Development and application of methodologies for reduced emissions from deforestation and forest degradation (REDD+) – Phase I

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World Agroforestry Centre

DEPARTMENT OF ENERGY & CLIMATE CHANGE

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Executive Summary

Assessment of available data

1. FAO datasets have, until recently, been the main sources of data on global forest monitoring. At the time of writing, the most recent, FRA2005, examines the current status and recent trends for about 40 variables covering the extent, condition, uses and values of forests and other wooded land based on information collated from 229 countries and territories for three points in time. The next assessment will be FRA 2010 for which a first FAO Global Remote Sensing Survey of Forests (RSS) will complement the national reporting. The expected outputs are forest area change data for 1975-1990, 1990-2000 and 2000-2005.

2. A significant number of raw remotely sensed data images are available to aid with estimation of changes in forest cover, including both static land cover mapping as well as time series data. These are listed and discussed in the report. There is a need for more consistent national scale data sets with confidence intervals specified and critical uncertainties identified in order to help prioritize further efforts

3. A number of databases are now available estimating forest carbon stocks and GHG emissions from land use change and forestry, and are listed and discussed in the report.

4. Monitoring of forest degradation (at national scale degradation is for the purpose of this report taken to be a sustained decrease in national forest C stock) is technically more complex than monitoring major shifts in local forest cover, so that methods for monitoring degradation are not as well established as those for monitoring deforestation. There is ongoing work to refine these techniques to recognize multiple forest-related land cover types varying in actual tree cover, requiring re-study of past images and other data to derive consistent time series.

5. Reducing emissions from deforestation requires consideration of forest degradation and forest management if changes in carbon stocks are to be captured properly and this is one reason for extending the concept of reduced emissions from deforestation (RED) to REDD+, which includes degradation as well as enhancement of carbon stocks. Monitoring should aim to capture all associated changes in carbon stock at the landscape level. Further extensions would be possible to capture interactions between land uses and these would in principle give the greatest consistency in accounting, though the monitoring requirements would be greater. This report focuses on deforestation and forest degradation, though the methods may sometimes be relevant to enhancement. With this understanding, the activities will be referred to as REDD+ throughout.

Drivers of deforestation

6. While global level drivers are undoubtedly important, local conditions, incentives and constraints determine where and why deforestation occurs. Regional differences mostly come from varying mixes of economic, institutional, technological, cultural, and demographic factors underlying the direct causes of deforestation . Understanding these complex feedbacks and local deviations is essential for designing equitable baselines for REDD+.

7. In Asia, the major *direct* deforestation drivers[1] are agricultural expansion (including expansion of cash crops such as rubber and coffee) and logging, with government forest and national development policies, international market demand for forest commodities, and poor governance are among the main underlying factors. Forest fires may be used to open up forest areas for economic activity, or advantage may be taken of naturally occurring fires. There is considerable heterogeneity in forest cover, deforestation rates, and direct and underlying drivers across the whole region.

8. Up until the last two decades, deforestation in Central and South America was mainly due to traditional shifting cattle ranching and cultivation, often driven by government colonisation programs and subsidies. In recent years, however, global demand for agricultural products such as beef and soybean and associated infrastructure development, such as roads, have become the most important drivers. In some countries, timber extraction and mining play a minor role, as does oil exploration in Venezuela, Peru, Bolivia and Ecuador. In some of the less stable states in the region, production of illegal crops such as coca and opium poppies are also significant drivers of deforestation. Since the mid-2000s, however, Brazil has reduced its deforestation rates by more than 50% through the creation of protected areas, parks, and indigenous reserves.

9. Conversion of forests into agricultural land is the main direct cause of deforestation in most African countries, both for subsistence agriculture as well as for cash crops such as sugarcane, coffee, cocoa, maize, and khat. Such land use change is associated with population growth, migration due to war, and structural adjustment policies imposed from externally. Logging is the most important cause of forest degradation. Although selective logging removes only a negligible percentage of trees, it can trigger large scale deforestation through migration which leads to extensive agricultural practices. Demand for fuel-wood is also a significant driver of degradation.

Methodologies for determining national-level baselines

10. Three types of baseline can be distinguished: (a) the *historical baseline*, which is the rate of deforestation and degradation (or the corresponding GHG emissions from these) over a certain time period in the past; (b) the projected *business-as-usual (BAU) baseline*, which is how emissions from deforestation and degradation evolve in the absence of any REDD+ activity, and (c) the *crediting baseline*, which is the level at which REDD+ payments are assumed to start.

11. Existing methodologies for estimating baselines are reviewed for the *project-specific*, *regional*, *country-specific* and *global* levels, and the *compensated successful effort* approach, which attempts to bypass baseline setting by linking carbon finance to efforts rather than to results, is also considered.

