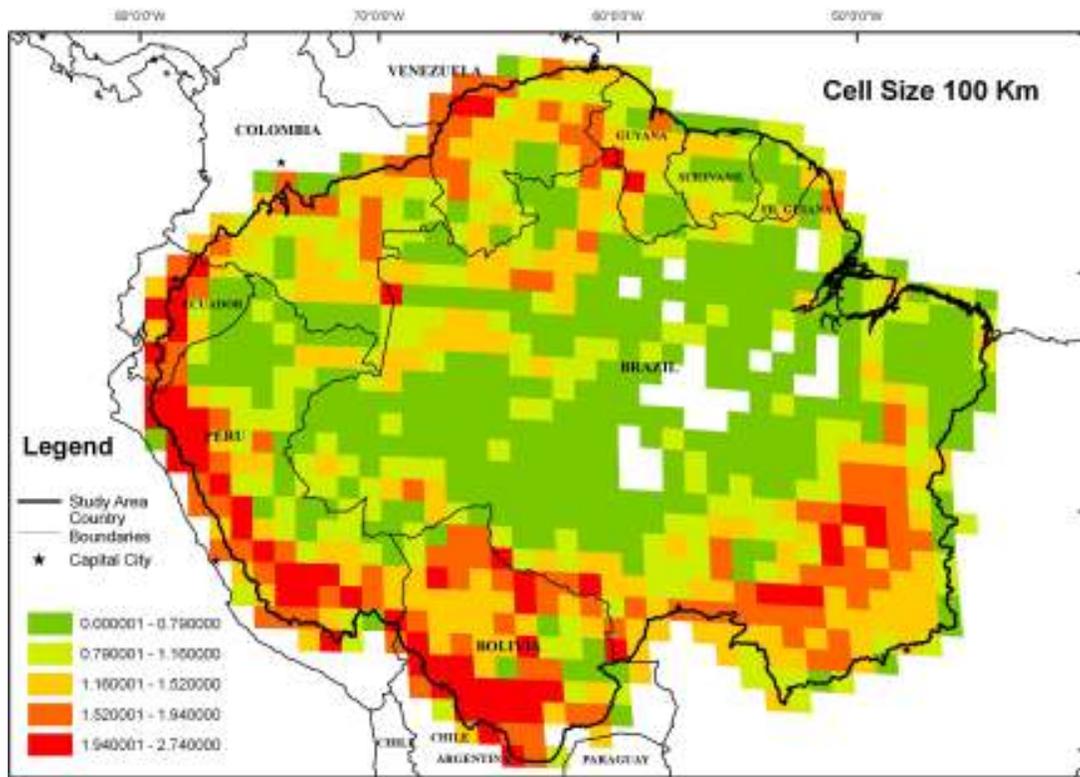
*Table 2.15 Index of habitat quality for different major ecosystem types and general land-use areas (higher values, indicate higher habitat quality), with bracketed values representing the % change to 2020.*

<b>Ecosystem</b>	<b>Non-protected, non indigenous</b>	<b>Protected area</b>	<b>Indigenous territory</b>
Dry forest	0.66 (-6.23)	0.80 (-3.95)	0.81 (-2.46)
Guayanan ecosystems	0.84 (-5.57)	0.87 (-1.47)	0.88 (-1.84)
Mangroves	0.77 (0.77)	0.76 (0.76)	0.88 (0.88)
Moist forest	0.81 (0.81)	0.84 (0.84)	0.85 (0.85)
Montane forest	0.77 (0.77)	0.80 (0.80)	0.79 (0.79)
Montane grasslands	0.85 (0.85)	0.78 (0.78)	0.75 (0.75)
Savanna	0.70 (-2.67)	0.78 (-1.90)	0.77 (-2.58)
Swamp forest	0.82 (-6.59)	0.80 (-2.06)	0.86 (-0.15)
Várzea	0.81 (-3.04)	0.81 (-4.51)	0.85 (-0.63)

The habitat quality map for 2020 shows the greatest changes in the most accessible areas. The non-protected/non-indigenous areas show the highest loss in habitat quality--a likely outcome as these are the areas where accessibility will increase the most. The major ecosystems that show the greatest loss are dry forests, Guayanan ecosystems, swamp forests and *várzea*. Moist forests are least affected.

**Species and habitat diversity** was used as a proxy for ecosystem functioning. Although relationship between species diversity and ecosystem functioning is still under debate (Loreau et al. 2001), evidence does exist that indicates that species diversity is important to ecosystem functioning at large spatial scales (Bond and Chase 2002). There is now a growing consensus that species diversity maintains ecosystem stability in changing environments (Loreau et al. 2001).

For our analysis, the database of species distributions hosted by NatureServe was first processed to create maps of species richness for birds, amphibians and vascular plants. Second, multi-scale maps of ecological systems diversity (using a detailed map of 608 ecosystems) were created (at 20 km, 50 km and 100 km resolutions). The diversity of ecological systems in each grid cell was evaluated using a Shannon's diversity index. When the grid cell contains only one patch the diversity is zero, but increases as the landscape contains more types of ecological systems or as the distribution among types of ecological systems becomes more equitable (McGarigal and Marks 1994). Similar to the analysis of species distributions, these maps were used to compare patterns of habitat quality with regional patterns of ecosystem diversity (see Figure 2.8, three maps over the next two pages).



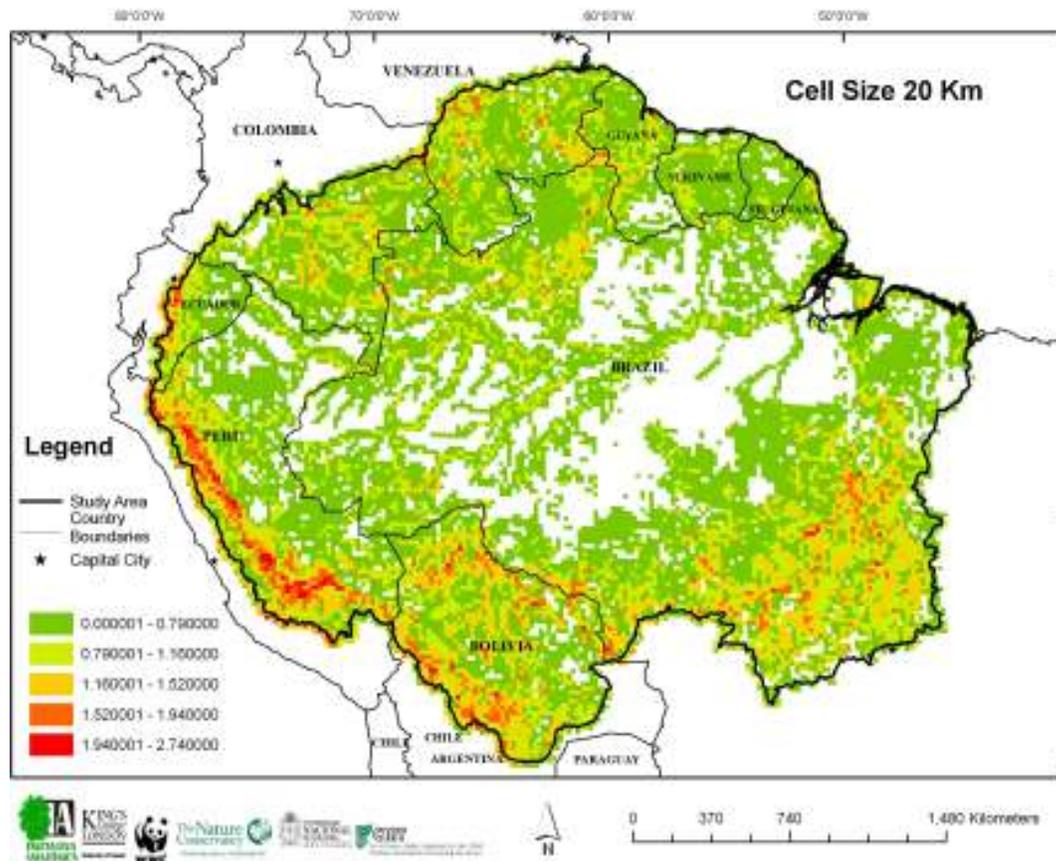


Figure 2.8 Diversity of habitats across the study region using different scales.

For both habitat diversity and species diversity, the maps show high diversity values in western Amazon and in the Andes. Montane forest and montane grasslands had high values in terms of habitat diversity. *Várzea* and moist forests showed the highest richness values for species richness.

Table 2.16 Distribution of habitat and species diversity among major ecosystems

Ecosystem	Habitat Diversity (indexed)			Species Richness (no. species)		
	Protected area	Indigenous territory	Non-protected/non-indigenous	Protected area	Indigenous territory	Non-protected/non-indigenous
Dry forest	0.661	0.631	0.760	576.353	564.067	504.420
Guayanan	0.679	0.591	0.697	626.416	656.401	653.683
Mangroves	0.517	0.628	0.633	708.088	494.092	508.229
Moist forest	0.391	0.411	0.371	676.551	654.989	677.263
Montane forest	0.944	0.771	1.188	567.283	601.871	392.154
Montane	1.293	1.529	1.119	333.557	323.031	222.463
Savanna	1.055	0.896	0.813	576.427	613.293	516.085
Swamp forest	0.521	0.756	0.398	748.436	544.254	662.013
Várzea	0.431	0.637	0.573	664.980	718.748	719.396

### 2.7.1.2. Implications for poor local stakeholders

Habitat quality itself, although related to forest product provision (next section) and other direct use services, has little direct use value for local stakeholders. It is, thus, a rather globally valued ES. A considerably high willingness to pay exists among external beneficiaries for biodiversity existence and option values in undisturbed ecosystems, preferably with exotic fauna. Although few concrete examples exist in the Amazon, such values can potentially be internalized locally through PES and PES-like schemes that involve direct payments for biodiversity conservation. The minimum conditions for this mechanism to work (additionality and property rights) apply here as well (see also section 2.5.2 and Chapters 3 and 4). Tourism and ecotourism (Chapter 4) are frequently cited examples of mechanisms through which local stakeholders can also benefit through direct (recreational, cultural) use values of biodiversity. However, especially in the Amazon, few experiences exist.

Table 2.17 Stakeholders and habitat quality

Local stakeholder groups	Well-being implications of key results
<b>Urban</b>	Few potential benefits arise as a result of indirect values of biodiversity. Threats to habitat quality and related direct use values might compromise income of urban stakeholders involved in tourism business. Since more tourism options exist in the Andes this is currently less relevant in the Amazon.
<b>Colonists/farmers</b>	Farmers with property rights in areas with still high but threatened habitat quality (see right panel in Figure 2.7) could benefit if demand for biodiversity conservation materializes.
<b>Traditional/Indigenous</b>	Many indigenous territories are located in remote/less disturbed areas with a potentially high biodiversity value. Whether PES schemes or ecotourism are feasible benefit transfer mechanisms needed to be evaluated in each case.

### 2.7.1.3. Provision of forest products

Selected for the analysis of forests products were: timber, fruits and nuts (and other foods from plants), fibre, medicinal plants, and bushmeat. A literature review identified species in these groups of importance to the livelihoods of different users in the Amazon basin and beyond. For these species, patterns of current distribution were estimated by comparing points of occurrence available in online collection databases with the TNC map of ecological systems for South America (Sayre et al. 2005). Species were also grouped according to beneficiaries: 1) medicinal species used by local communities (subsistence), 2) commercialized medicinal species, 3) timber species for local use, 4) commercialized timber species, 5) fruits and nuts for local use, 6) commercialized fruits and nuts, 7) fibres for local use, 8) commercialized fibres, and 9) locally consumed game. There was considerable variation in information available on species for each group.

Provision of ES was mapped for each of the eight groups of species defined above. The model considered that the current existence of the species in each group (and the provision of services associated with them) is a function of past patterns of use. The model combines the index of habitat quality and values of accessibility to estimate areas where the species in each group are no longer present, or conversely, where they should still be encountered. The maps provide a regional perspective in terms of areas of importance related to the concentration of species that provide specific services for different groups of users. A map is presented below with the example of the results for fruits and nuts (food) for local consumption (Figure 2.9).

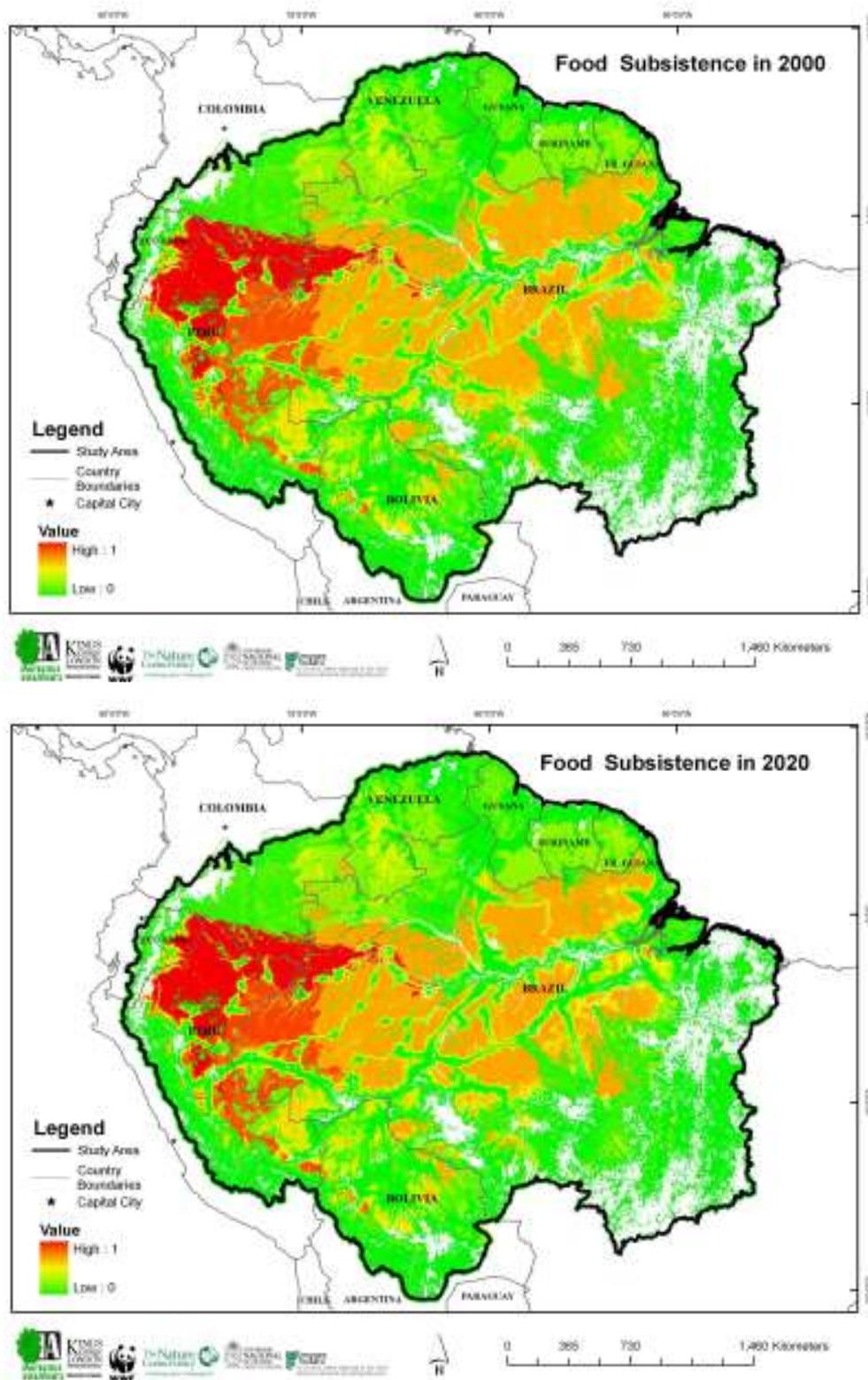


Figure 2.9 Provision of biodiversity for food in 2000 (top) and under future scenario for 2020 (bottom)

The results regarding timber and non-timber forest products showed that moist forests and *várzea* forests were the ecosystems with the highest provision of forest products. It is important to mention that moist forests occupy a much larger extent of the study area than other ecosystems, so it is expected that will have a higher importance in provision of forest products. Indigenous territories and protected areas have higher importance than background and urban areas in terms of provision of forest products. In particular, indigenous areas show the highest potential for forest products provision. The forest products provision maps also showed a higher value of provision in Western Amazon. Under the 2020 scenario, moist forests and montane forests have the greatest loss in terms of provision of forest products. The model also shows unsurprisingly that non-protected/non-indigenous areas will suffer the greater loss of ES provision.

It becomes evident from the results that patterns of habitat quality, provision of ES, species richness and habitat diversity do not necessarily coincide in space. In certain cases, areas of high biological diversity in terms of species richness (e.g. moist forests) also present high levels of provision of ES related to timber and NTFPs. However, these areas do not present high diversity at the ecosystem level. This condition could be different for other types of ecosystem services such as pollination, water provision, and hydrological regulation. It is likely that the structure and composition of the landscape becomes a critical factor for the sustenance of these services. In general, it was evident that protected areas and indigenous territories play an important role in the provision of biodiversity and forest products.

The result maps and tables were useful to show general patterns of habitat quality and forest products provision in the study area, but they should not be used to interpret local distribution patterns. Detailed maps and methodologies are available in the Annex section.

#### **2.7.1.4. *Implications for poor local stakeholders***

Few urban, peri-urban and agriculture-based livelihood strategies involve high degrees of dependence on forest products. Exceptions may be some products with developed markets, such as timber, and special fruit products (e.g. Açai or *Euterpe oleracea*). Some traditional populations, e.g. rubber tappers, have specialized in particular forest products, while indigenous populations are generally dependent on various forest products. The results in this section indicate where natural provision of forest products is high and where forest products are under pressure from deforestation and forest degradation. Where this pressure coincides spatially with land occupied by traditional and indigenous populations negative welfare effects for these groups are likely especially if they are not involved in (and capture the benefits of) the economic activities that reduce natural forest cover.

Table 2.18 Stakeholders and forest products

Local stakeholder groups	Dependence on forest products	Well-being implications of key results
Urban	Generally low, but eventually high for specific products and their value chains	If specific products are affected by deforestation and degradation, negative well-being effects are likely
Colonists/farmers	Moderate, depending on distance to market and forest product availability	Most farmers and colonists derive benefits from forest conversion. Hence, loss of forest products is compensated for. Exceptions exist where external pressure on forests compromises forest product provision for agriculture and extractivism based livelihood strategies.
Traditional/Indigenous	Often high and diversified	Locally, open access situations of forest product extraction might contribute to negative welfare effects where traditional/indigenous populations are both ES users and modifiers. But generally, it is external pressure, e.g. on unprotected indigenous lands that compromise extractivism based livelihood strategies.

#### Key research issues and questions to be addressed by ESPA: Ecosystem functioning

1. Better understanding of the scale (potential thresholds) and land cover characteristics required to maintain ecosystem services related to biodiversity (e.g., there is no information available regarding the scale for maintaining supporting services such as nutrient cycling or ecosystem stability).
2. Establishing the links between biodiversity at different levels (i.e. species, ecosystems) and the provision of specific ecosystem services (ES) such as nutrient cycling, ecosystem stability and disease control.
3. How human disturbances and habitat degradation can affect the provision of different ecosystems services provided by natural ecosystems. What are the thresholds, resilience and resistance of natural ecosystems to change before they start losing the capacity to provide different ES.
4. Better knowledge about biodiversity products (e.g., sustainable extraction rates, phenology, etc.) provided by the Amazon is needed to improve management and sustainable use; information is not well systematized for the region; some countries have only very basic information (e.g., Guyana).
5. Information on distribution of timber and non-timber forest products species and their use needs to be improved. Without precise information on species distributions, it is hard to estimate real provision or provision of forest products in the region.
6. Better understanding of the relationships of species valuable for humans, their ecosystems, the economics of extraction, and related value chains is needed to ensure sustainability of product extraction.
7. A lot of the existing information is unorganized and hard to find. A coordinated effort among countries in the region to create and manage a long-term biodiversity (existence and use) information system that can maintain updated information on biodiversity and forest products that benefit human livelihoods is needed.

*Further information: Baseline datasets in Google Earth (www.ambiotek.com/ESPA) and details on the terrestrial biodiversity analysis are available in Annex 6.*

### 2.7.2. Aquatic biodiversity

Aquatic biodiversity is of major importance in the Andes/Amazon region. It sustains some sectors of the population, provides basic nutrition for rural and urban inhabitants, and is a dynamic economic, social, and cultural element (Alonso et al. 2008). This section examines the current situation of aquatic biodiversity, with a focus on fish resources and fresh water ecosystems.

#### 2.7.2.1. Fish resources

The Amazon watershed harbours some 2,500 fish species (Gery 1984; Barthem, & Goulding 1997; Alonso et al. 2008). This biodiversity is not uniformly distributed across the region: Brazil has the greatest number of species (nearly 2,000), followed by Colombia (1,177), Peru (814), Venezuela (939), and Bolivia (635).

A large part of the Amazon economy is based on the use of this diversity of aquatic organisms, especially fish (Alonso et al. 2008). Commercial fishing for consumption uses approximately 200 species (Gery 1984). Capture of ornamental fish spans nearly 350 species (WWF, Incoder and Traffic 2006).

For this analysis, the study region was subdivided into 19 freshwater ecoregions (WWF and TNC 2008); and richness was mapped for each of these (see Annex 7 for figures). The greatest richness is found in Amazon Lowlands (880 species), Rio Negro (616 species) and Orinoco Guyana Shield (610 species). The greatest endemism is found in Amazon Lowlands (880 species), Guyana Shield (145 species) and Tocantins–Araguaia (115 species).

We identified locations with abundant fish resources where sustainable fishing could contribute to maintaining local communities' well-being and quality of life. We reviewed the literature and compiled fisheries' statistics from countries in the region. Results are used to estimate the approximate fisheries provision and need.

An estimated 365,550 tons/year of fish are consumed; and 220,200 tons/year are commercially traded. The estimated total (566,750 tons/year) is roughly half of the potential provision (Merona 1993). Seasonal variations in fish provision are related to the seasonal variation of water level. During the seasonal floods, resources are dispersed throughout the basin and, consequently, fishing is less efficient and productive. Fish provision falls below need—especially urban—during this period, leading to price increases. During the dry months, productivity and efficiency are higher due to concentration of fish resources. Montreuil et al. (1991) report that in Peru at least 70% of the capture is recorded during this period when provision greatly exceeds need and prices fall.

Over the years, provision of some species has declined and has been replaced by others. Taking the longest statistical series in the Ucayali region of Peru, the take of *dorado* (*Brachyplatystoma rousseauxii*) dropped from around 320 tons in 1980 to 22 tons in 2006. Species such as the *palometa* (*Mylossoma duriventris*) and sardine (*Triportheus spp*) that had very small catches in 1980 are now, along with the *bocachico* (*Prochilodus nigricans*), the most important commercial fish species in the Ucayali region. Capture rates throughout the Amazon have changed due to excessive fishing of some species (Alonso et al. 2008).

Main fish provision areas are shown in Figure 2.10. The greatest resources occur in the lower

watershed of the Amazon in the states of Pará and Amazonas, which correspond to approximately 28% of the total provision of the region.

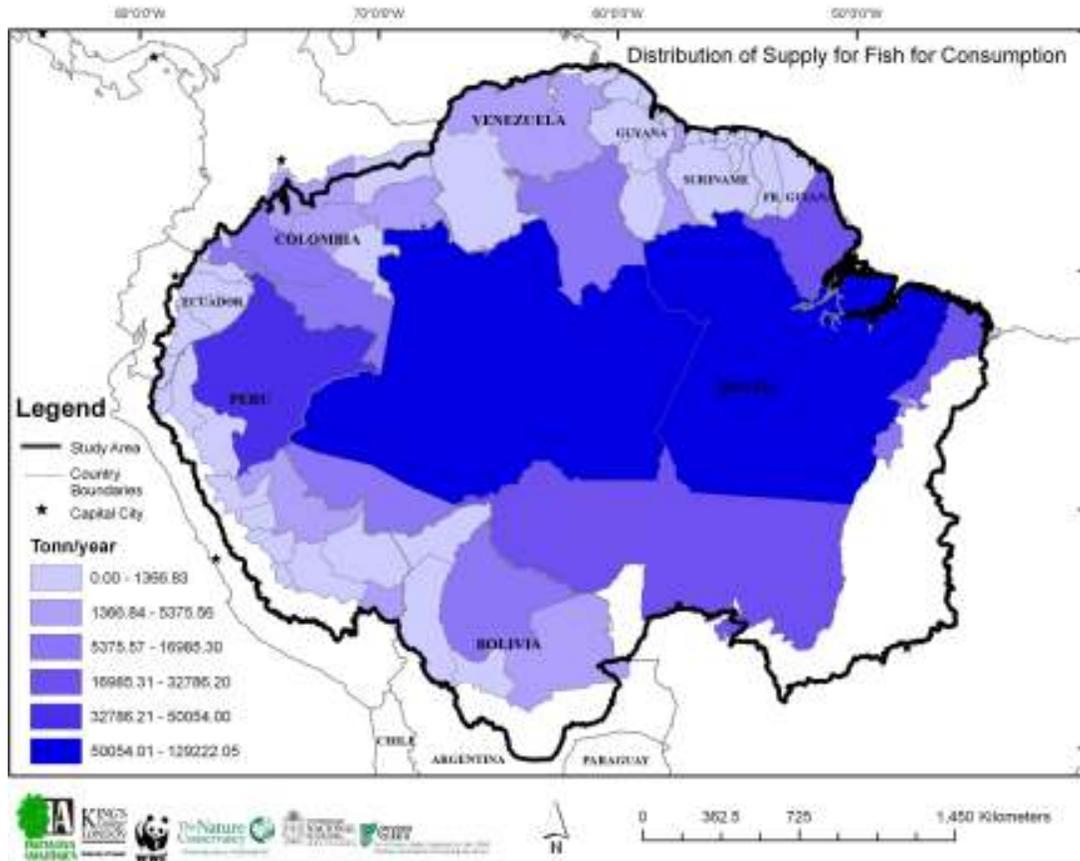


Figure 2.10 Distribution of provision for fish for consumption

*i. Surplus/Deficit from fisheries*

Deficit or surplus of fisheries' resources was calculated to show the areas apt to provision the need within and beyond the Amazon (blue in Figure 2.11) and areas with fish deficits (shades of green). Areas in light blue have minimal deficits, possibly due to lack of systematization of information or areas supplied by resources from local aquaculture.

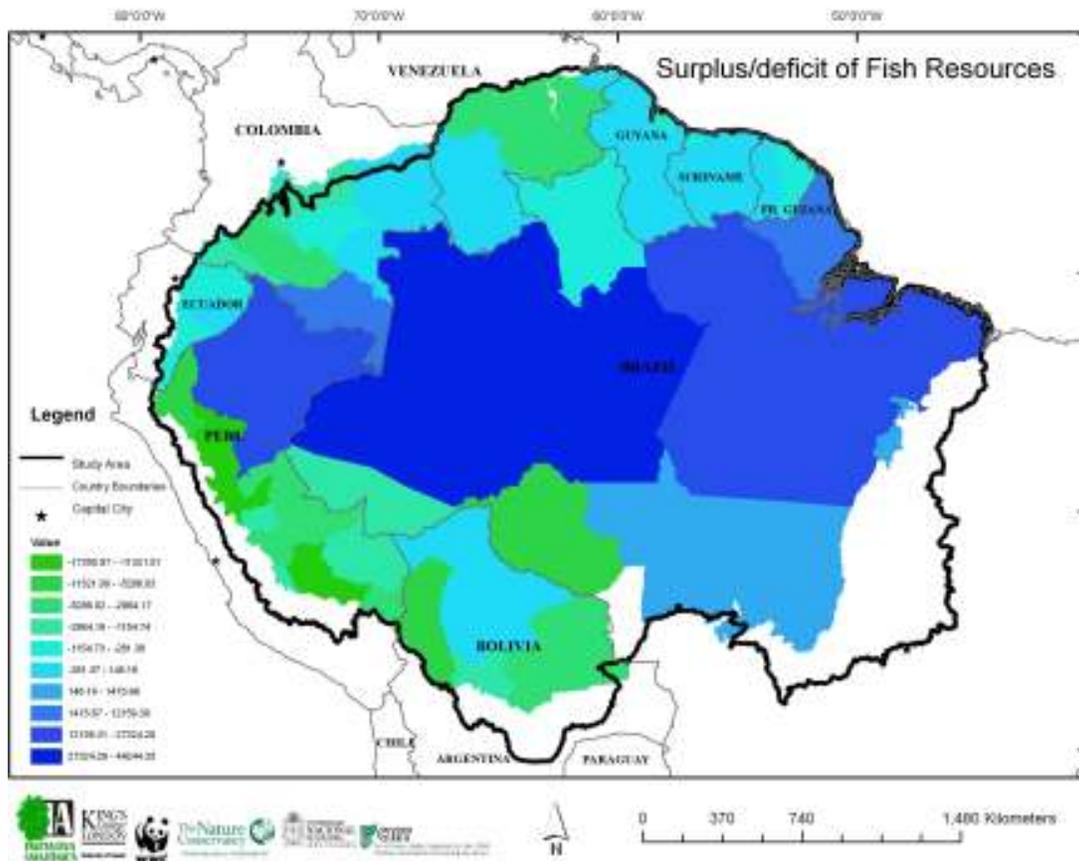


Figure 2.11 Surplus/deficit of fish resources in the Andes/Amazon

### 2.7.2.2. Implications for poor stakeholders

Based on regional data, fish resources can only be assessed at very broad regional scales. The urban poor are seldom directly involved in fishery, but might be affected through the value chain. Both colonists/farmers and the traditional/indigenous population are known to engage in fishery to complement diets and diversify income sources when they have access to fishing grounds. Income can be negatively affected especially where high value fish species, e.g. pirarucu (*Arapaima gigas*), are in decline. Local deficits (Figure 2.11), i.e. fish consumption greater than local supply, do not necessarily imply negative well-being effects. In fact, such deficits indicate that fish is imported from other regions, which implies moderate to high welfare levels. The contribution of fish to local well-being (and potential threats) are clearly knowledge gaps that deserve further analysis in terms of ES – poverty relationships.

### 2.7.2.3. Freshwater ecosystem assessment

Complementary to the exercise conducted for terrestrial ecosystems, the freshwater ecosystems analysis considers habitat quality, threats to aquatic systems, potential degradation, hydrological characteristics, and the capacity of the ecosystem to respond to disturbance. Analysis evaluates threats that affect aquatic ecosystems: i.e., agricultural ecosystems conversion, deforestation,

infrastructure (dams), human based contamination, and exploitation of oil and gas. Potential degradation and the ecosystem response are estimated for each threat (as per Polasky et al. 2007).

Figure 2.12 shows that basins with greater ecosystem degradation are located in the piedmont of Colombia, Ecuador, Peru, and Bolivia, and the southern Amazon Basin in Brazil (e.g., the Mamoré River Basin).

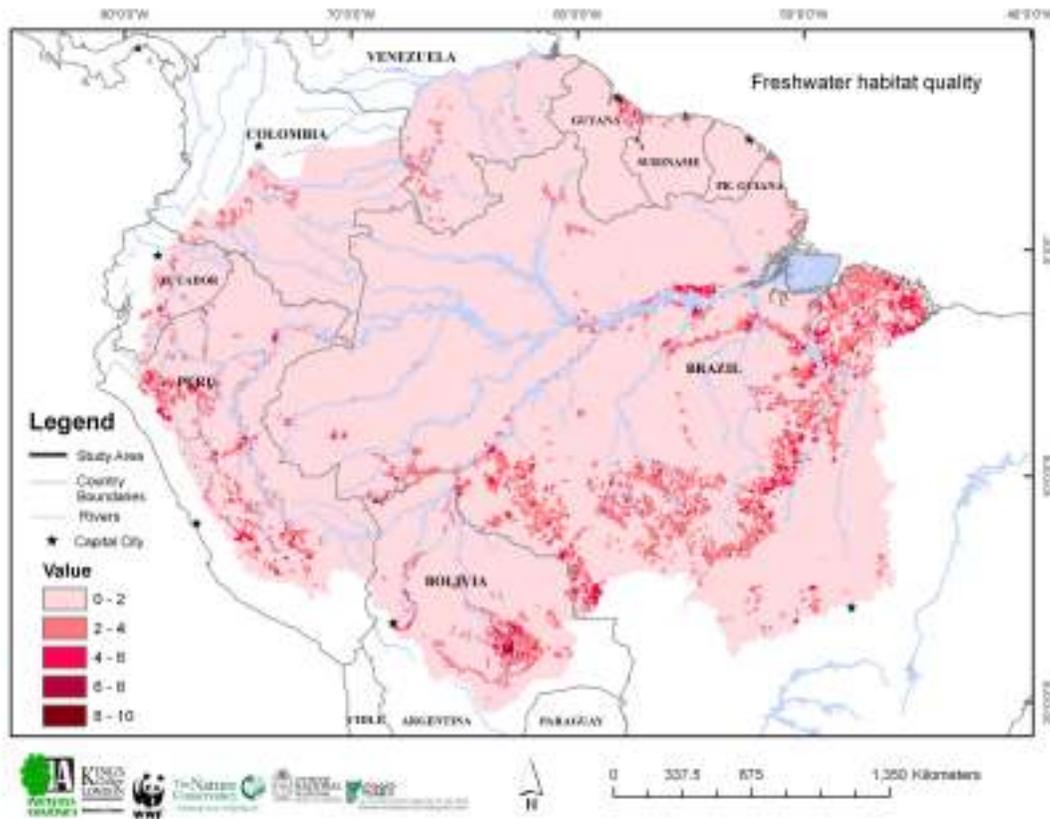


Figure 2.12 Freshwater habitat quality

Deforestation and oil drilling are the threats in the Putumayo, Caqueta, and Guaviare River Basins in Colombia, and in the Pastaza River Basin of Ecuador. Natural systems have been affected near Iquitos, Peru, by deforestation and urban pollution. Also affected are the piedmont areas of the Ucayali and Huallaga Rivers and their main tributaries near Tarapoto, Yurimaguas, Huanuco and Pucallpa. The Beni and Mamoré Rivers in Bolivia are affected, respectively, by the city of La Paz and by deforestation and agribusiness in Montero and Santa Cruz. The Madeira Basin and its tributaries Ji-Paraná, Jamari, and Rio Branco in Brazil are heavily affected, especially by dams coupled with deforestation and pollution from nearby cities. The Tapajós, Xingu, and middle - lower Tocantins basins are characterized by high levels of agricultural conversion and degradation.

The main channel of the Amazon River and lowland areas around Manaus, Santarém, and Parantins in Brazil; and Iquitos in Peru are highly affected by these urban centres. The Guyana aquatic ecosystems that drain into the Atlantic have been degraded by deforestation and agribusiness along the Georgetown – Linden corridor. See Annex 8 for detailed analysis and maps of freshwater ecosystems.

#### **2.7.2.4. Implications for poor stakeholders**

Since potential pollution is used here as an indicator for habitat quality, the results reinforce the implications for poor stakeholders from sections (2.3.1, 2.7.1.2, and 2.7.2.1). Freshwater habitat quality, as long as it does not compromise local livelihoods through reduced drinking water quality or fish stocks, is primarily a globally valued ES. However, health problems related to water pollution have been reported by both indigenous populations and colonist/farmers. They can also be a problem among urban dwellers with no access to basic sanitation services.

*Further information: Baseline datasets in Google Earth ([www.ambiotek.com/ESPA](http://www.ambiotek.com/ESPA))*

##### **Key research areas to be addressed by ESPA: Aquatic biodiversity**

1. Fish stock and population dynamics are not well understood. Provision studies in the Amazon have been limited in scope, isolated, and are of limited use for comparative studies. In the lower Ucayali in the Peruvian Amazon, Montreuil et al. (2003) evaluated species composition and provision by monitoring dock unloadings. Riofrio (1998) estimated provision by relating capture amounts vs. fishing effort in Pucallpa; as did Tello and Bayley (2001) for the commercial fleet at Iquitos. Guerra et al. (1990) and Granados (1987) estimated fish biomass (ichthyo-mass) by acoustic means.
2. Sustainable catch rates and required close seasons need to be established for threatened fish species.
3. The economics of fish supply and consumption have to be better understood in order to develop effective resource management strategies.
4. Fishery based value chains are not well studied and supposedly very heterogeneous across the region. It is not clear where degraded fish resources will compromise the well-being of the poor.
5. Fish resources are not only threatened by over fishing. ES that support fish resource maintenance need to be better understood to evaluate impacts of deforestation, hydroelectric dam construction and other measures.

## 3. Critical analysis of options to manage ES in the Andes/Amazon Region

### 3.1. Introduction

This chapter reviews the diverse set of options to manage ecosystem services with a particular, but not exclusive, focus on the Andes/Amazon. By focusing on the question: What do decision-makers need to know to make better decisions with regard to ecosystem services management? Our principal aim is to extract research and capacity-building priorities for better informed decision-making.

Decision-makers have three choices regarding the management of ecosystem services (ES): a) which ES to manage, b) the quantitative and qualitative objectives associated with each ES, and c) the “management options” (MO) for achieving these specific objectives. This chapter focuses on the final choice, that of selecting the proper MO from an array of options that includes the “standard” set of MO that are generally implemented by policymakers (e.g., land use regulations, taxes, subsidies, user fees), as well as a broader set of MO that require collaboration with stakeholder groups (e.g., reallocation of property rights and joint management of common property resources). Choosing among alternative MO can be difficult due to lack of information regarding relative effectiveness of the MO or to trade-offs between MO poverty outcomes and ES flows. Moreover, MO can reflect particular policy decisions (e.g., that define water rights in MO based on water markets). As such, policy-makers both influence potential MO and are faced with changing contexts over time in which MO are employed.

The rationale for public policy attention paid to ES is clear. ES are largely public goods in which environmental externalities, missing markets, and information asymmetries are characteristic. This holds especially for the ES described in sections 2.3, 2.4 and 2.5, but also some of the ES grouped under the category ecosystem functioning (e.g. existence values of biodiversity). In most cases, public good type of ES will be undervalued and overexploited without public sector interventions (Belli et al. 2001). Even ES that provide private benefits can be under- or overused due to “conservation investment poverty” (Vosti and Reardon 1997), i.e. lack of means to invest into the maintenance of natural assets. These cases also merit public policy attention. Because implementing MO is never costless, the existence of, for example, a market failure in the context of a given ES is not sufficient to justify policy action. Decision-makers must first assess the value to society of the effects of such a market failure, and also assess the effectiveness and costs of alternative options. In the case of water pollution, (see section 2.7.2.2), stakeholders may decide to invest in water treatment plants that substitute for natural water-purifying ecosystem services, especially if the demand for water purification can only be met by a large expansion of natural purification systems, and this expansion displaces income- and employment-generating activities in upstream areas.

Taking any action at all requires at least one MO for which the sum of expected benefits to society outweighs the sum of expected costs of implementing it over a specific time period<sup>3,4</sup> If this is not the case, then the socially optimal response is to take no action until this basic relationship is

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<sup>3</sup> These sums of benefits and costs represent the discounted streams of annual benefits and costs attributable to the MO over a specific decision-making time period.

<sup>4</sup> The word ‘expected’ is inserted here to introduce the notion of uncertainty in the flows and values of ES, and also the uncertainty in the performance of alternative MO. We will take up this issue of uncertainty later in the chapter.

altered.<sup>5</sup> When several MO exist that pass this first fundamental test, attention is then focused on the relative performance (see below) of alternative MO.

If specific objectives are identified related to a specific ES, the challenge is to identify a MO to get the job done. Ideally, one MO would be clearly superior in every way to all other alternatives (e.g., is effective, inexpensive, can be paid for by ES users rather than taxpayers, reduces poverty, and does not degrade other ES flows). Such MO are rare to non-existent, in large part due to trade-offs among development objectives and ES (Lee & Barrett 2001). MO differ by strategy and objectives: some may be quick and cheap to establish but ineffective at achieving stated policy objectives. Some MO may negatively affect the poor; while others may reduce poverty. Each MO will have characteristics that need to be identified and measured before selection can be made. Not surprisingly, chief among these characteristics is a measure of cost-effectiveness<sup>6</sup> (Moran et al. 1996).

Regarding trade-offs, Table 3.1 sets out candidate MO for retaining above-ground carbon in the Amazon: paying farmers to retain forest cover, forest use regulations, and establishing a cap-and-trade system that any land owner could participate in. If policymakers want to increase amounts of carbon retained on private forested land, they must decide on how to achieve this objective. To choose among MO, policymakers need the information in each cell of Table 3.1. It is unlikely that a given MO will dominate all others in all of the columns. For example, forest use regulations may be effective at achieving carbon-retention objectives and inexpensive to set up (though perhaps less to operate), but this particular MO may have adverse effects on rural poverty (Vosti et al. 2002). At the other extreme, a cap-and-trade system may be the most economically efficient and provide the greatest benefits to the rural poor; but this MO may be very expensive to establish and operate—especially in the hinterlands where markets function poorly and the rule of law is often lacking. Trade-offs among evaluation criteria for selecting MOs are likely to exist.

The size and direction of these trade-offs will depend on the socioeconomic, ecological, and institutional context in which ES flows occur and in which the MO will be undertaken. These factors vary over time and space with perhaps predictable effects on ES flows and MO characteristics. For example, a specific MO that was highly effective in managing an ES in densely populated micro-watersheds in the Andes region may be ineffective in managing the same ES in the Amazon because of low population density and poor transportation infrastructure. Considering change over time at a given locale, climate change will likely change rainfall/run-off patterns in the Amazon region (Richey et al. 1989) in ways that require policy attention to previously unmanaged ES (e.g., surface water flows) and development and deployment of new ES.

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<sup>5</sup> Since policy action can influence some of the elements of this calculus (e.g., investments can increase the effectiveness of a given MO, and hence increase the expected benefits associated with ES management), choosing whether or not to manage an ES is not always independent of MO choice.

<sup>6</sup> Cost-effectiveness is a fundamental criterion for choosing among MO for specific ES tasks, especially for those ES flows for which values cannot easily be established. Other criteria include important indicators of sustainability, such as those identified in the last three columns of Table 3.1.

*Table 3.1 Example of the summary criteria for selecting among management options for a targeted ES: carbon retention in Amazon forests*

Alternative MOs for Achieving a Given ES Objective  (e.g., Carbon retention in the Amazon)	Expected Impact on Targeted ES	Expected Cost of Intervention	Expected Cost Effectiveness	Expected Effects on Poverty	Effects on Non-Targeted Ecosystem Services	
	Tons of carbon retained  (tons in year T)	PV of establishment and operational costs  (2007 US\$)	Expected cost per expected ton of retained carbon  (PV of costs/tons of carbon, 2007 US\$)	Change in income of resource-poor smallholders attributable to carbon retention program  (PV of income changes, 2007 US\$)	Enhancements  (e.g., measures of plant/animal diversity)	Declines
Payments to farmers for carbon retained						
Forest use regulations						
Cap-and-trade system						

While the framework for MO selection set out in Table 3.1 is conceptually appealing, filling in the cells is an ambitious task beyond the scope of this chapter. Instead, our objective is to identify the types of research and training activities that need be undertaken in order to fill in Table 3.1 for selected ES and to better-position policymakers to use that information. We first provide an overview of MO that address both the causes and the consequences of ES under-provision (section 3.2). Second, this chapter lays out the basic mechanisms through which MO affect human behaviour related to ES flows (section 3.3). Third, we summarize factors that influence the performance of MO with respect to the performance indicators set out in Table 3.1 (sections 3.4 and 3.5). Identification of knowledge gaps helps us suggest MO-specific research and capacity-building needs, some of which may be undertaken by the ESPA Program. Based on what is known about the potential for alternative MO to manage ES flows in the Amazon and Andes, we finally review factors that affect the cost-effectiveness of selected MO (section 3.6).