12. A quantitative analysis of the factors influencing deforestation rates was attempted. Out of the large numbers of variables considered at the national level, only population density and the % population that is rural were found to give statistically significant predictions.

13. A linear mixed-effects model allowing for nested random effects was used to explore the potential of predicting deforestation rates from these variables. Mixed-effect models make efficient use of data when similar relationships are to be fitted to multiple groups in a data set. The efficiency gain is achieved by postulating the existence of common means with random

[1] Or proximate drivers, according to Geist & Lambin (2002).

perturbations around those means explaining the differences between countries. Many fewer parameters are then required.

14. The data were clustered hierarchically using two sets of variables: (a) the forest set: including information describing the forest status of the considered countries in 2005 according to the FRA dataset, and (b) the complete set: including the forest set and also socio-economics variables such as population density, GDP and growth rate. The clusters did not follow the geographical distribution of the considered countries, especially for that based only on the forest set. Predictions from the model showed a high degree of uncertainty, mostly due to the poor quality and availability of input data. This does not preclude causal understanding of the factors driving deforestation, but it does indicate shortcomings with the data currently available internationally.

REDD+ demonstration projects

15. Given the increase in interest and political will to include REDD+ in a future international climate agreement, many different actors are beginning to increase their REDD+ activity involvement. This study gives an overview of the state of progress on REDD+ activities, as well as exploring the activities associated with these projects, their co-benefits, and the reasons for institutions' regional or national placement of these projects and activities.

16. A bottom-up analysis of national REDD+ readiness activities and REDD+ projects was conducted The list of activities and projects was compiled from the literature, online databases of forest carbon projects, project websites, and interviews with REDD+-engaged individuals.

17. In examining the spread of these 117 REDD+ activities across the globe, the Amazon region appears to have the most projects and national readiness activities with 30 and 14 respectively, while as a single country, Indonesia stands out as hosting the most projects (15) and implementing the most national readiness schemes (6).

18. The most often mentioned criteria for REDD+ project and national readiness location selection were: biodiversity benefits, with additional location reasons said to be primarily prior relations with the country, region or stakeholders .

19. In order to explore further interest in siting REDD+ activities in particular countries or regions, three case studies on location choices from the three largest remaining contiguous tropical forests were selected: Indonesia, Brazil and Cameroon.

Chapter 1: Introduction

Background

Climate change is widely recognised as the most serious environmental threat facing us. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) concludes that warming of the earth's climate is indisputable, and that it is very likely that this is due to emissions of greenhouse gases (GHGs) from human activities, particularly from the last mid-20th century onwards. Atmospheric concentrations of the GHGs, which include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), are higher than any time over the last 650,000 years.

We need to find ways of reducing our emissions of these gases. The Kyoto Protocol (KP), agreed in 1997 at the third session of the Conference of Parties (COP-3) to the United Nations Framework Convention on Climate Change (UNFCCC), intended that participating developed countries (Annex I countries) collectively should reduce their total national GHG emissions by 5.2% below 1990 levels, averaged over the period 2008-2012. Developing countries (non-Annex I countries) do not have such obligations under the KP, but are able to participate in the Clean Development Mechanism (CDM), whereby Annex I countries are able to purchase credits for projects aimed at reducing GHG emissions in non-Annex I countries.

Whilst fossil fuel use remains the dominant concern, conversion of forests into agricultural land is a major source of GHG emissions. FAO (2006) estimates gross deforestation at 13 million ha of forests are lost annually, with net losses, allowing for afforestation and reforestation, at about 7.3 million ha y^{-1} (Nabuurs *et al.*, 2007). Degradation, defined as decrease of density or increase of disturbance in forest classes, affected tropical regions at a rate of 2.4 million ha y^{-1} in the 1990s. Deforestation releases an estimated 5.8 Gt CO_2 y^{-1} into the atmosphere (Nabuurs *et al.*, 2007), through the burning of the forest biomass, and from the oxidation of carbon stored in the soil under the trees during cultivation and in peatlands under drainage. Other GHGs, such as CH_4 and N_2O may also be emitted during slash-and-burn and subsequent land use. This represents some 17% of anthropogenic GHG emissions, greater than that from the whole global transport sector (Stern, 2007). FAO (2006) estimates Brazil and Indonesia to be the countries with the highest net deforestation rates, losing 3.1 and 1.9 million ha of forest annually, though these is recent evidence for decrease in Brazilian deforestation. Total per capita CO_2 emissions in Indonesia, for example, may be 30% above the average for Europe, despite a much lower energy use.