### **3.2. The literature review: methods and general observations**

We screened over 600 peer-reviewed journal articles, research reports, and institutional publications in English, Spanish, and Portuguese that dealt with MO. We identified 25 types of MO that allowed us to categorize entries according to: regional focus, ES addressed, socioeconomic effects (expected or observed), and approach (empirical, theoretical). Twenty percent of the reviewed articles had an empirical focus on Latin-America (12% Amazon, 5% Andes); 5% and 18%

focused on Africa and Asia, respectively.<sup>7</sup> For each MO category, key studies were analyzed to learn more about their performance under different agro-ecological and socioeconomic conditions and for managing different ES. Most of the publications dealt with carbon, water-related ES, and plant biodiversity; there were fewer studies of forest products, soil degradation, and air pollution.

Apart from literature on payments for ES, few publications addressed specific and well-defined ES. The ES concept has only recently been widely adopted in the scientific literature; and with the exception of water, few ES-specific policy instruments are available. Many of the early and most cited publications that use the ES concept (e.g. Costanza et al. 1998 or Daily 1997) have focused on providing quantitative and qualitative evidence of the benefits or value to society of ES. As argued in the introduction to this chapter, being able to measure the value of these benefits or the costs associated with foregoing them, is key to making informed decisions about whether, where, and how to intervene and manage ES. A recommendation that will emerge from this review is that more time and multi-disciplinary effort be dedicated to refining and measuring ES.

A few “pure” ecosystem services studies do use the ES concept to analyze causes and possible remedies of reduced and suboptimal ES provision (Sterner 2003). The Millennium Ecosystem Assessment (MEA 2005) provides one of the first, broad frameworks for defining and managing ES. The diverse events and processes (natural and human-induced) that affect ecosystem functioning are termed direct or indirect drivers of ecosystem change that can be addressed by potential responses; the latter being equivalent to what we call MO. We prefer the term “management,” because it better describes the required proactive, multi-stakeholder process of efficiently and equitably managing ES flows.

### ***3.3. Management options: what are they and how do they work?***

Options to manage natural resources or ES have been classified in many different ways. Bayon (2001) distinguishes public-good-specific, incentive-changing, and business options. Sterner (2003) divides MO into options to use markets, create markets, regulate use, and engage the public. The MEA establishes categories of response options, such as legal, economic, and social responses.

Classifying MO requires somewhat artificial conceptual boundaries. MO may use different mechanisms to achieve similar objectives and they can be applied by different actors at multiple spatial scales and in different socioeconomic contexts. Our typology of MO (introduced and explained below) does not aspire to improve on previous classification attempts; but rather provides a didactic tool for subsequent analysis of ES management options in settings where poverty alleviation is a key policy objective.

Despite differences among conceptualization of MO, all policy instruments for environmental management seek to influence human behaviour. Ideally, a decision-maker’s goal is to use MO to “adjust” human behaviour to achieve socially optimal use or conservation of natural resources (including ES flows) (Baumol & Oates 1988). In practice, decision-makers don’t know what this social optimum is; and even if they did, do not know the best MO to achieve it. While we may not know what is optimal, stakeholders do have strong preferences regarding natural resource management and ES flows. Also, market forces alone will not deliver what most stakeholders prefer. MO are necessary; but we need a framework for understanding them and for evaluating among them for achieving preferred natural resources and ES flow outcomes.

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<sup>7</sup> The remainder of the articles focused on developed country settings or problems, or were not specific to any geographic region.

A first step in doing so is to identify three basic (and admittedly not strictly exclusive) ways or mechanisms through which MO can affect human behaviour:<sup>8</sup>

- Establishment of general conditions that enable behaviour driven by private incentives to contribute to achieving a given ES objective (Enablement)
- Provision of (specific) incentives that change behaviour in ways that contribute to achieving a given ES objective (Incentives).
- Provision of (specific) disincentives that change behaviour in ways that contribute to achieving a given ES objective (Disincentives)

Figure 3.1 summarizes MO identified by our literature review according to these three categories.

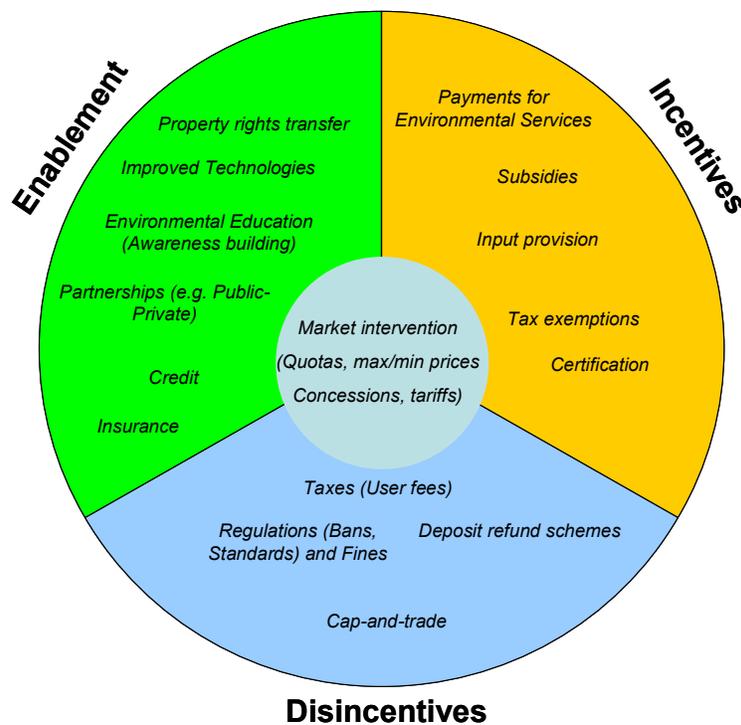


Figure 3.1 Basic management option mechanism for affecting human behaviour: enablement, incentives, and disincentives

### Enablement MO

“Enablement” MO contribute to conditions in which it may be in an individual’s, a household’s, or a community’s interest to use or modify a given ES in socially optimal ways. These MO can promote desirable ES outcomes that would emerge if behaviour was not constrained by private interests.

<sup>8</sup> We emphasize the word ‘can’ because the intensity with which a given MO is used and the duration of use of a given MO will, in part, determine its effect on human behavior – e.g., small price subsidies and short-term punishments may do little to change behavior.

For example, private entities cannot be expected to produce agricultural technologies with large public-good components or provide environmental education.<sup>9</sup> Although both MO (technology development and education) may enable farmers to improve ES management, investment in them will not guarantee more socially acceptable ES outcomes (e.g. reduced erosion from agricultural land, see section 2.6).

Enablement MO are generally unlikely to remove all constraints that preclude the desired human behaviour (e.g., credit provision may not be sufficient to overcome resource overuse due to insecure land tenure). In a less-constrained situation an individual may choose behavioural options that do not involve the targeted ES (e.g., credit provided for soil-enhancing investments may instead be used to pay for children's education). Nevertheless, MO in this category can contribute to more efficient and socially optimal ES use or to less damaging ES modifications (Kuyvenhoven 2004). Enabling MO are often viewed as complementary policies needed for effective implementation of some incentive and disincentive MO (Auty & Kiiski 2002). Because enabling MO by definition and design aim to increase options available to the rural poor, they can have negative effects on ES use or flows, e.g., providing rural credit in forested areas can increase deforestation (Vosti et al. 2002).

A frequently cited example of an enablement MO is the transfer of natural resource property rights to local resource users or to lower-level administrative units (Agrawal & Gupta 2005). Poorly defined or non-existent property rights, resource tenure insecurity, or open-access motivate natural resource "mining" strategies or the rapid exploitation of ES in the face of uncertain opportunities for future use (Hotte 2001; Schuck et al. 2002).

Economically competitive and environmentally friendly **alternatives** to traditional technologies will likely be adopted without specific incentives that encourage their use or disincentives that discourage the use of environmentally more damaging technologies (Qaim et al. 2006). If, however, access to such technologies is limited by liquidity constraints, MO such as rural credit schemes have shown increased adoption rates and ES use efficiency (Anderson et al. 2002; Anderson & Thampapillai 1990).

Government and civil society engagement in **environmental education** and **awareness building** is a major contributor to reducing the costs of environmental management by affecting human behaviour in ways that narrow the gap between privately and socially optimal ES flows (Kollmuss & Agyeman 2002; Palmer et al. 1998).

Relatively small investments in mutually beneficial **partnerships** can help solve environmental problems (Schwartzman & Zimmerman 2005), although implementing this particular enabling MO often requires long-term coordination, and the establishment and maintenance of a legal regulating framework (Visseren-Hamakers & Glasbergen 2007), all of which can be expensive.

Farm income (i.e., human welfare) and some types of ES flows are directly and negatively linked. Excessive rainfall can cause flooding that destroys crops; or droughts can make agriculture unfeasible. **Insurance** schemes have traditionally been used to mitigate negative effects related to extreme weather events (Hazell et al. 1986). The public sector has played important roles in establishing, monitoring, and guaranteeing such schemes. In situations in which risk undermines the incentives to adopt ES-friendly technologies or farming practices, insurance schemes can contribute to stabilizing or increasing incomes, and to ES conservation (Nail et al. 2007).

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<sup>9</sup> For a list of reasons why the private sector will not provide the needed goods or services, see Belli et al. (2001), Technical Appendix.

## Incentive-Providing MO

Where given ES are underprovided, overused, or underinvested in, the value of that ES may not be evident to or captured by individuals affecting their provision. Governments have often provided direct incentives that encourage ES conservation (Portney & Stavins 2000). **Subsidies** have been among the most frequently used incentive-providing MO--e.g., in the European Common Agricultural Policy and in some Latin American countries (Huber et al. 1998; Lowe et al. 1999). Europe has long guaranteed its farmers cheap access to credit and inputs. Unfortunately, subsidies for intensive ES uses can contribute to ES losses--e.g., water for agriculture or forest clearing for agriculture (Brouwer & Lowe 2000). **Input provision** and **tax exemptions** are ways of providing indirect subsidies for the provision or protection of ES. Yet, providing inputs below market prices can damage existing markets and targeting tax exemptions can be difficult for ES that are hard to monitor. Nonetheless, these policy instruments could be used, perhaps in combination with other MO, to change behaviour in ways that generate or protect ES (Oenema et al. 2006).

**Payments for environmental services (PES)**<sup>10</sup> are generally perceived to be the most direct way to stimulate the provision of a given ES. Albeit with few concrete examples, PES has received much recent attention (Börner et al. 2007; Wunder et al. 2008). Costa Rica was one of the first countries to implement a national PES scheme to manage ES such as biodiversity, soil erosion, water flow, and forest carbon stocks (Pagiola 2007). Effectiveness, cost-effectiveness, and equity effects of these pioneering projects have yet to be comprehensively assessed; and the context-specific factors that are likely to influence these indicators of MO performance not yet been identified or carefully studied (Pagiola et al. 2005; Wunder 2007). In the Andes, watershed PES schemes are mushrooming, partly because transaction costs of reaching agreements are lower in well defined watersheds with up-stream ES modifiers and downstream ES users (Southgate and Wunder 2007). In the Amazon, few PES-like schemes exist, and large-scale applications are limited by poor information on tenure rights of ES providers (Wunder et al. forthcoming).

**Certification or eco-labelling** is a widespread MO used to increase the market prices of products produced in ways that are less environmentally damaging, and hence provide incentives for implementing ES friendly production practices (Ferraro et al. 2005). The certificate separates markets for conventional and more eco-friendly products and allows consumers to pay (a premium) for the improved management of ES. Some refer to certification as market creation MO (Nunes & Riyanto 2001). Costs of establishing and managing certification and eco-labelling schemes need be included in the analysis undertaken to select the proper MO for managing a given ES or set of ES.

## Disincentive Providing MO

Disincentives are the most commonly used policy instruments for environmental management, especially in the Andes/Amazon neighbour countries (Huber et al. 1998). When costs associated with ES use or modification are perceived by society to be excessive, disincentives can be used to reduce and regulate activities causing ES losses. MO such as **regulations** (e.g., forest retention laws), **bans** (e.g., trade bans on endangered species), and **standards** (e.g., sex and size restrictions on the harvesting of certain types of wildlife) are examples for command-and-control MO. Fines and legal action (e.g., imprisonment) are generally used to enforce compliance (Pearce & Turner 1990). Command and control MO have been largely criticized as being economically inefficient and as having negative effects on poverty (Dietz et al. 2003; Holling & Meffe 1996). They are popular among decision-makers in part because they are relatively easy to establish--though

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<sup>10</sup> The "environmental services" addressed by most existing PES schemes are equivalent to ecosystem services with public good character, e.g. carbon fixation and biodiversity related benefits, or scenic beauty (Landell-Mills and Porras 2002).

less easy to enforce (Huber et al. 1998) and because they can generate government revenue in the form of fines.

Huber et al. also highlight that the revenue-generation of **environmental taxes** is a reason that this MO has been preferred by public policy decision-makers. Whether this revenue is enough to cover costs of enforcement and of MO management is an open question given that governments generally need to borrow to establish such programs. Environmental taxes in developed countries can bring about both ES and welfare gains (Bosquet 2000; Johnstone & Alavalapati 1998). In the context of developing countries, however, levying taxes to enhance ES flows may have negative welfare effects (Bruce & Ellis 1993) unless poor ES modifiers do not receive special treatment, e.g., tax exemptions.

**User fees** are an option for managing local ES use and modification, e.g., in national parks and **protected areas** (Green & Donnelly 2003). User fees in the form of resource extraction permits are a form of regulating resource use and extraction and hence of ES such as water use and timber extraction within and outside of protected areas (Simula et al. 2002; Sudirman et al. 2005). Properly enforced, protected areas (PA) are the purest form of natural resource and, hence, ES conservation. Large economic benefits can be derived from allowing some access to and use of PA, especially if PA are successfully integrated in local and international markets for tourism and other non-destructive uses (Amend et al. 2006). Whether PA achieve conservation objectives, however, depends on effective enforcement. Whether PA can cost-effectively achieve conservation objectives requires analysis of establishment and management costs. Hayes (2006) shows that for a large sample of PA, effectiveness in achieving conservation objectives is not necessarily higher than the effectiveness of other types of forest protection. Involving local populations in the design of use-and-protect strategies for PA has been found to be effective (cost-effectiveness is generally not addressed) and equitable (Cernea & Schmidt-Soltau 2006).

### ***3.4. Factors influencing performance of MO in achieving defined objectives***

The MEA approach to classify ES in terms of regulating, provisioning, and supporting services is useful to understand how ES contribute to human well-being. More specifically, it helps identifying pathways through which ES benefits accrue to particular stakeholders, thereby helping to determine who could and should cover at least some of the costs of the MO. From a management point of view, however, the MEA categorization may be less convenient because it groups ES with very different characteristics in the same categories. In fact, understanding implications of specific ES characteristics for management has been considered crucial to designing suitable intervention strategies (Kroeger & Casey 2007).

Choosing among MO requires the definition of specific development objectives. As suggested in Table 3.1, if the objective is to enhance or maintain the provision of a given ES, the abilities of alternative MO to deliver improved ES flows in cost-effective ways should be evaluated. Likewise, effects on secondary objectives, such as poverty alleviation and provision of non-targeted ES should be considered. Both, ES characteristics and the context in which MO are applied are factors that influence the performance of MO in achieving these objectives. In what follows, we highlight the most relevant of these factors.

#### **Excludability**

Certain MO can be discarded, including most featuring incentives and disincentives when the ES of choice has attributes of a private good. An ES has private good characteristics if beneficiaries can exclude others from reaping the same benefits. Forest products or soil quality on private land are

excludable ecosystem goods/services that, if extracted/used, provide benefits only to landowners.

Whether users of ES with private good characteristics can exclude others from deriving the same benefits generally depends on resource ownership or use rights (Ostrom et al. 2005). In both the Andes and the Amazon, many natural resources are, *de facto*, open access with ill-defined, incomplete, non-existent, or incompletely-enforced property rights (Ravnborg & Guerrero 1999; Seroa da Motta & Ferraz do Amaral 2000). Weak infrastructure and administrative capacities in developing countries limit the effectiveness of disincentive-based MO in these situations, because the effectiveness of such MO, too, depends on proper enforcement. This holds in particular for large part of the areas that section 2.7.1.2 identified as important for forest product provision. Also incentive-based MO for private good ES, such as PES schemes, are generally hard to justify because ES flow benefits are primarily local.

Swinton et al. (2003) found, for the case of Latin America, that ES with private good characteristics are subject to overuse if users lack the means (or opportunities) to invest in their maintenance or efficient use. In such cases, disincentives (e.g. taxes or fines) could well increase poverty. Enabling MO, such as property right transfers and supporting local communities to build efficient institutional arrangements that regulate resource use and access, are promising candidates to address such situations (IFAD 2003; McGrath et al. 1993).

That said, extracting forest products or ill-managed soils can produce externalities affecting ES with public good character, such as habitat quality reduction (section 2.1.1.1) or soil erosion (section 2.6.2). Carbon stock increases, too, are a classic example of a non-excludable (i.e., public) ES: benefits of carbon retention and fixation accrue to the society as a whole and not exclusively to the individual even if the individual owns the land. Hence, incentives for landowners to increase or maintain carbon stocks are adequate options if society feels these services are underprovided.

Finally, excludability has important implications for the ways in which ES management may contribute to alleviate poverty. If benefits of ES with private good characteristics can be captured locally, MO that enhance their provision will increase well-being of poor ES users (not necessarily modifiers). For instance, measures to reduce freshwater pollution from mining and urban settlements will benefit downstream water users. On the contrary, MO to reduce carbon emissions from deforestation (i.e. maintenance of ES with public good characteristics) will bring about few local benefits for the poor, unless they own land and are duly compensated for the forgone benefits of converting forests to other land uses.

### **The biophysical characteristics of ES**

The MEA definition of ES comprises all sorts of benefits provided by ecosystems. Understanding some of the basic biophysical properties of individual or bundles of ecosystem services and goods is necessary to evaluate the potential costs and effectiveness of MO. Here we concentrate on ES interdependencies as well as temporal and spatial dimensions of ES provision.

Not all ES are equally “systemic”, i.e. dependent on other specific ecosystem conditions and processes. Carbon fixation in plants, for example, is a universal process. Although it depends on climate and soil conditions, few other specific ecosystem components need to be in place for plants to sequester carbon. The presence of endemic species, such as fish or terrestrial wildlife, on the other hand, often depends on specific (sometimes unknown) habitat conditions (see section 2.7.1.1). That said, in natural forest ecosystems, many important ES are directly linked to forest cover, albeit not necessarily dependent on each other.

Biophysical independence has made it easier to quantify and predict ES stocks and flows in land use systems, and to identify and test policy approaches to managing ES (primarily carbon) in the

context of forest and in agro-ecosystems (Pagiola et al. 2002). In many cases, land cover is an acceptable indicator for above-ground carbon stocks, which is convenient from a management point of view. As indicated in section 2.3, water flow quantities and related ES are relatively independent from land cover (at least in the Amazon), but knowledge about basin characteristics and climate conditions inside and outside the actual ecosystem have helped to predict also this ES quite accurately (Schöngart & Junk 2007).

Apart from interdependencies, ES provision varies over time and delimited space (Kremen 2005). Rivers reach the ocean where they largely cease to influence land ecosystems. Elevation and associated climate in regions such as the Andes introduce spatial variations in provision of ES. In the Amazon where elevation is of much lesser importance, basin, bedrock characteristics, and tidal inundation introduce spatial variability to ES provision. For example, tidal movements in the Amazon allow for electricity generation in small-scale tidal power plants along some, but not all, rivers and temporally inundated areas (Charlier 2003).

Often there are also multiple temporal patterns to ES provision – diurnal, monthly, seasonal, and inter-annual. Diurnal temperature variations affect the crops that can be grown. The discharge of the Amazon has been shown to vary enormously depending on the ENSO cycle, with implications for hydropower generation, fluvial transport, and fisheries (Richey et al. 1989). If relevant, these natural patterns should play a role in decision-makers' choices of MO as well as the details associated with selected MO (e.g., whether or not to offer payments for maintaining or enhancing ecosystem services, and if so, how payments affect temporal patterns of ES provision).

Space and time can induce uncertainty regarding ES flows.<sup>11</sup> We may not know where the endpoint of influence of a particular stream flow might be at a given point in time because rainfall in a given year can extend or reduce that stream's flow. Some uncertainty can be reduced with investments in research/monitoring. Although decision-makers seeking MO for specific agro-ecological and socioeconomic circumstances may meet objectives "on average", there will be times and places when/where MO will over- or undershoot the objectives. MO selection and crafting may alter the amount of over- or undershooting, and time/effort spent doing so may contribute to the institutional sustainability of the selected MO.

### **Implications for management**

Excludability of ES benefits is relevant for choosing the right category of MO. Direct incentives, such as PES and subsidies require threats to public ES benefits to be justified. If ES benefits are private and primarily local, ES loss is probably due to conditions that disincentives are likely to aggravate, e.g. insecure property right, conservation investment poverty or limited access to technological alternatives. MO that enable ES modifiers to use ES more efficiently seem to be a sound way to address such situations.

ES interdependence is relevant when MO are designed to target specific ES as opposed to bundles or higher units of management, such as forest cover or entire ecosystems. Managing individual ES can cause undesired side-effects on other ES if interdependencies are not well understood or externalities affect other ES, e.g. ground water pollution from forest plantations to boost carbon fixation. Likewise, hydroelectric dams affect not only water flow volume and speed, but also related ES, such as aquatic biodiversity and sediment flows downstream. "No touch" MO, such as strictly protected areas are therefore standard MO to address interdependent and hard to measure ES, but

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<sup>11</sup> The same may be true for the value to society of particular ES, e.g., the value of surface water during the wet season can be much lower than the value of surface water during the dry season; we deal only with the issue of uncertainty in ES flows here.

they limit opportunities to capture local ES benefits. During stakeholders consultations (see Chapter 5) it was repeatedly suggested that individual ES are not necessarily the best unit of management for ES in the Andes/Amazon context. For example, landscape level management might be better suited to conserve cultural ES, such as recreation and scenic beauty (see example 4 in table 4.3 in the next chapter). This is mainly, because it is not readily clear, which specific components of the ES providing environment make up its value to users.

Spatial and temporal dimensions of ES provision are relevant, because humans adapt to (and derive benefits from) them in different ways. Hence, rapid and unexpected changes (e.g., due to policy or climate change) can imply huge costs to those dependent on the affected ES. The 2005 drought in the Amazon magnified the implications of water shortages to the local and regional economies that have developed under conditions of relative water abundance (Zeng et al. 2008).<sup>12</sup>

Climate change and human-induced land cover change in the Andes/Amazon region can increase the complexity of measuring and managing ES with strong systemic linkages, such as biodiversity-related services and services related to water flows. It also alters the ecological determinants of non-systemic ES provision, such as carbon retention in forests, e.g. through increased fire susceptibility of moist forests.

Natural temporal and spatial ES flows are being altered by human activities to harness ES benefits (e.g., diverting rivers for irrigation) or to reduce associated damage from ecosystem disservices (e.g., levees for flood protection). As opposed to climate-related impacts, such efforts are driven by the economic returns to ES flow modification, which, too, tend to follow spatial patterns (Chomitz & Thomas 2003; Pfaff 1999; Thünen 1826, see also next section).

Hence, spatial and temporal dimensions of ES flows and benefits and associated uncertainties matter to decision-makers that are faced with choices between MO. Managing ES is further complicated because beneficiaries of ES flows are often separated (in time and space) from ES modifiers. A first step towards managing a given ES therefore is to understand how the (natural) characteristics of this ES and its use and modification affect:

1. the types of net-benefits<sup>13</sup> that the ES provides,
2. the ways in which these benefits are generated,
3. the temporal and spatial scales at which benefits are generated, and
4. to whom, where and when these benefits accrue.

The second step is to ask how alternative MO may affect these four items.

In practice, managers may not have the means to measure actual ES flows, e.g., those flowing from different compositions of plants in a given locale. Hence, decision-makers are often forced to manage land uses (or other broader units that are relevant for ES provision) in the hopes of influencing specific ES flows. **Figure 3.2** depicts a method for managing ES through land uses. First, ES flows are identified (ES1) although often not well-measured (e.g. pollination). Second, land uses (e.g., for maintaining bee populations, Land Uses 1) likely to generate these flows are promoted. If policies are successful in promoting these land uses (Land Uses 2), it is assumed that

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<sup>12</sup> "Record drought cripples life along the Amazon". New York Times, December 11<sup>th</sup>, 2005.

<sup>13</sup> It is important to note that not all ES flows necessarily generate only benefits; e.g. floodwaters often imply cost, and, the value of additional stream flow (once requirements are met) might be zero or negative.

this success is proportionally replicated for all targeted ES (ES2). A problem is the extent to which heterogeneity within land uses affects flows. Although a forest use regulation and a cap-and-trade system may be equally effective in retaining a specific total amount of forested land, the geographic distribution of the forests generated by the two MOs and consequences for ES, such as habitat quality, will likely differ (Debinski & Holt 2000).

In fact, decision-makers are often forced to manage ‘bundles’ of ES via decisions that affect land use and land use change. Conserving ES ‘bundles’ may be a way to piggy-back some unknown, immeasurable and/or highly undervalued ES. Yet, bundling may just as well include low value ES, which could be compromised in exchange for local income generation. Efforts are being made to un-bundle ES and to determine the social value of doing so—with part of the value added stemming from a greater ability to choose more cost-effective MO capable of focusing on specific ES.

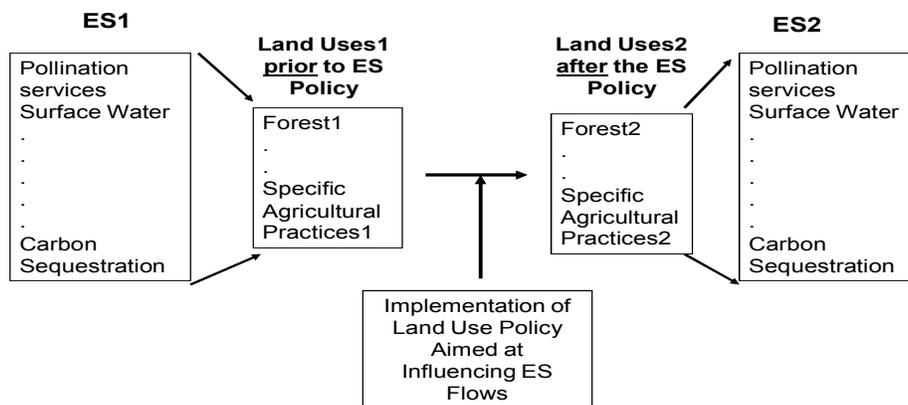


Figure 3.2 Managing ecosystem services via management of land use

### Other factors affecting choice of MO

A series of factors unrelated to ES characteristics can affect expected indicators of MO performance set out in Table 1. We begin with a discussion of socioeconomic factors and then focus attention on institutional factors.

*Socioeconomic factors* can influence the willingness and ability of individuals or groups to engage in efforts that change the flows of ES and can affect achievement of ES objectives relative to particular MO. Key factors are size and timing<sup>14</sup> of flows of private benefits derived from ES-flow-modifying activities and investments that come in the form of increased expected profits and asset values, or both.

Expected profitability of ES modifying activities is affected by access to transportation, technology and information. Yet, how these factors affect ES flows is site- and ES-specific. Although road construction in the Amazon generally leads to deforestation and related ES losses, investments in transportation and other infrastructure are ways to promote sustainable agricultural intensification that can reduce ES losses over time (Zaal & Oostendorp 2003).

<sup>14</sup> Timing is important because the flows of benefits and costs associated with specific activities and investments are discounted to account for time preference, and the discount rate can be high for resource-poor economic agents.

The type (increased profits or asset values), size, and timing of the net benefits associated with ES flow-modifying activities and investments, and the stakeholder groups to whom these benefits accrue, are relevant decision variables for MO selection. Where such activities and investments are very profitable (e.g., forest conversion for soybean production), PES schemes will be expensive and perhaps beyond the willingness to pay of ES beneficiaries. Land use taxes (that reverse financial flows among stakeholder groups, vis-à-vis PES) or land use regulations may be more cost-effective even if enforcement/monitoring costs are included.

Finally, the presence poverty itself should affect MO choice. This is where the different concepts and measures of poverty discussed in the introduction come into play. The low-income poor may or not be hurt by MO that establish disincentives, such as fines or user fees, for local private ES use or global public ES modification. It will depend on the degree to which these poor stakeholders depend on using or modifying these ES. Most standard poverty measures do not capture these dimensions and are, hence, of limited use for such kind of evaluations. As shown in Chapter 2, existing data allows us to show where these low-income groups are located and to characterize (at least in rural areas) the general state of some local life supporting ES in their environment. However, it is not at all clear whether low-income groups can actually benefit from these ES, especially if access is related to land tenure and property right issues (see also below). A general lack of such information in the Andes/Amazon context represents a serious limitation for regional assessments of the ES dimension of asset-based poverty (see section 1.1).

Conservation investment poor, on the contrary, may be better off paying small user fees or taxes, than having to follow strict environmental regulations that could discourage innovative land use practices and technologies with associated ES benefits (Börner et al. 2007). Such groups often practice hillside agriculture (Andes) or small-scale slash-and-burn farming (Amazon); i.e., production systems often characterized by low opportunity costs of ES provision, which makes them theoretically viable targets for PES schemes.

MO that enable ES users and modifiers to deal with ES more efficiently, if this is in their own interest, are a sound way to address poverty. To achieve this, existing technologies sometimes need to be adapted to specific conditions; or new and competitive technologies for more efficient ES use have to be developed. Obviously, addressing poverty requires other non-ES oriented interventions as well, e.g. basic education and other public services.

*Institutional factors* affect the profitability of ES efforts and, thus, the cost-effectiveness of MO. Law enforcement and the definition and security of property rights are basic preconditions for the effectiveness of many MO. Regulations will usually not be followed if the benefits of non-compliance outweigh the costs. The same applies to taxes and other MO from the “disincentives” category in Figure 3.1. Lack of the “rule of law” also can affect “incentive” MO: PES schemes may be ineffective if the recipients (e.g., landowners, in this case) cannot exclude others from modifying services deriving from their land. PES may actually support property right enforcement by rural communities and, overall, lead to positive environmental and welfare outcomes (Engel & Palmer 2008).

Other MO, such as community-based resource management, require collective action, civil engagement, and organizational capacity (Kellert et al. 2000). Yet, social capital in recently-settled areas such as the forest margins is typically lacking and investments in social capital building MO can take time to yield desired results (Fearnside 2001). The potential for building social capital is enhanced if those who modify ES flows can communicate and negotiate with users and if the benefits of negotiating outweigh transaction costs of doing so (Lubell et al. 2002). Promising are cases with clearly defined ES benefits and well known groups of ES modifiers and users, e.g., small watersheds with upstream water modification and downstream water use. As May (1991) notes, both poverty and spatial dispersion of beneficiaries of a particular ES flow often reduce the visibility

of ES-welfare relationships, and thus limit both private and policy responses to ES management.

Local problems often require local solutions. Governments have delegated management of some natural resources (and hence ES) to lower-level administrative units, such as states or districts. Decentralized management, however, poses new challenges to ES management, among them the risk that unprepared and underfinanced local governments lack needed administrative and technical capacities (Toni & Kaimowitz 2003). According to official statistics, roughly 30% of municipalities in the Brazilian Amazon do not have environmental secretariats in their local government structure. In those that do, there is an average of 0.6 staff available per square kilometre of average annual forest loss. Both, limited infrastructure and poor capacities for national and international articulation mean that only 13% of municipalities can raise funds for their environmental agenda.

To conclude, even if local governments and local civil society are prepared to cost-effectively handle local ES flow management challenges, such challenges are generally not exclusively local, but rather 'spill over' spatially and temporally into the domains of other decision-makers. Some very important ES flows with large public good components do not coincide with, or are contained within, administrative boundaries, and managing them therefore requires cooperation across policy-making boundaries. In the Amazon and Andes this applies especially to water and biodiversity (fauna) related services. In the respective countries the need for cooperation has given rise to the foundation of the Amazon Cooperation Treaty Organization (ACTO). However, multilateral environmental agreements and partnerships around the world are plagued with the same difficulties that arise at local level, e.g., free riding (individuals, communities or even countries reaping the benefits of ES management without paying their share of management costs) and high transaction costs of inter-governmental negotiations (Chang & Rajan 2001).

### ***3.5. MO for ES in the Andes/Amazon region, and their expected effects on poverty***

This chapter does not provide a recipe for selection of specific MO to meet specific ES flow objectives under particular agroecological or socioeconomic conditions. Rather, we provide insights into factors that should influence such decisions and suggest research priorities to fill knowledge gaps. In this section we look at selected existing and promising MO and highlight specific conditions in the Andes/Amazon context that are likely to affect their cost-effectiveness in addressing both poverty and ES objectives in the region.

Table 3.2 summarizes these conditions for each MO. Column 1 identifies the class of MO. Column 2 identifies the ES to be managed. Column 3 identifies necessary conditions for poverty-neutrality. Column 4 identifies factors that can reduce MO's potential to alleviate poverty; and the final column (5) examines factors affecting the cost-effectiveness of a given class of MO in achieving ES management objectives. The factors mentioned in the table are not meant to be universally valid. Instead, they point to conditions that prevail in significant parts of the Andes/Amazon, but that may not be relevant in others.

Beginning with Column 2, it is clear that most MO can be used to address ES flows associated with either specific ES or bundled ES. In practice, however, the great majority of MO have been used to influence human behaviour with respect to broad natural resource categories--such as forests or fisheries--with expected but most often unmeasured direct effects on specific ES flows. The exception are PES schemes designed to address one or two well-defined ES, such as carbon or biodiversity related services, but which likely have spill-over effects (of different magnitudes and perhaps in different directions, vis-à-vis the targeted ES) on other ES.

Table 3.2 MO and factors that influence their potential cost-effectiveness and poverty impacts in the Andes/Amazon

MO	ES Target	Conditions for potential to reduce (or not exacerbate) poverty	Factors that reduce MO potential to alleviate poverty in the Andes/Amazon	Factors reducing cost-effectiveness in achieving ES objectives in the Andes/Amazon
PES (Subsidies)	Specific - Carbon - Biodiversity - Water - Scenic beauty	-If the poor can offer additional ES provision -If the poor have effective rights to exclude others from modifying ES	-If poor can offer little additionality -If poor have weak, insecure property rights -If costs of achieving participation are high	-High opportunity costs -Spatial heterogeneity of opportunity costs -Institutional inefficiency
Taxes (user fees, etc.)	Specific and unspecific - Timber - NTFP - Water - Carbon - Biodiversity - Scenic beauty - Climate regulation	-If tax revenues are reinvested in (compensating) poverty alleviation measures or -If the poor can directly capture the revenues or - If the poor are excluded from tax	-If poor are allowed to capture user fees they may lack capacity to attract users -If poor are highly dependent on ES subject to taxes	-Weak enforcement capacity -High transaction costs (monitoring and enforcement)
Certification	Specific/unspecific - Water/Air quality - Carbon - Biodiversity - Soil quality - Climate regulation	-If the poor have market access -If the poor can capture price premiums, and -If the poor can meet quality standards	-Limited market access -Limited potential for economies of scale to reduce certification costs -Costs of investments into technology	-High transaction costs (monitoring of difficult to measure ES) -Weak enforcement capacity
Technological Innovation	Specific and unspecific - Various	-If poor have technology access (knowledge, extension, infrastructure) -If the poor can afford up-front investment costs	-Limited technology access -Conservation investment poverty -Information and skill asymmetries	-High opportunity costs of conservation investments -High development costs (R&D system)
Regulation (bans, standards, protected areas)	Specific and unspecific - Various	-If regulations do not affect essential ES consumption (or if so, compensating mechanisms are in place) or -If regulations include special treatment of poor ES users	-Low bargaining power to negotiate compensation and special treatment	-Weak enforcement capacity -High transaction costs (monitoring and enforcement) if under pressure
Local Institutional Arrangements (community-based resource management, partnerships)	Specific and unspecific - Various	-If the poor have equal bargaining power in the negotiation process -If institutions are set up in a way that promotes poverty alleviation	-Low administrative, organizational capacity of local governments -Low bargaining power -Few cooperative experiences	-High returns to free riding
Environmental Education	Specific and unspecific - Various	-If the poor have access to education (infrastructure, costs) and -If education addresses ES issues relevant for the poor	-Low level of teacher training in rural schools -High costs due to poor transport infrastructure	-High returns to environmentally damaging behaviour (lack of rule of law)
Cap-and-Trade Schemes	Specific - Air quality - Climate regulation - Various others	-If the poor are sellers and -If the poor have market access	-Limited market access	-Weak enforcement capacity -High transaction costs (monitoring and enforcement)

Designing and implementing MO to achieve poverty-neutrality or to reduce poverty generally implies additional costs (e.g., those associated with building participatory or institutional capacity), thus reducing cost-effectiveness from an ES point of view. Hence, few decision-makers have been willing to incur these costs. Perhaps more importantly, an adequate measure of poverty has to be defined that captures the relevant dimensions of poverty in a given ES management context.

In general terms, poverty effects vary across categories of MO and stakeholder contexts. Poverty effects of “enabling” MO (e.g., technological innovations) depend on whether the poor will be able to reap benefits of ES management. If access to alternative technologies is limited, the poor generally do not benefit and may even become poorer as non-poor adopters’ effects on (say) product prices are felt. The poor may also lack experience, skill, and bargaining power, limiting their ability to effectively participate in the MO. In the case of “disincentive” MO, interventions need to be designed in ways that leave the poor unaffected. “Incentive” MO (e.g., PES), on the other hand, often require a minimum level of participation in markets to work effectively. Conservation payments to subsistence farmers make little sense if there are no or only distant markets that provide staple foods to complement production losses. In the case of ecolabelling, mechanisms are needed to ensure that price premiums actually trickle down to the poor instead of being captured by intermediaries--as has been the case for some certification schemes (Harris et al. 2001).

Finally, given that poverty has different characteristics, poverty effects of the same MO may be different across stakeholder groups. Urban poor are less affected by restrictions on land use or the establishment of protected areas. Such MO may matter most to landless rural dwellers that depend on open access resources, but also to rural colonists if they affect their share of land available for agriculture (e.g., the Brazilian forest retention standard). Likewise, policies that affect prices for basic goods (e.g. energy or gas taxes) may have less impact on rural subsistence producers than on urban low-income groups.

### **Options for managing ES in the Amazon**

The majority of the Amazon region--located in Brazil--is *de jure* highly regulated. Some 41% of the Brazilian Amazon comprises protected areas or indigenous territories. The remaining land is subject to the national forest retention standard that requires 80% of landholdings to remain as primary forest. In practice, however, illegal deforestation continues wherever profitable, mainly along roads and highways (Laurance et al. 2002). Effectiveness of natural resource management objectives requires that “disincentive” MO be strengthened by increased penalties and/or more rigorous enforcement. In many areas of the Amazon enforcement costs are extremely high and eventually less cost-effective than providing incentives such as PES for avoided deforestation, especially in remote areas (Nepstad et al. 2007; Swallow et al. 2007). In theory, PES have the potential to auto-enforce themselves: payments can be simply reduced or suspended if contractual agreements are not met by ES providers. Reality still has to show to what extent this conceptual advantage prevails.

Despite its appeal, cost-effective ES management through direct incentives poses serious challenges. Tradeoffs between development and ES must be addressed in cases where incentives are too costly, i.e. in areas of high agricultural potential (Vosti et al. 2002); and the global community that benefits from public ES must be willing to compensate local actors for lost development benefits in the face of ES maintenance. Moreover, highly concentrated landownership in the Amazon means that effective PES schemes will have to embrace large landowners. This has shown to provoke considerable discontent among equity advocates.

Where property rights are secure, resource use is relatively homogeneous, and communities are willing to cooperate (e.g. in some indigenous or extractive reserves or even in well delimited older colonization projects in the Brazilian Amazon)--building capacities for effective management,

organization and institutional development is likely to help maintain essential ES and to contribute to poverty alleviation. Moreover, rewards for forest stewardship, e.g. through activities that support protection and management of protected areas, represent means to engage local stakeholders in ES conservation with welfare benefits.

That said, virtually all MO to enhance ES provision in the Amazon will have to face a poor state of information on land tenure, with different implications arising from this in each case. Fledgling initiatives to establish decentralized rural property licensing and registration systems require support to increase coverage and become compatible to allow for regional level policy planning.

### **Options for managing ES in the Andes**

Land cover change and subsequent soil erosion in the Andes affects farmers through loss of soil fertility and structure and downstream water users through reduced water quality and quantity. Development of technologies that reduce soil erosion and that protect or re-establish riparian vegetation have long been favoured by ES managers (Ataroff & Rada 2000; Southgate & Macke 1989; Zimmerer 1993). But, frame conditions need to be favourable for technological innovations to be adopted.

Watersheds can be complex both in terms of hydrologic systems (e.g., size, number of sub-basins, seasonal patterns of surface water flows) and in terms of different ES users and their effects on ES. Hence, community based watershed management schemes seldom emerge on their own. Ravnborg and Guerrero (1999) emphasize the importance of establishing platforms for negotiation between ES users and ES modifiers, and note that mutually beneficial negotiation outcomes sometimes crucially depend on third-party facilitation. In complex settings involving large watersheds and multiple stakeholder groups, transaction costs of setting up such platforms are therefore likely to reduce cost-effectiveness of communal management approaches.

PES schemes have been viewed as a cost-effective option to address watershed-level externalities (e.g., sediment runoff) that reduce ES benefits of downstream users (Landell Mills & Porras 2002). Southgate and Wunder (2007) concluded, however, that most initiatives have not yet reached mature states and that key determinants of sediment displacement are still not well enough understood to effectively trace cause and effect relationships in order to design payment mechanisms. Case studies from the Andes have also shown that PES are unlikely to emerge where downstream water users are poor(er) than upstream ES modifiers or where the combined willingness to pay of small downstream communities for improved watershed services is too small to compensate for opportunity costs of conservation measures upstream (Poats 2007).

Water user fees are a standard MO in watershed management. Revenues should ideally be reinvested in maintaining water service provision. It is, however, not always obvious whether such tax revenues are best invested in improving technology to deal with sediment runoff, in compensating users for maintaining ES flows, or in enforcing regulations that oblige them to do so. No cheap, quick, easy-to-apply, transparent tools for examining trade-offs among such watershed-specific investments are available--although their potential usefulness in policy-making is high. A good starting point is to quantify opportunity costs of ES conservation. For hillside zones in the Colombian Andes, Agudelo et al. (2003) show that conservation opportunity costs differ remarkably depending on both ES or natural resources type and ES modifier category. Livestock rangers had rather low opportunity costs of conserving soils and sequestering additional carbon types, whereas costs were much higher for coffee growers.