Although the Kyoto Protocol itself is ambiguous on inclusion of forestry projects, by COP-7 in Marrakesh in 2001 it had been decided that the Clean Development Mechanism (CDM) would extend to *afforestation* and *reforestation*. Uptake so far has not been very great, partly because of the special rules that apply, and partly because forestry activities are not eligible under the European Trading Scheme. Emission reduction by *avoided deforestation* was intentionally excluded from the CDM because of the risk of leakage – emission reductions in one location causing emission increases elsewhere.

Since about 2005 there is a growing recognition that the global emissions from deforestation cannot be neglected, particularly with the realisation that some mitigation actions, such as increased use of biofuels, may, in the absence of effective safeguards, lead to increased deforestation rates and global GHG emissions. Stern (2007) concluded that reducing deforestation is potentially a highly cost-effective way to reduce emissions relatively quickly, as well as providing co-benefits in terms of soils, water, climate protection, protection of biodiversity and livelihoods, rights of local communities, and sustainable forest management. Indeed, a recent study suggested that with appropriate carbon pricing, emissions from deforestation could be stopped by 2020 (Rokityanskiy *et al.*, 2007). Stern recommended that, with help from the international community, policies on deforestation should be shaped and led by the nations where the forests stand, and that compensation from the international community should be provided to take account of the opportunity costs of alternative uses of the land, the costs of administering and enforcing protection, and managing the transition.

At the COP-9, Santilli *et al*. (2005) presented a proposal for Compensated Reductions addressing some of these issues, in which non-Annex 1 forest countries could voluntarily choose to reduce their national emissions from deforestation. A certain annual rate of deforestation would be based on a historical period and used as a baseline. Verified reductions in deforestation rate below this rate would gain carbon credits which could e.g. (and subject to international agreement) be sold on carbon trading markets or to other governments. As this was to be at the national level, it would help to address the issues of national leakage, as displacement of emissions to elsewhere in the country would still be accounted for in national inventories, although this would not be the case for international leakage (Mollicone *et al.*, 2007b).

At a workshop in Bogor, Indonesia, in 2005, Schlamadinger *et al*. (2005) assessed the Santilli *et al*. (2005) proposal in more detail, and proposed improvements which included the possible need for upfront financing to establish avoided deforestation schemes (with appropriate safeguards built in to ensure that emission reductions were actually delivered), the appropriate setting of baselines, and ways in which revenues generated from avoided deforestation could be actually used to address the drivers of deforestation at the local level (i.e. to the landowners who would have to change their behaviour). Revenues from avoided deforestation would have to be set against other income possibilities for the land. Possible mechanisms mentioned included a carbon tax, payments to the landowners not to deforest, or investments in improving neighbouring agricultural productivity so that deforestation was not required.

These proposals marked significant progress in the thinking, but remaining issues include how appropriate baseline deforestation rates are determined, how differences from these baselines would be measured, and uncertainties in these differences are quantified. The sensitivity of credits to uncertainties (particularly in relation to degradation as opposed to deforestation), and the implications of this for carbon markets and efficiency of emissions reduction, need to be examined. The application of techniques for monitoring the change in national and regional carbon stocks caused by deforestation and degradation need to be improved. Mixed land-use mosaics present a specific challenge. Concerns have also been expressed regarding potential loss of national or provincial sovereignty over natural resources, and that avoided deforestation schemes could create so many carbon credits that they would flood global carbon markets and trigger a price collapse that would undermine the market incentives for reducing emissions in other sectors (e.g. energy), although the Eliasch Review (2008) suggests that this need not be a problem, given reasonable levels of supplementarity.

The first commitment period of the KP expires in 2012, and a successor agreement is needed. COP-11 (2005) agreed on a two-year period of discussion about Reduced Emissions from Deforestation and Forest Degradation (REDD+), focusing on “relevant scientific, technical and methodological issues, and the exchange of relevant information and experiences, including policy approaches and positive incentives”. At COP-13 (2007), REDD+ was a key agenda item, and it was decided that all countries should work towards improving data collection, estimation of emissions from deforestation and degradation, monitoring and reporting, and addressing institutional needs of developing countries. The drivers of deforestation should also be addressed, with a view to reducing emissions from this source through a range of policy approaches and positive incentives. At the 29th meeting of the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) in Bonn in June 2008, countries identified the main outstanding methodological issues, which required further work in relation to estimation and monitoring, reference emissions levels, displacement of emissions, national and sub-national approaches, capacity building, effectiveness of actions, and cross-cutting issues. The COP-15 (Copenhagen, Dec 2009) made some progress on REDD+, including a methodological decision, but did not finalise the treatment of REDD+ in a future climate treaty. The Copenhagen Accord (CA) did however prioritize the immediate setting up of a REDD+ mechanism.