As we show in the following chapter, tourism and ecotourism represent a widespread mechanism to harness the benefits of the highly valued cultural ES in the Andes region, where ancient cultural sites are often located in visually attractive settings. The cases under study clearly show positive ES

outcomes as a result of ecotourism. However, Wunder (2000) notes that ES gains depend on whether tourism essentially changes labour and land allocation decisions, which must not generally be the case. Moreover, the economic opportunities of tourism have to be weighted against their potential impacts on cultural integrity in traditional populations.

In general, more spatial heterogeneity in ES provision in the Andes means that uniform approaches to ES management are probably even less appropriate than in the Amazon. Local problems arising from ES modification (e.g. erosion) are arguably more commonplace than in the Amazon. Yet, opportunities for reaping economic benefits of direct use values (e.g. ecotourism) more often coincide spatially with ES modifying activities. Research has spotted some of the conditions that need to be in place to make MO work in different contexts. What lacks is knowledge about where these conditions are favourable in order to cost-effectively integrate promising MO into a regionally consistent ES conservation and poverty alleviation strategy.

### **Region-wide options for managing ES**

Andes and Amazon ecosystems are linked through biophysical processes such as water flow and climate regulation (see spatial analysis in Chapter 2), and through socioeconomic systems such as trade, migration, transport infrastructure, and common cultural territory of indigenous populations. Some biophysical processes are better known than others (e.g., rainfall-runoff relationships in the Andes/Amazon vs. weather-biodiversity relationships). Even for better understood relationships, however, our ability to predict effects of natural or human-induced shocks or disturbances on ES flows is limited. Some researchers predict that the Amazon ecosystem may soon reach an ecological tipping point, which will radically alter vegetation distribution and related ES (Nepstad et al. 2008). Assessing and preventing such scenarios from happening clearly requires regionally coordinated management approaches--based on research that provides a more comprehensive understanding of what constitutes ecosystem stability and the determinants of the human behaviour affecting it (Burgos et al. 1991; Feddema et al. 2005).

Downstream water users in the Amazon are affected by sediment flows due to upstream deforestation or pollution from industry and urban centres. Large-scale investments in reservoirs for hydropower generation may have tremendous effects on both river discharge and migratory fauna and, hence, on downstream ES benefits. Understanding and measuring both ES and poverty impacts of such interventions are necessary to achieve cost-effective, and equitable regional ES management. Filling knowledge gaps will require regional scientific cooperation. Currently, there are few incentives for researchers to collaborate with partners from other Andes/Amazon countries. International scientific cooperation has occurred more in the form of bilateral agreements addressing national rather than regional resource management issues<sup>15</sup>. The same is true for inter-governmental cooperation. Common resource management is, however, one of the issues addressed by the Amazon Cooperation Treaty Organization (ACTO), which gives hope for innovative regional responses to common resource management issues. Self-organized regional initiatives of institutions in research and education, such as the Amazon Initiative Consortium (AI) and the Association of Amazonian Universities (UNAMAZ), may provide platforms for the articulation of research and capacity building to support regional policy processes.

### **3.6. Implications for research, capacity-strengthening and policy**

Several fundamental questions have to be addressed if stakeholders in the Andes/Amazon region

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<sup>15</sup> The IAI (Inter-American Institute for Global Change Research) and the Iberoamerican Program: Science and Technology for Development (CYTED) are noteworthy exceptions from this rule.

do not like what they see in the context of ES flows or the effects of these flows on poverty. Unfortunately, the knowledge base for addressing such questions is, at present, weak.

**First**, what is it that stakeholders see in the Andes/Amazon regarding ES flows, poverty, and the links between them?

Chapter 2 provides a snapshot of what science has been able to contribute to answering this question at the regional scale. Although we can measure income-based poverty and its dynamics, knowledge gaps stem from insufficient empirical studies of the poor and the nature of their poverty. Both natural and human-made factors influence poverty. Hence, better knowledge about the relative importance of particular ES flows in causing or reducing poverty, especially in the long term, is needed to justify policies that aim at improving well-being through better ES management.

The scientific base for many ES flows is weak. Some clear cases can be made for rather indirect use values of global ES, such as carbon stocks and the distribution of some endemic species. In these cases research needs to focus on how policies (i.e. PES schemes and other incentive providing MO) have to be designed to make sure these values are internalized at the local scale without excluding the poor from reaping their due share of benefits.

It remains largely unclear, at national and regional scales, where and how many locally valued ES flows contribute to sustaining welfare of vulnerable low-income groups. Case studies, many of which are cited in this and/or analyzed in the next chapter, provide important hints that complement findings in Chapter 2. I.e., fishery is an important economic activity in the Amazon (especially for some low-income groups). It is also highly vulnerable to both climate change and human induced modification of water related ES flows. Hence, substantial local benefits can be expected from investments in water quality and improved fish resource management. In the Andes, cultural ES are threatened by urban sprawl and agricultural expansion, but bear potential to generate more stable income streams to poor rural dwellers.

Such hints are well received by local initiatives and international cooperation when there is potential for replication. Yet, to move forward with ES related policy recommendations at national or regional levels, research needs to focus up-scaling results to have impact on decision-making.

Although progress is being made in framing and understanding issues, our review calls for more scientific effort in discovering stakeholder perceptions. One important priority is to more clearly define and measure ES flows, with particular emphasis on the spatial and temporal dimensions of these flows, and on the sources and associated degrees of uncertainty. Such research must be inter-disciplinary because what people see when they mention ES flows is framed by their value systems and desires to meet basic needs. Links between ES flows and poverty must be better understood, even if this improved understanding may lead us to choose policy measures other than managing ES flows to reduce poverty.

**Second**, if stakeholders are unhappy with what they see, why is this so and what is the extent of their displeasure?

Answering this requires knowledge of private and social benefits associated with ES flows or costs associated with changes in these flows, how benefits/costs vary across stakeholder, and how society might use these stakeholder-group-specific benefits/costs to help make policy choices. In Chapter 5, we summarize perceptions of key stakeholders in the Andes/Amazon. This consultation has helped to bring up issues that the analysis of existing data on ES and poverty would have overlooked. Nonetheless, policy relevant prioritization of ES management issues needs to translate stakeholder perceptions into objective measures.

An important knowledge gap is, therefore, the lack of methods to measure the benefits associated with particular local ES or of bundles of ES, and how these benefits change as ES flows are altered. To address decision-makers' needs, these methods must consider the site-specific nature and temporal patterns of ES flows and must generate distributions of expected benefit flows that capture the inherent uncertainty associated with most ES flows and their values to society. Work on new ways to establish and manage dialog related to ES flows among stakeholder groups is progressing, and is generally seen as necessary for achieving successful and sustainable outcomes. Large gaps do remain in identifying the most efficient methods of establishing and managing multi-stakeholder interactions and in how to generate and deliver science-based information that is useful to such interactions.

**Third**, if stakeholders don't like what they see, what *can* be done?

Answering this question requires an understanding of biophysical relationships relevant to given ES flows and how these would be affected by policy action, and an understanding of human behaviour of those using or modifying ES flows and the responsiveness of this behaviour to alternative policy actions. The next chapter and some of the research reviewed here provide important hints on the reasons of success or failure in specific contexts, but the general picture remains fragmented.

Constraints to research progress in this area are the complexity of biophysical relationships and the many, often stakeholder-specific, factors that influence human behaviour. Chief among biophysical knowledge gaps are consequences for non-targeted ES flows of actions affecting targeted ES flows. Regarding human behaviour, progress is being made at the level of individual or household decision-making. However, in the Amazon and parts of the Andes, many of the pressing issues related to ES flows, forest product extraction on open access land, pollution and sedimentation in micro-watersheds, and informal urban and peri-urban settlements must be resolved at the community or higher levels where comparative theoretical and empirical efforts are still insufficient.

Once again, integrated research approaches with comparative elements and potential for up-scaling are needed. When isolated research comes to contradicting results, a common explanation is that the region and its socio-cultural and bio-physical settings are heterogeneous. Although this is a true statement, it does generally not contribute to better decision-making. To answer this and the next question, policy and other decision-makers need to know where heterogeneity matters and how the MO at their disposal, with all their inherent imperfections, can best (i.e. cost-effectively) be integrated into a coherent policy framework.

**Finally**, if stakeholders don't like what they see, what *should* be done, and by whom?

This is the most relevant pair of policy questions--and one that require the definition of ES-specific policy objectives, information on the effectiveness and efficiency of alternative management options for meeting these objectives, and information on poverty effects of these MO. In some cases, the answer to the first question will be, "Do nothing, at least for now". In other cases the answer will involve identification of a particular MO for improving a specific ES flow; while in another the answer may involve investing in man-made alternatives to natural ES flows. In all cases, answers to the second question must identify the nature of partnerships required to take action and the division of labour among ES users, modifiers and intermediaries (see figure 1.3).

Given the knowledge gaps identified above, the literature generally provides little guidance to this fundamental pair of policy questions. Continued progress in filling these gaps will eventually help address these questions. Part of this lack is due to the failure to frame research needs in ways that respond to these questions. Establishing a framework focused on addressing these questions will identify new gaps in knowledge as well as innovative ways of using existing knowledge to do so.

### **Key research issues and questions to be addressed by ESPA: Management options**

1. Research on the relative importance of particular ES flows in causing or reducing poverty, especially in the long term.
2. Work to elicit and understand stakeholder perceptions (valuation) regarding ES flows.
3. Research to understand the private and social benefits associated with ES flows, costs associated with changes in these flows, how benefits/costs vary across stakeholders, and how society can use this information to make the right policy choices.
4. Work to understand how ES flows can be affected by policy action and to understand to what degree human behaviour is responsive to alternative policy actions.
5. Identifying the conditions (and their spatial distribution) under which incentive-based MO can be cost-effective alternatives to disincentive-based MO
6. Promote pilot experiences in a comparative framework to determine how enabling MO can be used to increase the capacity of the poor to capture the benefits of incentive providing ES.

## 4. Lessons learned from the region: Contribution of ES management options to improved well-being

The previous chapter reviewed existing MO and defined key selection criteria for achieving the objectives of enhanced ecosystem service provision and well-being based on the literature. This chapter reviews projects having an explicit goal of managing ES to improve human well-being. We discarded projects that enhance ES unintentionally, e.g., those that focus on increasing productivity of crop production and thereby improve soil capacity to retain water and nutrients. Reviewed projects dealt with innovative approaches to conservation and recuperation of ES and their contribution to well-being. The chapter is structured as follows: Section 4.1 introduces the case studies, shows to which MO category each belongs, and lays out the components used for the review. Section 4.2 uses six criteria to examine the case studies from the perspective of their impact on ecosystem services and well-being. Section 4.3 evaluates the case studies' potential for up-scaling (replicability) and assesses cost-effectiveness (see also previous chapter for why this is necessary). Based on the analysis of the case studies, section 4.4 evaluates the potential of ES management options to reduce poverty and increase environmental sustainability in the Andes/Amazon region. Finally, the main messages and priority research issues for the ESPA programme are presented.

### 4.1. Management options and ecosystem services

Case study projects were selected and reviewed according to MO shown in Table 4.1. Most of the projects employ MO that fit into the group of "incentive-providing" MO, as presented in Chapter 3: those characterized by the provision of (specific) incentives that change behaviour in ways that contribute to achieving a given ES objective.

Table 4.1 Management options used in selecting and reviewing case studies

Project/Programme (MO) type	Ecosystem service provided <sup>16</sup>
Extractive reserves ( D + E )	Non-timber and timber forest products
Forest management certification ( I )	Timber products
Fair trade certification and organic certification ( I )	Crop production
Commercialization of non-traditional products ( I )	Non-timber products
Ecotourism ( I )	Landscape beauty - recreation
Conservation of goods and cultural services ( I + D )	Cultural services
Carbon credits from reforestation or avoided deforestation ( I )	Carbon stocks
Payment for environmental services – for hydrological services by means of conservation of forests ( I )	Water regulation and water quality

I = incentive providing; E = enabling; D = disincentive providing

<sup>16</sup> As justified by the project. However other services could be bundled

Twelve case studies were reviewed according to the components presented in Table 4.2. The table consists of a structured framework presenting the baseline information needed to assess case studies' performance in terms of ES and well-being. The selected projects are prominent in the region. Some of them are well known because of their contribution to conservation of ES and ecosystems, their impact on well-being and poverty, and/or because they are innovative, unique or simply because they are well promoted. A widespread limitation was that many ES-focused projects are still in initial stages of implementation and provided limited lessons learned.

*Table 4.2 Components analysed in the case studies.*

<b>Component</b>	<b>Aspects (measurement issues)</b>
General features	Location Ecosystem type Ecosystem service description and category Management option Scale of the ES Environmental threat Target population Number of beneficiaries
Context	Availability of natural resources Road access Proximity to urban centre Labour availability Natural resources' state and access
ES Impact Indicators	Carbon stock changes (CERs or ha) Water quantity (m <sup>3</sup> or protected ha), Biodiversity (protected ha) Non-wood forest products (ton or ha) Ecotourism (protected ha) Cultural service (conserved species or ha, resulting from a specific cultural service)
Socioeconomic Impact Indicators	Perceived income impact (maintained, reduced or increased) Benefit distribution: Price of ecosystem products to the producer and the consumer Number of links in the commercialization of products Level of transformation of the product Role of the target population in the scheme Type of benefits received by the target population Type of resources provided by the target population Potential of the scheme for financial transfer from rich to poor sectors
Replicability evidence	Evidences of replications Participation of donors in the experience (% of total costs, kind of contribution) Type of donor Participation of investors, governments, NGOs (% of total costs, kind of contribution)
Sustainability	Resource use management plan Type and role of partners or associated stakeholders Type of alliance (public, private or public-private) Type of matching funds Dependence on external contribution

Table 4.3 introduces the 12 projects reviewed in this situation analysis in terms of MO type, name, and location. A more detailed description can be found in Annex 9.

*Table 4.3 Location, description, and initial situation of reviewed case studies*

<b>Management option</b>	<b>Name of experience</b>	<b>Location</b>
(1) Fair trade certification and organic certification	Organic coffee certification and fair trade. CECOVASA (Farmers cooperative)	Puno Province, Peru
(2) Ecotourism	La Chonta ecotourism project	Department of Santa Cruz, Bolivia
(3) Ecotourism	Chalalán : A community-based ecotourism project	Bolivia, Madidi National Park (between 6000 and 200 masl)
(4) Conservation of goods and cultural services provided by ecosystems	The Potato Park: Agro-ecotourism, conservation of native potato varieties and of indigenous peoples' traditional knowledge	Pisac, Cusco. Sacred Valley of the Incas (3600-4600 masl), Peru.
(5) Commercialization of non-traditional products to reduce pressure on forests	Coconut fibre for manufacturing automobile parts and conserve the rainforest	Marajó Island, Pará state, Northern Brazil.
(6) Extractive reserve and certification of sustainable forest management	Chico Mendes: An agro-extractivist reserve with forest management certification	Municipality of Xapuri, Acre, Brazil.
(7) Extractive settlement and certification of sustainable forest management	Seringal Porto Dias, Extractive Settlement Project with forest management certification	Municipality of Acrelândia, Acre, Brazil.
(8) Carbon credits generated from reforestation	Plantar Reforestation Project	Minas Gerais, Brazil (Cerrado)
(9) Carbon credits generated from carbon sequestration	Peugeot / ONF Project: Reforestation project for carbon sequestration	Municipalities of Juruena and Cotriguaçu, Northwest Mato Grosso state, Brazil
(10) Carbon credits generated from reforestation and avoided deforestation	Noel Kempff National Park: A CO <sub>2</sub> emissions avoidance (avoided deforestation) project	Chiquitania, Department of Santa Cruz, Northeastern Bolivia.
(11) Carbon credits generated from reforestation and avoided deforestation	Bananal Island Carbon Sequestration Project for social equity	Bananal Island, Tocantins state, Brazil.
(12) Payment for hydrological services: conservation of forests	Payment for Environmental Services for the conservation of the cloud forest	Bolivia, Los Negros River watershed, Department of Santa Cruz.

#### **4.2. Criteria used to assess the impact on ecosystem services and well-being of case studies' management options**

Six criteria were used to assess impact: 1. time frame for capturing economic benefits, 2. reversal of environmental degradation/conservation of ES, 3. local added value, 4. redistribution of benefits, 5. community empowerment, and 6. potential for transfer of resources from wealthier to poorer sectors. These criteria and relevant assumptions are presented in Table 4.4.

Table 4.4 Criteria for evaluating case study impacts on ecosystem services and well-being

Criteria	Assumption	Qualification
Time frame for capturing economic benefits	Long-term benefits do not solve immediate needs of the poor (high discount rates that apply to poor communities reduce magnitude of long-term benefits)	Short-term benefits: + Long-term benefits: -
Reversal of environmental degradation / conservation of ES	Reduction of degradation processes or conservation of ES prevent poverty and contribute to improve well-being conditions.	Diminish degradation/improves conservation: + Does not contribute to stop degradation or to conservation: -
Local added value	Local incorporation of added value to ecosystem goods permits to increase the economic benefits for the local communities.	Does exist: + Does not exist: -
Redistribution of benefits	Direct involvement of communities in the distribution of benefits avoids concentration of benefits by wealthier sectors and maximizes community economic benefits.	Producers are land owners: + Producers capture higher benefits than consumers: + Small producers capture higher benefits than medium and large-scale producers: +
Empowerment of communities	When local communities are partners (not only beneficiaries), the project will have a higher probability of increasing well-being.	Locals directly promote new alternatives: + Locals are involved in commercialization alternatives: + Locals are part of management decision-making and implementation: +
Potential for transfer of resources from wealthier to poorer sectors	Transfer of resources from wealthier to poorer sectors results in a higher probability to increase economic benefits and equity.	The management option gives opportunity to such transfer :+ The management option does not give opportunity to such transfer : -

Results are synthesized in Table 4.5. Below we summarize the key results of the case study analysis for each of the six criteria and additional, albeit not systematically measured, performance indicators.

**Criterion 1.** Economic benefits and the required elapsed time to capture them

Commercialization of goods in established markets provides immediate economic benefits to communities. Examples of such markets include those of certified products with ES benefits such as organic coffee (e.g. shade grown and fair traded brands) and a few non-timber forest products. Hence, they also address Criterion 2. ES are maintained via price mechanisms directed largely towards the good rather than the service per se.

Another mechanism that could provide immediate economic benefits in the short-term is PES for hydrological services provided through forest protection in upper catchment areas of the Andes.

However, payments often barely cover the opportunity cost of forest protection and, hence, bring about few welfare gains. One of the cases in Bolivia (see Annex 9) featured in kind payments to promote honey production which has a potential to provide higher cash flows and profitability than traditional slash-and-burn agriculture.

In some cases, practical applications of MO only resulted in long-term or small welfare gains, for example, in carbon sequestration and reforestation projects or ecotourism, where the community may participate only earning day wages equal to gains from agricultural or other traditional activities.

*Table 4.5. Evaluation of socioeconomic and environmental criteria of management options explored by the case studies.*

Management option	Criteria					
	1	2	3	4	5	6
	Economic benefits (income / productivity)	Reversal of environmental degradation / ES conservation	Local added value	Redistribution of benefits	Empowerment of communities	Potential of resources transfer from wealthier to poorer sectors
Extractive reserves						
Forest management certification						
Fair Trade / organic certification						
Commercialization of non-traditional products						
Ecotourism						
Carbon stock increases through reforestation / afforestation projects						
Carbon stock increases through avoided deforestation						
Protection of ecosystems' cultural services						
PES (hydrological services)						

## **Criterion 2.** Reversal of environmental degradation and/or ES conservation

Few projects directly measured the impacts of management options on specific ES. We therefore use proxies such as the number of hectares conserved or the amount of carbon not emitted or removed from the atmosphere. However, considering these proxy variables it was found that all management options are directly or indirectly contributing to ES conservation or enhancement.

## **Criterion 3.** Local added value

Certified shade grown coffee and transformation of non-timber forest products, or non-traditional agricultural products (e.g., coconut fibre for the car industry) are good examples of the local value added criterion if demand remains stable. This criterion does not pretend to disqualify other experiences that by nature could not imply an added value locally (such as protected areas), but it places a premium for experiences that have and take advantage of this opportunity.

## **Criterion 4.** Redistribution of benefits

It appears that several MO have resulted in benefits for poor stakeholders whenever:

- Land and/or resource tenure is secure.
- Beneficiaries directly participate in commercialization of an ecosystem good.
- PES payments are direct to ES providers.
- Local communities are prioritized as beneficiaries when cultural services or traditional knowledge is applied to natural resource management (NRM) (e.g., Potato Park in Peru).

Few benefits were captured in other cases due to:

- Local populations served as a labour force (e.g., in reforestation/afforestation projects intended to build C stocks) rather than as recipients of social benefits.
- Land managed for avoided deforestation or C emissions was owned by the state.
- Where a large portion of benefits from ecotourism are captured by commercial interests (e.g., the Chalalan Ecodge in Bolivia).

It is important to note that benefits for the poor often do not depend on the selection of MO, but on project design and implementation.

## **Criterion 5.** Community empowerment

Beyond financial gains, local communities valued improved capacity to manage and obtain new resources, to organize themselves to achieve common objectives, and to perform new activities. Most projects contributing positively in this regard did so because:

- Extractive reserves, by definition, require involvement of local communities in sustainable management and, sometimes, in commercialization of forest products.
- Ecological certification also often includes requirements for working conditions (e.g., as in the reviewed case of certified timber extraction).
- Fair trade certification has required farmers to be organized in cooperatives, which in turn, promotes social capital. Certification also requires clarification of land tenure rights, which can help to empower communities.
- Community based collection, transformation, and commercialization of non-forest products

requires organization and administrative capacities. The reviewed projects have facilitated such capacity building.

- Recognition of cultural values, traditional laws and knowledge, and local institutions can lead to empowerment, as in the Potato Park case.
- PES schemes that replace ES degrading activities by others, have provided training and generated new skills--as was the case in Bolivia, where forest conservation and honey production replaced slash-and-burn agriculture.

Community empowerment was weak or zero if communities merely served as labour force instead of being involved in a participatory manner throughout project planning and execution (e.g., in foreign investment projects to build carbon stocks). On the contrary, whenever social benefits from reforestation were an explicit project goal, communities were empowered through involvement (e.g., the contrast between the Bananal Island Project and the Plantar Project). To promote community empowerment in avoided deforestation projects, such projects must provide locals with alternatives instead of merely compensating them financially for their opportunity costs.

#### **Criterion 6. Resource transfers from wealthier to poorer social sectors**

The type of markets evolving around goods and services with ecosystem components influences the extent to which resources can be redistributed among stakeholders. Rubber and conventional timber are usually traded in competitive markets that provide little niche opportunities for smallholders. Scarce or somehow exclusive goods, however, may allow smallholders to capture price premiums - as is the case of certified organic coffee and other fair trade products, and Brazil-nuts. As mentioned in the previous chapter, ecotourism also provides opportunities for resource's transfer from wealthier to poorer sectors. So do PES schemes that bundle carbon services with cultural services, such as landscape beauty and recreation. In these cases, demand generally comes from visitors and buyers from developed countries (see previous chapter for caveats).

Resource transfer was less evident in the avoided deforestation projects and hydrological PES schemes analysed. In the avoided deforestation project in Bolivia, for example, carbon credit revenues are not received by poor local communities because the state owns the project.

Service buyers in the Negros PES scheme, Bolivia, are small, low-income downstream municipalities. They pay upstream farmers, but the amount barely covers the low opportunity cost of maintaining undisturbed the cloud forests, compromising efficiency in achieving ES objectives. This is a strong argument for not implementing PES schemes where the willingness (or capacity) to pay is lower than the costs of maintaining ES flows. Where such conditions prevail, PES will not work.

Cultural services linked to the management of ecosystems in the Andes showed little resource transfer potential. Although native potato varieties are being protected in the case of the Potato Park, there is little evidence of willingness to pay for the good, in part because the varieties are already domesticated and commercialized. There also appears to be little demand for the traditional knowledge promoted by the potato park.

### ***4.3. Replicability and cost-effectiveness of case studies***

#### ***4.3.1. Replicability of cases***

Most of the reviewed projects show potential for replication only under specific conditions and

subject to adaptations. Assessing replicability requires analysing project failure and success and potential for scaling up. Most reviewed projects started between four and 20 years ago - time enough to demonstrate potential for scaling up. Some considerations regarding replicability of the reviewed projects include:

- Fair Trade projects. Several other projects that were not reviewed rely on fair trade to deliver both socioeconomic and environmental benefits.
- Community-private enterprise partnership for commercialization of non-traditional products: The initiative of Pará, Brazil, producing coconut fibre by-products was motivated by a similar South African project and, subsequently gave rise to a project in Belém, Brazil, using curauá palm fibre for a paper factory.
- Extractive reserves and certificated community based-forest management: The concept of extractive reserve resulted from the pioneer work of Chico Mendes and rubber tappers from the Brazilian state of Acre, and has expanded from the four reserves created in 1990, to 39 extractive reserves (35 of which in the legal Brazilian Amazon) that occupied almost 10 million hectares by the end of 2006.
- Community based forest management projects tend to be associated with the process of certification. In Bolivia, there are 2,157,694 ha with sustainable forest management already certificated (CFV 2006). By early 2008, 20 certified management projects totalled more than 1.6 million hectares in natural forest areas of the Brazilian Amazon (FSC 2008).
- Carbon projects: The selling of Certified Emission Reductions (CER) through reforestation/afforestation activities has been replicated. In some cases CER are seen as a way to recover a part of upfront reforestation costs and locals are initially employed, but capture few benefits. In others, private companies attempt to demonstrate corporate social responsibility by delivering social and economic benefits to locals as enterprise partners.
- Ecotourism and PES: These efforts are being replicated in general rather than in reference to the reviewed projects. For example, the idea of in-kind PES and the investment of US \$1.4 million in Chalalan, Bolivia, to create an ecotourism lodge managed by locals have yet to show replication potential.

The conclusions regarding replication are:

Private coffee projects that included profit-motivated training contributions resulted in higher prices paid for certified and/or transformed ES and goods. In the coffee and forest certification processes, not only a better price but the clarification of land tenure enabled the scaling out of that management option.

Carbon project management options are replicable; albeit benefits to local populations are tied to other factors.

For extractive reserves, replicability has much to do with compliance with policies regarding land tenure and value chain development for extractive products resulting reductions in social and political conflicts. Also, the extractive reserves must have a state level framework to be officially recognized, and there should be an organized, pro-active stakeholder group (such as the rubber tappers in Brazil) interested in and pushing for the policy instrument.

In some projects, development and conservation agencies funded or subsidized testing of MO. In the absence of such investments replicability could not be determined. Again, the highly funded ecotourism project and PES projects where payment sources come from foreign conservation organizations come to mind. Yet, these costs are not included routinely nor analyzed transparently

in the accounting for the effectiveness of such initiatives. Moreover, high funding is not replicable by definition, and tends to undermine community organization, in addition to creating dependency and vulnerability to inspection and control.

#### *4.3.2. Cost effectiveness of achieving environmental management objectives*

Effectiveness of MO should be assessed by comparing costs of the measures relative to ES outcomes, and the enhancement of well-being (Chapter 3). Unfortunately, the case studies often provided little information regarding costs and well-being indicators of outcomes.

Where information was reported, cost-effectiveness for environmental objectives was assessed using number of ha managed or conserved as a proxy variable. For example, in projects related to water quantity and biodiversity, conserved forested area is used as an indicator. Regarding carbon stocks and avoided deforestation projects, amounts of expected carbon removals or avoided emissions are calculated; although the magnitude of investments are not reported.

For income generation, salaries or total income were used as indicators of well-being. The cost effectiveness of improving well-being is not addressed in this section but it is reflected in the qualitative analysis conducted of the six previously explained criteria.

In terms of environmental cost effectiveness, large projects included the Noel Kempff carbon trading project via avoided deforestation, the Chalalan ecotourism project, and the coconut fibre project. Investments were from US\$ 4.60 to 23.00 per ha. The largest project was Noel Kempff with 890,000 ha and an investment of US\$ 11/ha, while the ecotourism project (300,000 ha) had an investment of US\$ 4.60/ha. Differences reflect the number of families involved and types of expenditures. The highest investment of these large-scale projects was by the coconut fibre project (US\$ 23/ha) due to infrastructure and training needs for a new and specialized activity.

Areas covered by the reviewed small-scale projects ranged from 250 to 3,000 ha. These focused on ecotourism, PES schemes, and extractive settlements combined with forest management certification. Level of investment varied greatly. The PES scheme in the Bolivian Andes had the lowest per ha costs: roughly US\$ 6.50/ha to protect approximately 3,000 ha of cloud forest. La Chonta (Bolivia) ecotourism project invested US\$ 20/ha, four times more than the investment required for the Chalalan ecotourism project. The extractive settlement project had the highest investment (US \$154/ha) which seems to be due to certification compliance requirements.

It is difficult to identify one option as the most cost-effective. However, some general guidelines could be derived for achieving environmental cost-effectiveness. These guidelines are derived for the management options associated to the projects commented above (Table 4.6).

#### *4.3.3. Cost-effectiveness of management options to generate income*

In terms of well-being and relative to number of families and generated family income, fair trade coffee provided the highest benefits (4,316 families with an annual income of US\$ 2,000/family). The coconut fibre project benefited 100 families at US\$ 4,000/year. Unfortunately, the project failed as expected demand did not materialize. The Chalalan ecotourism project benefited 90 families with incomes of US \$706/year/family. The other projects involved either few families or low incomes--as is the case with other ecotourism projects and water-based PES projects. Investment per family in the reviewed projects was estimated between US \$12,500 to US \$54,000. The table below presents factors influencing environmental cost-effectiveness of ES-oriented projects

Table 4.6. Factors influencing environmental cost-effectiveness of ES-oriented projects

Management option	Opportunity	Condition	Threat	Best condition for achieving environmental cost-effectiveness	Potential for poverty alleviation
Ecotourism	Some areas in the Amazon and Andes-Amazon zone with low population could be attractive for tourists, at low investment per ha and per family	Need to control these large areas through property rights and/or declarations as protected areas or national parks	Ecotourism is a market that could be easily saturated	A National Park or declared protected area  Attractive and accessible for tourists  Low population	Low:  Few families are generally involved, and not applicable for a wide range of conditions
Carbon markets: Avoided deforestation	Large forested areas under deforestation pressure, especially in the Amazon	Needed is clarification of land rights to recognize carbon credit beneficiaries	Avoidance of leakages could be something unmanageable or very expensive  Illegal land-grabbers & speculators could continue displacing poor communities and get benefits from ES	Land with property rights  Large areas still with forest but threatened  Low population per ha to avoid high leakage control costs	Medium:  While poor communities could lack land tenure rights, the project could be a means to obtain them. Poor communities have lower opportunity costs than big farmers, ranchers, timber companies, making carbon credit prices attractive.
Commercialization of forest products	Those with large areas (extractive reserves) but practicing slash-and-burn agriculture could change to intensive productive systems, reducing the pressure on forest	A productive alternative based on demand. Farmers with large areas suitable for conservation that compensate for high cost of new technologies and alternatives in intervened areas.	Saturation of markets and lack of demand	A productive alternative with market  Farmers with access to large areas  Land tenure rights	Medium to high:  Employment generation depending on alternative; products with stable demand could derive income levels maintained over time
PES schemes – hydrological services	Undisturbed forests playing a role in regulation of water flows but threatened by deforestation pressures.  Low opportunity costs for conserving forests because most feature slash and burn agriculture and subsequent extensive cattle ranching	Areas of conserved forest large enough to influence river flows during critical climatic periods.	Lack of capacity to pay by the ES beneficiaries	Forest land with low potential for intensive and profitable production systems  Evidence for reduction of water flows and quality because of deforestation	Low  Potential beneficiaries in the Andes may be poor communities, but the amount of current payments help maintain rather than increase incomes.  To increase income: payments higher than opportunity costs and wealthier ES beneficiaries able to provide higher and stable payments

#### ***4.4. Potential of ES management options to reduce poverty and increase environmental sustainability***

After revising these selected cases some thoughts have arisen about the potential of MO to reduce poverty and improve ES. Some of them are derived directly from the results obtained from the case studies' analysis. Some other are exposed here as additional ideas that could be considered as options to boost the management of ES for poverty reduction and prevention.

##### ***4.4.1. The reviewed management options do not solve the economic deficiencies of current production alternatives in the Amazon***

Current production activities in the Amazon bear little potential to generate surpluses and meet short-term needs of the poor. MO, such as forest management certification, extractive reserves and carbon trade, generate benefits related to land tenure, organizational capacity of communities, and local empowerment. Although these types of benefits are important for communities, most of them will be truly an advantage if more favourable conditions are negotiated to capture economic benefits.

Management options such as forest and coffee certification try to open up new market niches for the respective products, which could result in greater immediate benefits for farmers. However, this strategy is not being applied for other Amazonian products.

Most of the studied projects reflect the environmental goals of project promoters rather than on structural or market strategies in trying to benefit poor communities. MO then failed after initial successes based on high investment levels (e.g., coconut fibre production for automotive industry).

##### ***4.4.2. Existing MO do not increase environmental competitiveness of the Amazon***

Most of the management options are applicable to a broad range of ecosystems (except for, maybe, the extractive reserves, which depend on specific resources). Forest management certification, fair trade mechanisms, carbon credits trading, and PES are applicable to other locations. In the Amazon, these MO need to be able to compete with other areas. Due to low poverty densities in rural areas, one might argue, the Amazon is at a competitive disadvantage where investments seek welfare gains. The competitive advantage clearly lies in providing global ES at low costs. The multiplier effect of increasing income (in this case while improving ES) is greater in the non-Amazon areas of Colombia, Ecuador, Peru, Brazil, Bolivia, and Venezuela than in the Amazon given higher population densities and because several ES could be maintained while increasing agricultural productivity. Most, not all MO, are more competitive where energy, fertilizers, and transport are more easily available compared to the Amazon.

##### ***4.4.3. The link between production of ecosystem goods and their commercialization provide few comparative advantages to the Amazon***

Sustainable productive alternatives in the Amazon are also implemented elsewhere using similar management practices, but providing higher productivity levels--e.g., as is the case with rubber, passion fruit, cacao, and peach palm. This comparative disadvantage of the Amazon reduces the potential for sustainable exploitation of ecosystem goods and for benefiting the poor. Few other goods with real market options and with low probability of being massively produced in other

ecosystems have been identified for the Amazon. The (so far) successful case of marketing açai (*Euterpe oleracea*) products in the United States and Japan is perhaps the best known exception.

#### *4.4.4. Success of MO in achieving poverty objectives depends on the context in which they are developed*

Benefits of conservation projects depend on number of beneficiaries, project area, and opportunity costs among others. Payments for avoided deforestation could be low for a mature forest at equilibrium. To be profitable, investments to avoid leakages should be low as well. This means that projects select areas where communities have few incentives to intervene in the forest (i.e., areas with low quality of soils, few commercial trees, and poor road access). This reduces chances of implementing avoided deforestation projects in populated areas and in communities that lack alternatives to substitute their current forest-based activities. In other cases, projects may out-compete timber companies previously generating employment. This poses real risks to local communities; and therefore requires higher investments in new productive alternatives. In these cases, the net effect on poverty may be zero as a substitution rather than improvement of income is provided.

#### *4.4.5. Effects of Amazon deforestation on global climate could be the only externality that justifies compensations or payments for conservation*

Global environmental services derived from the Amazon related to global climate may be the only externality that can justify high investment in the region. This externality could help mobilize resources from the global community; but would require stronger scientific evidence regarding the relationship between deforestation rates and the magnitude of the impact on climate change. Externalities such as water regulation and biodiversity less clearly affect society, but still might be worth enough to motivate local PES schemes.

#### *4.4.6. The transitional zone between Andes and Amazon and the areas of influence of the largest urban centres in the region are well-positioned to derive benefits from ES provision for the poor*

The size of the Andean - Amazon region makes sustainable regional development very difficult. The foothills or transitional zone between the Andes and the Amazon (piedmont or *ceja de selva*) is an ES priority as it provides and receives substantial environmental services downstream and upstream, respectively. Few efforts focus on the area, although the region features more fertile soils, market proximity, and technological options than many others. Sustainable and productive alternatives could provide economic benefits to farmers, ES to downstream beneficiaries, and could absorb the labour force of migratory populations. Such development would stem further movement to the lower Amazon such that compensation for environmental services could be negotiated. Surpluses generated could be transferred back to the Andes to compensate for ES that benefit the transitional zone such as the regulation of river flows. Thus the production of economic benefits could match the environmental ones, optimizing land use benefits and making profitable alternatives for providing ES. Other well-positioned zones are the areas of influence of the larger urban centres in the region. The cities of Manaus, Belém and Santarém in Brazil, Iquitos and Pucallpa in Peru, or Santa Cruz in Bolivia, with their increasing problems associated to the impact of unbalanced urbanization in ES, would greatly benefit from concentrated efforts to enhance the provision of services that benefit the urban and peri-urban poor.

**Key research issues and questions to be addressed by ESPA: Lessons learned from case studies**

1. Improve impact monitoring (ES and poverty indicators, such as those used in this and the previous chapter) in projects and programmes that address poverty and environment linkages
2. Build on the lessons learned set out in this chapter to derive critical conditions for the success and failure of interventions. Ecotourism and certification are promising options, where are they feasible and where not?
3. Develop new indicators that capture ecosystem services provision at temporal and spatial scales relevant for management, which may differ depending on management contexts and objectives.
4. Developing methodologies to estimate (both ex-ante and ex-post) total implementation costs, which may require cost monitoring frameworks especially in the case of large-scale government programs
5. Define criteria for replicability in differing socio-cultural and political contexts.

## **5. Ecosystem services research, training, and policy needs in the Andes-Amazon region**

The situation analysis assessed research, training and policy needs in Brazil, Bolivia, Colombia, Ecuador, Peru and Venezuela. Consultation meetings were convened in each country with relevant stakeholders (November-December 2007); and inter-institutional committees were established. In September 2007, the ESPA-AA team has created a web-site, for the posting of project documents and relevant information related to the situation analysis: [www.ecosystemsandpoverty.org](http://www.ecosystemsandpoverty.org). The web-site received more than 4,000 visits during the September-April period. Surveys posted on the internet and handled to workshop participants were used to determine perceptions of stakeholders regarding relationships between ecosystem services and poverty alleviation. Secondary information was reviewed in books, journals, policy papers, and web pages.

Preliminary results were presented to stakeholders from the six countries during two regional workshops (for the Andes and for the Amazon) (January-February 2008). Workshop reports and report of consultations in the six countries can be assessed at <http://www.ecosystemsandpoverty.org/index.php/latest-results/>. Feedback provided by stakeholders allowed for adjustments throughout the project. This chapter includes: (5.1) results of the electronic and personal surveys, (5.2) ecosystem services and well-being research needs, (5.3) training needs, and (5.4) analysis and comparison of policies in the Andes-Amazon region dealing with ecosystem services and their relationship to well-being.

### **5.1. Stakeholder survey**

The electronic survey (administered through: [www.ecosystemsandpoverty.org](http://www.ecosystemsandpoverty.org)) sought information on four topics: a) conceptual approaches regarding relationships between selected ES and well-being, b) best management options for ES in the region, c) research and training needs and the most suitable institutions and stakeholders in the region, and d) policies that support poverty alleviation through ES management. Of the responses, half came from Brazil and half came from Peru, Colombia, and Ecuador.

Questions that involved the prioritization of ES and their contribution to the welfare of local communities did not reveal clear preferences (Table 5.1). A larger sample would be necessary to distinguish between stakeholder groups and their contexts, which quite likely would have resulted in a more conclusive picture. Stakeholders specially emphasized the importance of hydrological services as well as soil quality and services related to genetic diversity. It became clear that ES with local benefits (e.g. forest products and water quality) bear most potential to improve well-being through direct uses. Nevertheless, stakeholders also recognized the potential to improve local well-being through mechanisms that internalize the global value of ES, such as carbon retention and fixation or biodiversity existence values.

The survey exercise clearly showed that the ES categories used by the MEA may appear intuitive for descriptive purposes, but do rather not come in handy as a conceptual basis for empirical studies. ES need to be much better defined to avoid double counting of service contribution (e.g., interdependencies between genetic diversity and forest products and pest control), clear distinctions need to be made between internal (local) and external (global) benefits when discussing ES benefits with stakeholders. Moreover, ES assessments need to be context specific, as they are valued differently depending on livelihood strategies.

Table 5.1 Stakeholder perceptions ES and their contribution to well-being at local and global scale

ES category	Local well-being contribution*	Global well-being contribution*
<b>Water regulation (quantity and quality)</b>	2	1
<b>Forest products</b>	1	5
<b>Genetic diversity</b>	3	4
<b>Local and regional weather regulation</b>	5	3
<b>Carbon fixation and storage</b>	8	2
Soil quality	4	8
Scenic beauty	9	6
Cultural services	7	9
Pollination	6	11
Disasters' prevention	10	7
Pest control	11	10

\*1 highest, 11 lowest priority

Somewhat similar conclusions can be drawn from our attempt to elicit opinions about the usefulness of a variety of poverty measures in the Andes/Amazon context. Stakeholders revealed a preference for nutrition and health related indicators and judged standard poverty measures, such as the poverty-line approach or the dollar-a-day measure least useful. It might well be that this (over-) emphasis on nutrition and health is due to the fact that these dimensions are generally omitted from standard measures; hence, the general approval of the human development index as an integrated poverty measure, albeit without environmental dimensions.

Stakeholders showed a clear preference for payment-based approaches to ES management, such as PES, as promising MO for the Andes/Amazon (Table 5.2). At the same time they emphasized community based management solutions and approved the conventional approach of establishing protected areas.

Table 5.2 Stakeholder perceptions: Promising MO to address ES problems in the Andes/Amazon

MO type	Local well-being contribution*
Payments for ecosystem services	1
Traditional and community management	2
Protected areas	3
Sustainable productive systems	4
Environmental education	5
Improving governance	6
Forest (use) management	7
Ecotourism	8
Territorial planning	9

\*1 highest, 9 lowest priority

As main barriers to the introduction of more innovative MO, stakeholders mentioned policy and methodological barriers as well as training needs. Cultural barriers were judged of rather minor importance.

In general, the electronic survey results are not inconsistent with findings in Chapters 2, 3 and 4. They confirm the importance of locally valued and poverty relevant ES, such as water quality and biodiversity related services (e.g. forest products). These are, in fact, the ES to which traditional livelihood strategies are most adapted and that, therefore, represent a priority for interventions that aim at maintaining local well-being through local ES conservation. However, stakeholders do recognize the opportunities that stem from the global ES that the Andes/Amazon ecosystems provide, arguably, at a comparative advantage. Nevertheless, stakeholders are aware of the barriers that need to be overcome to convert these global ES into income for marginalized populations in the region. As the following sections indicate, at least the methodological and capacity related dimensions of these barriers clearly represent entry points for the ESPA programme.

## ***5.2. Ecosystem services and well-being research needs***

Both in the electronic survey and in consultation meetings, stakeholders identified key knowledge gaps regarding ES management in the following fields: hydrology, meteorology, and general ecosystem functioning; local perceptions of well-being and ES, and socioeconomic as well as cultural factors affecting ES use and modification. These gaps were similar across countries. A strategy to address research gaps must acknowledge the specific potential and importance of each ES in a country or region. For example, even though water services were identified as key throughout the region, water quantity is the main need in the Andes; while water quality is the priority in the Amazon. Therefore, research in the Andes should focus on understanding the potential of ecosystems to provide and regulate the amount of water; while research in the Amazon needs to examine the role of ecosystems and vegetation cover on water purification. The latter involves research not only on the dynamics of demand and supply of ES, but also on ES independent market forces and failures that affect ES through externalities.

Table 5.3 presents research priorities identified for each ecosystem service or main research subject and potential responses for the ESPA program (see potential institutional partners in Annex 10). For research needs associated with specific ecosystem services, information needs for decision making are emphasized (hydrology, productivity, carbon stocking rates). Monitoring protocols using standardized methodologies are needed for all services considered. Such protocols require cooperation among organizations such as the ones participating in the ESPA Program.

*Table 5.3 Information gaps, research needs, and proposed solutions (source: ESPA electronic survey and national and regional consultations).*

<b>Ecosystem Service / Research Subject</b>	<b>Research Priorities</b>	<b>ESPA Program Potential Actions</b>
Water services	Basic hydrological information (evaporation, precipitation, flows)	Develop a regional network of experts and institutions to gather basic information through standardized methodologies (to include a regional database)
	Monitoring protocols	
	Relationships among different types of ecosystems and their capacity to store and produce water	Develop a program to assess the capacity of natural and transformed ecosystems to store, regulate and clean water in the Andes - Amazon region.
	Relationships among different types of ecosystems and their capacity to improve water quality	
	Restoration and sustainable management options methodologies	Develop standardized methodologies for management options that contribute to poverty alleviation (PES, community ecosystem management and protected areas)
	Determination of the impact of climate change on water services	Develop a program to assess the effects of climate change on natural and transformed ecosystems and their capacity to store, regulate and purify water in the Andean - Amazon region.
Soil Services	Basic edaphic research on Andean - Amazon region	Develop and consolidate a regional network of experts and institutions that gather basic information through standardized methodologies (include regional data base).
	Monitoring protocols	
	Land use changes and their relation to productivity and water regulation assessment	Develop a program to determine the impact of land use changes on soil productivity and provision of other services in the Andean-Amazon region.
	Soil restoration and management methodologies	Develop standardized methods for management options that contribute to poverty alleviation and were identified for the region (PES, community ecosystems management and protected areas)
	Productive systems optimization protocols	Develop standardized methods that minimize negative impacts and improve provision of ES by production systems.
Climate regulation services	Assessment of C stocking rates of native vegetation	Develop a program to assess the capacity of natural and transformed ecosystems to store and fix carbon in the Andes-Amazon region.
	Amount of carbon stored in vegetation, soil and water.	
	Methane and other carbon equivalent compounds estimations in water bodies.	Develop a program to determine the capacity of Andes-Amazon water bodies to regulate emissions of methane due to organic matter decomposition.
	Development of fair and equitable mechanisms to recognize carbon sequestration.	Develop a program to evaluate the fairness of carbon projects and to formulate strategies to improve the welfare of the vulnerable and poor.

Ecosystem Service / Research Subject	Research Priorities	ESPA Program Potential Actions
	Amazon dieback: developing a framework for assessing likelihood, and potential impacts for local people, biodiversity and global climate.	Taking on the recommendations of the Oxford 2007 Conference through scenarios analyses based on collaboration with LBA project and additional work with local stakeholders to assess the likelihood of the dieback scenarios, the causal processes and the potential implications for the Amazon and beyond.
	Monitoring protocols	Develop and consolidate a regional network of experts and institutions that gather basic information through standardized methodologies.
Ecosystem Products (Goods)	Sustainable use protocols	Consolidate a network of experts and institutions to gather basic information using standardized methodologies.
	Monitoring protocols	Consolidate the biotrade and <i>Bolsa Amazonia</i> programs, focusing on implementation of biotechnology as a key factor to add value to Andean-Amazon products.
	Biotechnology implementation	
	Generation of added value for products obtained from the ecosystems.	Consolidate a network of experts and institutions to advance development of biodiversity inventories in areas of high risk of transformation. (including a regional database)
Flora and fauna inventories		
Biodiversity services	Traditional uses and techniques assessment	Develop a program to assess cultural knowledge concerning management and conservation of ES in the Andes-Amazon region.
	Restoration methodologies	Implement pilot studies to standardize methodologies of natural restoration to improve the provision of biodiversity services.
	Evaluation of impacts on biodiversity use	Consolidate a network of experts and institutions to gather basic information using standardized methodologies (including a regional database).
Social and Poverty Issues	How ES and well-being are perceived by different types of local communities	Facilitate a program to develop poverty indicators based on local perceptions of well-being and ES.
	Poverty indicators needed to account for Andean-Amazonian conditions	
	Evaluate the vulnerability of communities on ES depletion	Implement pilot studies to determine the contribution of ES to consumption and well-being of local communities in Andean-Amazon region.
	Determine the contribution of ES to self-consumption	
	Collective action, associative arrangements and life plans	Strengthen collective arrangements for natural resource management based on community life plans.
Market Issues	ES valuation	Develop a program to standardize economic valuation of ES in the region.
	Value chains	Consolidate biotrade and <i>Bolsa Amazonia</i>

Ecosystem Service / Research Subject	Research Priorities	ESPA Program Potential Actions
	Added value of ecosystem products	programs, focusing on biotechnology as a key to generate added value to Andean-Amazon products obtained from natural resources.
	Market surveys and tendencies	Identify trends in ES consumption or use to establish the demand tendencies and the potential to generate markets for ES.
	ES market creation	Develop a regional PES program focusing on priority ES (water quantity and quality, soil services and ecosystems products)

Two questions recurred throughout the enquiry. First, the scales at which different ecosystems provide benefits to humans; and, second, how ES provision changes as ecosystems are transformed (see also Chapter 3 for a discussion). Programs need to be able to measure the capacity of Andes/Amazon ecosystems to provide services and to identify intervention mechanisms that favour maintenance or enhanced ES provision.

The survey and national and regional consultations also emphasized the need to: a) consider traditional knowledge of natural resource use (e.g., build an inventory of traditional management practices through participatory mechanisms), and b) examine the influence of market forces on the provision of ecosystem services. The latter involves research not only on the dynamics of demand and supply of ES, but also on ES independent market forces and failures that affect ES through externalities.

### *5.2.1. Proposed agenda for the ESPA Program to address research needs*

Here we consolidate the identified research gaps in five program components, with the objective of advancing the understanding of ways that ES can benefit vulnerable and poor populations in the Andes/Amazon. The components of this agenda are presented next. Chapter 6 proposes key sites and contexts where advances in each component are likely to bear potential to scale up results.

- Identification, characterization, definition, and valuation of ES provided by natural and transformed ecosystems in the Andes/Amazon.
- Especially for difficult to value ES, assessment of the multiple contributions of ES to well-being of vulnerable and poor populations in the Andes-Amazon region.
- Development and/or adaptation of MO and intervention strategies in natural and transformed ecosystems. Focus on maintaining and enhancing ES benefits for vulnerable and poor populations and integration with national/regional economic development objectives and related tradeoffs and synergies.
- Development and support of pilot studies that establish the key relationships between ES and well-being.
- Mechanisms to strengthen institutions related to ES and poverty alleviation in the Andes/Amazon

### **5.3. Ecosystem services and well-being training needs**

Training and capacity building needs to focus on strengthening primarily local government

structures and the institutional environment (NGOs, civil society organizations and the local and regional education sectors) involved in making MO work. Stakeholders identified key issues during the national and regional workshops. In order of importance, these are:

- Building awareness of ES – well-being interrelationships and the role of humans in modifying them.
- Mainstreaming the inclusion of traditional knowledge in the development of new technologies for resource use and transformation.
- Disseminating skills and methods for monitoring and documenting ES – well-being relationships (e.g. use of open source software and data base management, training in valuation methods).
- Mainstreaming ES – well-being relationships in ecological and economic zoning approaches.
- Improving environmental fundraising capacity of local institutions (focus on new opportunities at national and international level, such as PES).
- Disseminating best-practices in ES management (promoting exchange and dialogue among stakeholders in similar contexts).

In addition, stakeholders identified information needs for each selected ecosystem service. For hydrologic services, programs to increase capacity of stakeholders in integrated watershed management and to identify and assess the impacts of climate change are needed. Information needs regarding soil quality are related to methods of assessment, measurement, and soil quality management approaches. For climate change mitigation, capacity building of local stakeholders to participate in carbon markets and other modalities are required. Finally, strengthened capacity of local stakeholders to participate in markets of forest products, negotiate resource access, and protection of traditional knowledge are needed.

Stakeholders emphasized the need for training programs tailored to regional priorities that integrate ecosystem services with improvement of local well-being (Annex 11 shows training organisations). It was recognized that existing programs and initiatives rarely provide an integrated view of environmental and economic issues, provide little follow up and dissemination and are deficient of trained personnel, funding and infrastructure.

A key limitation was lack of funds. It was deemed urgent to further involve the following donor and cooperation agencies: multilateral (IDB, World Bank, UNESCO, UNDP, GEF, FAO); bilateral (European Union, DFID, GTZ, USAID, AECI); regional organizations (ACTO, Andean Community of Nations, IICA); private sector (oil companies); private foundations (e.g., the BBVA, Moore, Ford, MacArthur, and Gates foundations); global NGOs (WWF--Russell Train Scholarship, IUCN, CI, TNC), national, regional and local governments, and universities and research centres based in the region and abroad. These organisations are currently involved in different programmes with training and capacity building components that could represent entry points for an ESPA capacity building strategy.

During the national and regional workshops, participants identified a number of activities that can be carried out to develop the proposed training and capacity building agenda (Table 5.4) and the key institutions that are potential sources of support for such activities (see also Annex 11).

*Table 5.4 Activities and institutions identified as having potential to increase the capacity of local and regional stakeholders.*

Activity	Key institutions considered by stakeholders
<ul style="list-style-type: none"> <li>▪ Stakeholder consultations</li> <li>▪ Promoting networks among existing training and capacity building programs and projects</li> <li>▪ Extract lessons learned from these programs</li> <li>▪ Building networks among organizations that execute training and capacity-building</li> <li>▪ Multi-disciplinary definition of specific training and capacity-building needs</li> <li>▪ Basic education and media involvement</li> </ul>	<p><b>Regional Level:</b></p> <ul style="list-style-type: none"> <li>▪ National or regional NGOs in collaboration with local governments, with support from international NGOs</li> <li>▪ Research organizations, consortia and programs</li> <li>▪ Regional government level organizations</li> </ul> <p><b>National Level:</b></p> <ul style="list-style-type: none"> <li>▪ National NGOs in collaboration with local governments, with support from international NGOs</li> <li>▪ Governments</li> <li>▪ Universities</li> </ul>

Based on the above, the following actions are considered as priorities for the ESPA Program:

- Help identify the information needs and support involvement of different stakeholders in training and capacity building programs related to ES and well-being.
- Establish mechanisms to link to existing national and international programs, e.g. in technical cooperation agencies, universities, research centres, NGOs, etc., in order to include ES and well-being issues in research, training and capacity building programs in the region.
- Implement training and build capacity in the area of ES and well-being.
- Develop ways to share experiences and lessons learned, reduce weaknesses, and maximize strengths of existing programs across national boundaries.
- Increase awareness among local stakeholders (governments, communities, etc.) of the relevance of implementing training and capacity building programs in the area of ES and well-being.
- Increase awareness of governments regarding the importance of these programs in the making of social, educational, and environmental policies

#### **5.4. Policies dealing with Ecosystem Services and their relationships to well-being**

Major drivers affecting the Andean-Amazonian environments result in deforestation and, hence, carbon emissions and biodiversity loss. On the other hand, growing international demand for non timber forest products and for ecosystem services such as carbon and hydrological services offers new opportunities for both environmental sustainability and improvement of the well-being of local populations. Several governments have therefore developed policies to reduce deforestation.

Environmental strategies and action plans seeking sustainable development have been developed at the national level within the Andes-Amazon region. All the Andean-Amazonian countries have ratified multilateral environmental agreements acknowledging and promoting the conservation of

ecosystem services. The Convention on Biological Diversity (CBD) includes an ecosystem-based approach in its policy and legal framework. The approach stresses the need to protect ecosystem services, establish protected areas, and design incentives that protect provision of these services. The United Nations Framework Convention on Climatic Change (UNFCCC) and the Kyoto Protocol acknowledge the importance of forests for climate change mitigation. The United Nations Convention to Combat Desertification (UNCCD) stresses soil protecting forest services. The RAMSAR Convention on Wetlands assessed the role of wetlands in the regulation of water services, and builds on the recommendations of the MEA (Resolution IX.1). RAMSAR encourages signatory countries to designate areas for inclusion in a list of globally relevant wetlands.

Based on secondary sources, we reviewed the approaches taken by Andes/Amazon countries to implement these environmental agreements. We also evaluated policies and legal instruments in terms of how they seek fair distribution of the benefits and the mechanisms proposed for attaining their objectives. Information is provided in Annex 12 on legislation and respective relationships with the ecosystem services.

#### *5.4.1. Results*

Delegates to the Climate Convention meetings in Bali recognized the “urgent need” to reduce emissions from deforestation. They launched the adaptation fund, a “mechanism that shall finance concrete adaptation projects and programmes that are country driven and are based on the needs, views and priorities of eligible parties”. This mechanism provides substantial opportunities.

At regional level, the Regional Strategy for Biodiversity of the Andean Community of Nations (CAN) acknowledges the role of traditional communities in maintaining biodiversity. The Amazon Cooperation Treaty Organization (ACTO) seeks to unite the efforts of its member countries in promoting development of the Amazonian region in a way that guarantees an equal distribution of the benefits derived from the sustainable use of the natural resources and the improvement in the well-being of its inhabitants.

Regarding forest products, the Bolsa Amazonia program (created in 1998 by the BIOTRADE initiative of the United Nations Conference on Trade and Development--UNCTAD) promotes value chain initiatives that contribute to the sustainable use of the biodiversity of the Amazonian region. In 2002, CAN in collaboration with the Andean Development Corporation (CAF) and UNCTAD developed the Andean Program of Biotrade. Colombia pioneered a National Program for Sustainable Biotrade that promotes collection, production, processing, and commerce of goods and services derived from native biodiversity, under parameters of environmental, social, and economic sustainability. Peru, Bolivia, Ecuador and Venezuela have implemented similar programs with the support of UNCTAD.

Progress is being made regarding the design and establishment of policies for compensating and paying for environmental services. The Public Policy for the Acknowledgment of Forest Ecosystem Services of the Department of Santa Cruz, Bolivia (established in 2007) attempts to financially compensate owners of forest areas who provide such services. In 2003, Brazil’s federal government created the Socio-Environmental Development Program for Smallholder Production, (PROAMBIENTE) which considers the concept of bundling of environmental services provided by smallholders. PROAMBIENTE evolved from social movements that sought to reconcile productive and conservation activities. Now managed by the Department of Policies for Sustainable Development of the Brazilian Ministry of the Environment, the program provides financial incentives for investing in sustainable production systems that also provide ecosystem services. To be eligible for incentives, producers must conserve biodiversity, soils, and water resources; and must reduce

deforestation and the use of fire. Since 2007, Colombia is developing a National Strategy for Payment of Ecosystems Services.

The Program for Protected Areas of the Amazon Region (ARPA) was created in 2003 by the Federal Government of Brazil and coordinated by the Ministry of the Environment. The program has created 41 protected areas covering 22.5 million hectares. ARPA represents a new conservation approach relying on new legal, institutional, and economic mechanisms for the financial sustainability of the system.

These initiatives highlight the need to protect ecosystems and their services, at different scales through different mechanisms. In the next section, we present conclusions regarding policies on biodiversity and protected areas, forests and water resources. Discussed are ecosystem services covered by the policy; the connection between these services and well-being, and the policy mechanisms that try to secure the provision of services (see table in Annex 12). We attempt to show progress being made without drafting an exhaustive list for all countries.

#### *5.4.2. Policies on biodiversity and protected areas, forests and water resources*

##### **5.4.2.1. Biodiversity and protected area policies**

All countries in the Andes/Amazon recognize that protected areas secure the provision of services for economic, social, and environmental development. The Protected Areas Policy of Colombia assesses the role these areas play in the provision of services such as genetic resources, climate control, maintenance of flora and fauna, maintenance of watershed functions, and cultural services such as recreation, education, and scientific opportunities. Policies also acknowledge services by type of protected area: National Recreation Areas in Ecuador are connected to services of scenic beauty. Peruvian Historical Sanctuaries were established to protect cultural services.

Policies have gradually recognized areas populated by indigenous and peasant communities. In Brazil, the 2006 National Strategic Plan for Protected Areas highlights the importance of indigenous lands. The National Parks' Policy of Colombia recognizes the autonomy of indigenous communities. The National Strategy on Biodiversity maintains that communities must have access to land with consolidated rights to guarantee that benefits derived from biodiversity are fairly distributed. Ecuador's National Biodiversity Policy and Strategy (2001-2010) emphasizes the participation of indigenous and Afro-Ecuadorian peoples as well as local communities in the decentralized management of protected areas and ecosystem services

Brazil has noteworthy experiences growing from the enacting of the policies for protected areas, like the extractive reserves created in the Amazonian region. These areas have counteracted the negative effects of policies that fostered conversion of forests into grazing and croplands. The National Environmental Law of 1998 in Brazil grants concessions for sustainable community use and conservation of renewable natural resources. Through the Chico Mendes Bill of 1999, rubber tappers in the state of Acre began to be compensated for their contribution to maintaining the forest by a 20% subsidy added to the price of natural rubber.

Most countries have made progress in their policy instruments and mechanisms. Ecuadorian legislation has developed mechanisms that aid populations dependent on marginal production systems. Brazilian biodiversity legislation (since 2002) compensates for services provided in protected areas by instruments such as the ICMS Ecológico (Ecological Tax on the Circulation of Goods and Services), a fiscal incentive for biodiversity conservation that compensates municipal governments for the loss of potential tax revenue resulting from the creation of protected areas.

#### **5.4.2.2. Forest Policies**

Some national policies acknowledge the importance of forests in the provision of ecosystem services and offer key definitions on the subject. In Ecuador, ecosystem services are defined as, “benefits that the humans directly or indirectly gather from the functions of biodiversity (ecosystems, species and genes), specially ecosystems and native forests and forest plantations...” In the Forest and Wildlife Law of Peru (since 2001), forest ecosystem services are defined as those, “...whose purpose is to protect the soil, water regulation, conservation of biological diversity, conservation of ecosystems and scenic beauty, carbon dioxide absorption and generally the maintenance of essential ecological processes.”

Regarding ecosystem services and well-being, forests, if used sustainably, are acknowledged as prime providers of goods and services. Bolivian forest policy, supported by the Sustainable Forest Management (BOLFOP) project, declared that areas providing Brazil-nuts, gums, and palm hearts, among others, will be preferably granted to traditional users such as peasant associations.

Policies also address territorial zoning, forest management plans, voluntary forest certification, and incentives. In Colombia, state granted economic incentives through the Certificate of Forest Incentive for Reforestation (CIF) reward reforestation by private concessionaires and the positive social and environmental externalities derived. Commercial forestry is not allowed in the Venezuelan state of Amazonas. In Bolivia, market instruments such as forest certification included in the Forest Law of 1996 are being implemented. As a result, more than 2.5 million hectares have been certified, contributing to sustainable forest management.

National policies on climate change have responded to the Convention on Climate Change and the Kyoto Protocol. Colombia in 2002 identified strategies to face climate change, mostly regarding sale of mitigation services, and is currently developing the National Policy on Climate Change. In recent years, the Brazilian government has implemented several measures to reduce deforestation, including the expansion of protected areas, stronger enforcement to control illegal logging, and the introduction of better certification of land ownership. At the Bali 2007 meetings of the UNFCCC, Brazil presented a detailed plan to promote reduced emissions from deforestation (REDD), renewable energy, and clean development mechanisms.

Indigenous lands are undoubtedly an effective management option in terms of slowing down forest clearing and conserving biodiversity in high-deforestation frontier regions. This is the case for Indigenous Communal Land Holding (Tierra Comunitaria de Origen, TCO) in Bolivia, and Native Community Territories (Comunidades Nativas) in Peru. Indigenous lands occupy 20% of the Brazilian Amazon, and are considered the most successful barrier to deforestation. As opposed to parks and other inhabited protected areas, indigenous lands provide livelihood security to communities that would otherwise be extremely vulnerable in their pursuit for social reproduction. Despite increasing contact with the larger society, the example of indigenous lands in the Brazilian Amazon, which present significantly low deforestation rates when compared to areas under protection in parks, attests the effectiveness of the approach in both promoting ecosystem services and enhancing livelihoods.

#### **5.4.2.3. Water Policies**

Policy and legislation regarding water resources consider services derived from aquatic ecosystems and their connection with well-being and poverty reduction. Policies recognize the need to guarantee water quality and equitable access. All countries have formulated policies and regulatory frameworks for water resources, incorporating aspects such as integrated river basin management,

sewage management, and conservation of strategic watersheds.

Countries have developed financial mechanisms to conserve water resources. In Colombia, legislation created instruments such as requiring power companies to pay for protection of rivers and restoration or rehabilitation of water sources. The Brazilian Water Law (Law 9433 of 1997) establishes charges for water use with fees used for watershed and forest conservation. Water conservation is part of National Environmental Legislation in Ecuador. It provides voluntary mechanisms such as the Fund for the Protection of Water (FONAG), a private fund in operation since 2000, which, “uses the profits from its investments to jointly finance [...] rehabilitation, conservation and maintenance of the watersheds, from which the inhabitants of the Metropolitan District of Quito and its area of influence obtain the water they require for all their human and production needs“. Reforestation is highlighted within FONAG through actions such as the ones in Guayllabamba watershed, Pichincha province, where more than 1,300 ha are planted with native species. This watershed supplies most of the drinking water of the Metropolitan District of Quito and its wider area of influence. FONAG also sponsors programs of environmental education and monitoring of water resources in protected areas, and provides training programs in the integrated management of watersheds. Given the positive impact, several municipalities aim to replicate these FONAG-funded programs.

#### **5.4.2.4. Conclusions**

There is now considerable environmental legislation that acknowledges the importance of ecosystem services and their connection to well-being. Needed are strategies that support such policies at different scales and that seek both ecosystem services and improved well-being. The case studies presented in Chapter 4 consider management options, relationships with national, local and regional policies, and the improvement of the quality of life.

International and national efforts currently favour policies that deal with payment and compensation for ecosystem services. Yet, a great deal of efforts is still needed to consolidate this approach. Consolidation can be promoted through opportunities such as the creation of small funds easily accessible to support conservation units such as protected areas to achieve the RAMSAR status because of the services provided. Stakeholders in the present study stressed the importance of guidelines for such payments at a regional scale. Organizations such as ACTO and CAN might become a platform for integrating and harmonizing initiatives on ecosystem services and well-being in the Andes-Amazon region.

There is an opportunity for institutions such as NERC, DFID, and ESRC to promote and develop mechanisms that contribute to reduced climate change and promote equitable access to resources by local communities. In the Amazon, REDD projects such as the Bolsa Floresta promoted by the Brazilian state of Amazonas could facilitate maintenance and conservation of endangered ecosystems. The Andean region presents opportunities to support projects under the Clean Development Mechanism (CDM). Those opportunities will be influenced by ecological and institutional factors such as the nature and objectives of the PES mechanisms and the type of ecosystems services provided in each region. Maintenance of the existing carbon stocks in the Amazon through REDD projects could facilitate maintenance and conservation of endangered ecosystems and will help to reduce carbon emissions due to deforestation. In the Andean region, reforestation projects under the CDM will constitute the main sources of payment mechanisms for greenhouse gases' capture service.

PES and REDD will not work everywhere. Especially where the opportunity costs of conservation are extremely high (e.g., high value timber or soybean production) it is unlikely that payments can be offered to compensate for the foregone benefits of forest conversion. Moreover, lacking tenure

information and insecure property rights will limit direct payments to areas where such minimum conditions cannot be guaranteed. The establishment of protected areas, such as extractive reserves and indigenous lands may be a solution where pressure on forests is low and/or where control and enforcement are efficient. In high pressure areas, where forest conversion is highly profitable, solutions may lie in low impact technological innovations, certification schemes and environmental regulation. As mentioned in Chapter 3, research is needed that further establishes the conditions under which particular policies and their MO components are likely to work best and, on the basis of this, identifies priority intervention sites for pilot experiences.

**Key issues to be addressed by ESPA: Stakeholder opinions and policy review**

1. Widespread multi-stakeholder participation at all stages of policy research and follow up.
2. Emphasis on ES relevant to local communities considering traditional knowledge.
3. Definition and measurement of ES and well-being based on local level considerations.
4. Analysis of spatial and temporal dimensions of ES provision.
5. Establishment of stakeholder specific baselines and indicators as part of the monitoring of ES and impacts on well-being.
6. Incorporation of lessons learned from ongoing studies regarding ES in the design of new research and capacity-building initiatives.
7. Inclusion of relevant ecosystem services not encompassed in the legal frameworks of the Andean-Amazonian region (e.g., pollination and pest control services).
8. Promote training and capacity building in ecosystem services and well-being while strengthening already existing programs and local, national, and international initiatives.
9. Promote the restoration of degraded ecosystems in order to improve the provision of basic ES for poor or vulnerable communities.
10. Regional-level analysis of impacts of policies and related management options on ES provision and well-being under changing economic and environmental conditions (scenario analysis).

## 6. Conclusions and recommendations

The starting point of this situation analysis was that for the Andes/Amazon (albeit more so for the Amazon), levels of ES are high and poverty low compared to other study areas of the ESPA Program such as sub-Saharan Africa and South and SE Asia. Chapter 2 confirmed this, but showed where and to what extent important local and global ES are threatened. Chapters 4 and 5 made a case for the potential of cultural ES (not measured in Chapter 2 due to limitations in data availability) to contribute to poverty alleviation and prevention, especially in the Andes. In general, ES with local direct use values (e.g., forest products, water quantity/quality, local climate regulation, soil productivity and fish resources) are most important for the well-being of the poor. With some exceptions, the urban poor are less directly dependent on these ES, but they might be affected, through value chain effects, if ES such as soil and water quality, deteriorate. The Andes/Amazon region is rich in globally valued ES (e.g., carbon retention in forests, and biodiversity related ES) and probably at a comparative advantage in providing these at low costs. However, until today, this has resulted in very few tangible benefits for small-scale producers and traditional/indigenous inhabitants, many of which belong to the rural low-income groups. Clearly, part of the reason lies in the unequal distribution of the land that provides both global and locally valued ES and in the lack of well-defined land-tenure, a frequent requirement for indirect benefits of global ES to be channeled to local ES modifiers. That said, this situation analysis indicates considerable scope for improving the way ES are managed (see Chapters 3 and 4), which represents a strategic entry point for the ESPA program in the Andes/Amazon.

An important result of this situation analysis is that resource and ES abundance do not necessarily mean that the poor are less vulnerable to changes in ES provision. In fact, the opposite has been the case where rural livelihoods heavily dependent on natural resources are dispossessed of this natural capital due to encroachment and unequal power relations, being expelled from their lands or forced to re-adapt to conditions of significantly lower resource availability. The struggle of these social groups can be aggravated by rapid changes in local ES provision, e.g., through accidental forest fires, large-scale deforestation, building of hydroelectric dams, irregular floods, and climate change induced droughts. ES dependent traditional populations are hit more than others by these events, as repeatedly attested by violent conflicts in the Andes/Amazon.

Another relevant distinction between the Andes/Amazon and the other ESPA study areas is the relatively strong level of social organization and grassroots participation in policy processes, including environmental policy. As a consequence, our research and capacity-building recommendations for the Andes/Amazon region emphasize investments in human and social capital for the *prevention* of ES degradation. To prevent and reduce poverty, such investments need to secure and reinforce natural resource access for those whose livelihoods traditionally depend on it. The challenge is that both poor and wealthier colonists (less than many traditional indigenous cultures) along the region's agricultural frontiers can and do have dramatic impact on ES provided from this globally important ecoregion. Roads, chain-saws, and slash-and-burn agriculture have been combined to initiate the process of deforestation and land use change - a process that often results in degraded pastures, concentration of wealth, and social marginalization in both rural and urban environments. Nonetheless, cases of successful sustainable resource management exist, that need to be better understood, strengthened, and scaled out.

The overall question remains: How to work with all stakeholders, particularly the poor and vulnerable communities, such that interventions enhance well-being without destroying valuable ecosystem services and the ability of ecosystems to provide such services?

Perhaps fortunately, the region as a whole features a high proportion of urban peoples, growing middle classes, and the continued expansion of a civil society that pushes towards the enforcement of fully developed citizenship rights. Hence, some of the poor may benefit more from the positive effects of globalization and social policies than through local level exploitation of environmental services. However, historical developments in the region suggest that many will not. Part of the answer to the above question, thus, is to better understand the functioning of the ecosystems and their services, and the complex and context specific livelihood strategies of the poor. This is needed in order to test and identify proper ways to introduce viable management options and integrate them in a sensible policy framework in a cost-effective manner. Often this will involve taking advantage of markets, and when appropriate, working in public-private partnerships.

Various forms of this answer have been around for some time, and this report includes recommendations that are meant to increase their effectiveness and impact. Yet, success in alleviating poverty and in reducing the impacts of the poor on their environment has been difficult to achieve. There is a continued need to better understand the Andes/Amazon ecosystems, the nature and expressions of poverty and livelihood strategies of the poor, and their inordinate environmental impacts. Equally relevant is to comparatively assess the convoluted processes associated with unequal power relations that have often resulted in economic stratification and social differentiation across the region. Local nuances encompass, among others, ethnicity, religion, occupation, and gender issues. Many projects and programs have introduced supposedly sound management options. Failures in terms of adoption and impact have followed and have often been dismissed as market failures, “resistance” on the part of the poor, lack of government support or commitment, and the like. Limitations in the understanding of the underlying social dynamics are seldom fully acknowledged as causes of failure.

A partial explanation for the lack of uptake of new technologies and management options is that most such options require intensification of land use. It is, however, critical to examine the extent to which individuals, households, and communities respond to economic and ecological conditions that are intertwined with power relations and political structures. Both actor-centered, and social-structural approaches would agree that intensification is costly and out of reach for most of the poor; certainly more costly than extensive options - whenever the agricultural frontier is not closed.

Few smallholders can rely on safety-nets that would allow to buffer against the risks involved in intensive input-based agriculture in remote forest environments. Well-known, time-tested, but extensive swidden agriculture, therefore, often represents the preferred option even if it implies migrating out into new forest margins after soils are exhausted. Policies to close the agricultural frontier need to establish farmers on already open land. To achieve this, even well designed policies will largely depend on two conditions. First, serious structural reforms need to address land inequality, especially in Brazil. And second, production technologies and management options that are technically feasible, culturally acceptable and economically competitive.

On that basis, policy makers need to establish a feasible balance of incentives and disincentives. Unfortunately, policy-based disincentives (taxation, fines, exclusion) have had a poor track record in the Andes/Amazon, mainly because they are poorly enforced. Fortunately, in the case of the Amazon there is a growing willingness to pay for important global ES (e.g., the existence and option values of biodiversity and the reduction of emissions from deforestation). However, payment mechanisms have yet to be developed that can actually reach poor resource modifiers such that they can and do change practices that compromise ES provision. The Andes, where many payment schemes and compensation mechanisms have emerged in recent years, may provide important lessons learned for the Amazon. Systematic and comparative research is needed to make this happen.

The recommendations for research and capacity building developed in this report seek to find a

balance among scientific approaches and conservation and development strategies to protect local, regional and global ecosystem goods and services and prevent poverty related to their loss. Many management options with potential to achieve these objectives require adjustments in existing policy frameworks. Overall, the recommendations consider the region's predominant features, as follows:

1. Large-scale commercial interests are controlling increasing shares of the region's resources. As a result, large quantities of globally valued ES are lost and traditional populations and poor rural colonists face ever more limited resource access and degrading local ES. Consequently, also urban and peri-urban poverty increases and poses additional challenges to environmental and social policies.
2. At the same time, comparatively low (but growing) numbers of poor rural inhabitants can and often do have considerable negative effects on globally valued ES.
3. Many rural poor have adapted their livelihood strategies to abundant ES and may, therefore, be more vulnerable to abrupt changes in ES provision; a scenario that this report shows is realistic, and therefore threatens the survival and socio-cultural reproduction of indigenous and other traditional cultures.

The body of this document has provided a wealth of recommendations for research and capacity building. Below we have structured these issues and suggest priorities for biophysical, socioeconomic and interdisciplinary research in the ESPA Program. Based on these priorities and stakeholder consultations in the Andes/Amazon, we subsequently sketch out potential research projects with capacity-building components. We further provide hints on how project impact can be optimized.

### **6.1. Priorities for ESPA research and capacity building**

To address its objectives in the Andes/Amazon, the ESPA Program should promote research and strengthen capacities in three priority areas:

1. Understanding and predicting spatial and temporal dynamics of key locally and globally valued ES (especially, forest products and fish resources, local and regional climate regulation, water quality/quantity, and carbon sequestration) with a special focus on:
  - Integrating traditional spatial scales of study (individual sites) to policy relevant regional scales such as the one addressed in this situation analysis. Also taking into account the important implications of geographic and environmental differences throughout the region on the development of *locally adaptive and effective* regional policies. Recognizing the impact of trans-frontier and trans-continental linkages especially for climate and water.
  - Identifying critical thresholds of change in the provision of ES due to human impacts (such as deforestation), climate change, and their interaction, and devising monitoring, prevention, adaptation, and mitigation measures to ensure that significant thresholds that would lead to increased poverty and vulnerability are not crossed through ecosystem mismanagement.
  - Developing and disseminating practical methods to monitor and document local changes in ES provision and spatial-temporal management support systems to identify the agents and processes driving such changes, as well as testing *in silico* preventative policy measures.

2. Understanding, measuring and valuing the contribution of locally important ES to generate well-being among heterogeneous local stakeholder groups, with a special focus on:
  - Developing and testing comparative frameworks to integrate ES-related welfare into region-wide index-based poverty measures.
  - Identifying and mapping location and stakeholder specific vulnerability, based on indicators of the state of ES provision, and threats' assessment.
  - Developing and disseminating methods and tools to forecast natural and policy-induced changes in ES provision and their likely impacts for local well-being, as well as to predict the effect of alternative management options to mitigate such impacts.
  - Establish and institutionalize a regional knowledge management platform on ES and well-being to support prioritization of local and regional policy initiatives through interdisciplinary research for development outputs.
  
3. Promote innovative approaches to reduce the transaction costs and strengthen the incipient implementation of incentive based management options for enhanced ES provision (e.g. certification/ecolabelling, payments for environmental services, ecotourism; as well as other novel MO) and conduct comparative research to extract lessons learned with a special focus on:
  - Globally and locally valued ES which are affected by externalities of local income generating activities.
  - How, where and for whom incentive-based management options need to be combined with enabling management options in order to maximize benefits for the poor.
  - Developing and disseminating decision-frame works and related tools for policy makers to decide where and under what conditions incentive-based management options will work and what can be done if minimum conditions are not in place.

The first area involves primarily biophysical, the second interdisciplinary, and the third primarily socioeconomic and policy research. The research projects sketched out below represent a synthesis of priorities indicated by stakeholders and the key messages of the analytical sections of this report. Projects fall into one or more of the three priority areas. Most, not all, include capacity-building components.

## **ESPA-AA Suggested Project 1**

### **Projects / Goals**

- Identifying minimum conditions for ecosystem stability in the Andes/Amazon

### **Research questions**

- What are the expected impacts of climate change on local water availability and flows in the Andes/Amazon?
- Is forest cover critical to maintaining hydrological stability in the Amazon? If yes, what are the minimum criteria of forest cover (size, location, degree of fragmentation, etc.) to maintain hydrological stability? Is the current protected areas' network sufficient for maintaining ecosystem stability?
- What is the relative importance of climate change and deforestation in promoting Amazon dieback? Under what conditions could dieback be avoided or mitigated given that climate change is inevitable?

### **Location/Approach**

- Regional and trans-frontier research necessarily involving formal scenario analysis and field measurements

### **Impact Pathway**

- ESPA research needs to link into existing initiatives (e.g., LBA, national research programs) and promote regional cooperation and networks.
- Results need to be fed into projects (3, 5) to assess the economic impact of key scenarios and inform policy makers

### **Capacity-building component**

- Ideally this ESPA component provides incentives for regional cooperation. It could generate a critical mass for developing and maintaining open access regional climate and hydrological data bases and thereby enhance the capacity of scientist to take regional instead of national level perspectives.

## **ESPA-AA Suggested Project 2**

### **Projects / Goals**

- Defining sustainable levels of timber and non-timber forest product extraction and related minimum technological requirements

### **Research questions**

- Given current technology, what are sustainable rates of extraction for important forest products?
- Do extraction technologies differ across stakeholder categories, and if yes, which elements of existing technologies allow for higher rates of extraction without compromising ecosystem functions?
- What are minimum biophysical conditions for non-forest based production systems to coexist with forest product extraction (e.g., fragmentation due to slash-and-burn agriculture and timber extraction)?

### **Location/Approach**

- Selected official indigenous territories and extractive reserves. Other locations needed to be identified in cooperation with project (3). Maps in section 2.7.1.2 may serve as a starting point.

### **Impact Pathway**

- Results are relevant for both policy planners and local or community based resource management initiatives.
- Explicit links to both should be established prior and maintained throughout project implementation.
- Project activities will require building inventories of forest products, which can be a powerful means of negotiating community support.

### **Capacity-building component**

- Involvement of local decision-makers and extractivist communities is generally seen as a precondition to achieve real ownership (e.g. of inventories and planning methods). Since local and traditional knowledge are key to this project, it can contribute to building capacity among extractivists to integrate technology and traditional knowledge more efficiently.
- Communities will not be able to maintain and expand inventories on their own. Hence capacities for planning and database management need to be developed in local government and non-government organizations as well.

### **ESPA-AA Suggested Project 3**

#### **Projects / Goals**

- Regional assessment of human vulnerability to variability and changes in ES provision

#### **Research questions**

- Which locally valued ES are important for which stakeholder groups and where?
- Which expected changes in local ES provision are relevant for which stakeholder groups, where and when? E.g., how will climate change impact on the water based environmental services, in particular for transport and HEP generation?
- Where, when and for whom will changes in local ES provision imply increased poverty?

#### **Location/Approach**

- Chapter 2 provides important hints mainly on the spatial dimensions of these questions. This project builds on results from projects (1) and (2) and is relevant for both the Andes and the Amazon. High spatial resolution is important especially in the Andes where ES provision is very heterogeneous.

#### **Impact Pathway**

- Changes implying increased poverty are very relevant to policy. To have impact, this project requires links to national and regional decision-makers. Results need to be communicated in accessible language at higher policy levels and form the basis for activities put forward in projects (4,5,6).

#### **Capacity-building component**

- This project is inherently interdisciplinary. Research in the Andes/Amazon has historically been dominated by disciplines. The ESPA Program could provide incentives for national research institutions to link up with international research centers and develop new interdisciplinary and participatory vulnerability mapping tools and related capacities.
- To establish such tools in national research agendas, cooperation with higher education institutions is necessary. Participation of local students (tomorrow's decision-makers) is desirable.

### **ESPA-AA Suggested Project 4**

#### **Projects / Goals**

- Monitoring and forecasting ES provision for policy planning and adaptation to climate change and variability

#### **Research questions**

- Which changes in ES flows can be forecast and how?
- Is forecasting cost-effective and if yes, for which ES and where?
- Is a region-wide nowcasting system for important and poverty-relevant ES a realistic future scenario?

#### **Location/Approach**

- This project builds on the previous and needs to take a regional perspective to satisfyingly answer the research questions. An interdisciplinary approach is necessary to make sure results are policy relevant (question 2).

#### **Impact Pathway**

- The energy and transport sector, especially in the Amazon, but also commercial agriculture can be expected to be willing to pay for forecast information.
- Mechanisms could be developed at relatively low costs to allow for the poor to "free-ride" on improved forecast information (e.g. through local television and radio programs).

#### **Capacity-building component**

- As in the previous project, capacities may be developed in this project by involving higher education institutions in conducting research and tool development.

## **ESPA-AA Suggested Project 5**

### **Projects / Goals**

- Developing and disseminating knowledge, methods and decision tools to evaluate ES / well-being trade-offs of economic and ES-specific policy measures.

### **Research questions**

- How can results from ESPA and related research be better integrated in local, national, and regional decision-making processes?
- Which type of information and knowledge (data, skills, methods) do decision-makers need to better evaluate trade-offs between ES and other development objectives
- How can this information be made available to decision-makers?

### **Location/Approach**

- This project is the logical last step of an impact oriented ESPA approach. Knowledge needs to be managed more efficiently and has to be accessible to both researchers and decision-makers in adequate forms.
- Again, a regional approach is necessary and existing mechanisms to promote the regional policy dialogue (see Chapters 3 and 5) need to be strengthened.

### **Impact Pathway**

- Although decisions are often made on political grounds, better information on ES / well-being relationships can make a difference, if can be used in political negotiation processes. The ESPA program can contribute by providing tools and knowledge for environmental policy makers to quantify the tradeoffs involved in making decisions that compromise ES.

### **Capacity-building component**

- To develop useful decision tools, researchers need to involve decision-makers and make sure they provide useful knowledge.
- It is important to train technical staff in both government and non-government institutions in using decision-tools and knowledge management systems.
- Methods and tools that can successfully be integrated in university curricula are likely to be the preferred choices of future professionals.

## **ESPA-AA Suggested Project 6**

### **Projects / Goals**

- Identifying necessary biophysical, socioeconomic and institutional conditions for pro-poor incentive-based ES management (e.g., conditional cash transfer (PES), certification/ecolabelling, ecotourism, etc.)

### **Research questions**

- Which are the necessary biophysical, socioeconomic, and institutional preconditions for incentive-based ES management options to achieve specific ES objectives in the Andes/Amazon?
- Which global and locally valued ES can realistically be addressed through incentive-based management options?
- Under which conditions are these mechanisms poverty neutral and well-being enhancing?
- How can incentive-based MO be made (e.g., through integration with enablement MO, see Chapter 3) pro-poor?

### **Location/Approach**

- This project addresses key issues for the ESPA Program. It also reflects the current debate on payment based mechanisms, such as Reduced Emissions from Deforestation and Degradation (REDD). The approach should therefore be regional and based on the conceptual basis provided by the literature cited in Chapter 3.

### **Impact Pathway**

- Many incentive-based management options still need to demonstrate that they can work. Promoting pilot experiences is, therefore, considered crucial.
- Many local and national policy-makers are interested in these mechanisms. This momentum should be used to achieve impact.
- Comparative research frameworks are needed to scale up results and make sense of individual experiences, success and failure.

### **Capacity-building component**

- Implementing incentive-based management options requires new and often lacking capacities, especially at local level.
- With incentive-based mechanisms often comes the need for local governments to compete for funds in increasingly decentralized governance systems.
- Apart from communicating results to non-scientists it is, hence, necessary to strengthen institutional and administrative capacities and link local policy-makers to international funding sources.

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