At the UNFCCC Workshop on *Methodological Issues relating to Reducing Emissions from Deforestation and Forest Degradation in Developing Countries* held in Tokyo in June 2008, one of the key conclusions was that whilst IPCC Guidelines and Good Practice Guidance provide methodologies that can be the basis for developing countries to estimate and monitor the emission reductions associated with deforestation and forest degradation, it is more difficult to address forest degradation than deforestation, and further consideration of methodologies to address forest degradation is required.

This project

This project focuses on the methodologies for estimating GHG emissions and carbon stock changes resulting from deforestation and degradation and establishing baseline levels. There are four objectives:

1. To review the scientific and other literature on existing methodologies for estimating historical and future rates of deforestation and forest degradation for a sample of countries contributing to tropical deforestation, and to identify further data sources that might be used for refinement of these estimates.
2. To review the scientific and other literature on the drivers of deforestation in these countries, with particular emphasis on socio-economic factors, taking into account recent developments such as biofuel demand.
3. For the same countries, to attempt to relate key corresponding socioeconomic indicators of these drivers to variables to rates of deforestation at the national level.
4. To use the results of the project together with our own experience to identify and recommend demonstration projects where methodologies to reduce emissions from deforestation and degradation below reference baselines (without leakage) can be demonstrated in a possible second phase of the project.

The project is a partnership between Macaulay Land Use Research Institute (MLURI) in Aberdeen, Scotland, and the World Agroforestry Centre (ICRAF) based in Nairobi, Kenya. ICRAF is the lead organisation in, and coordinates, the ASB (Alternatives to Slash-and-Burn) Partnership for Tropical Forest Margins, which has enabled interdisciplinary research on deforestation in tropical forest margins for over 15 years between more than 80 international and local institutions across Asia, Africa and Latin America. ASB has benchmark sites in the western Amazon basin of Brazil and Peru, the Congo Basin forest in Cameroon, southern Philippines, northern Thailand, and the island of Sumatra in Indonesia.

Chapter 2: Assessment of available data on forest cover and country-specific estimates of REDD+ emissions and projections

The international REDD+ debate has called attention to both the stocks (assets) and flows (fluxes) of carbon from forested areas in developing countries. With fluxes due to degradation of the terrestrial C stocks (~5.8 $GtCO_2$ yr-1, Nabuurs *et al.*, 2007) at least four times the size of the emission reduction agreed in Kyoto, inclusion of reduced emissions from deforestation and forest degradation need to be included as part of a future climate agreement. Discussion of the flows (emissions) relates to knowledge of the assets (stocks): with a stock size of around 200 GtC at least an order of magnitude larger than annual global total anthropogenic carbon emissions of around 29 $GtCO_2$ yr^{-1} (7.9 GtC yr^{-1} in 2007), the protection of the stocks is important both for those under immediate threat (recent track record of high emissions), and those where threat can increase, depending on perceived incentives for threat response.

Forest cover data

<u>FAO data sets</u>

FAO has, until recently, been one of the very few sources on global forest monitoring. The FAO Department of Forestry reported on world forest resources every five years from 1948 to 1963, but was then suspended because of poor tropical forest data, although it was resumed in 1981 by launching the series of Global Forest Resource Assessments (FRAs), focusing mainly on the tropics. At the time of writing, the most recent (FRA2005) examines the current status and recent trends for about 40 variables covering the extent, condition, uses and values of forests and other wooded land based on information collated from 229 countries and territories for three points in time: 1990, 2000 and 2005. It is important to note that monitored data are only available for 1990 and 2000 while data for the year 2005 are extrapolated. The next assessment will be FRA 2010 for which a first FAO Global Remote Sensing Survey of Forests (RSS) will complement the national reporting. The expected outputs are forest area change data for 1975-1990, 1990-2000 and 2000-2005 (Herold *et al.*, 2008). FRA data are widely used, and the estimates of tropical forest areas and deforestation rates have been quoted in thousands of documents. More than 2,000 scientific publications that cite FRAs were scanned by Grainger (2008). In the same study 159 publications were found in which FRA data make a substantial contribution.

Table 1: Changes in estimation of natural forest areas (1000 ha) from FRA's between 1980 and 2005 (Grainger, 2008).

	FRA 1980	FRA 1990		FRA 2000		FRA 2005		
	1980	**1980**	**1990**	**1990**	**2000**	**1990**	**2000**	**2005**
Africa	703	569	528	684	629	672	628	607
Asia Pacific	337	350	311	307	265	342	312	296
Latin America	931	992	918	936	905	934	889	865
Total	1970	1910	1756	1926	1799	1949	1829	1768
N. Countries	76	90	90	90	90	90	90	90

Estimates of natural forest area for a number of countries from these FRAs are shown in Table 1. Successive FRAs may present different values for the same year. This is probably due to different methods of estimation and to the probable increase of data quality. It is unclear whether the latest survey data are really the most accurate possible and if the differences between revised estimates and those they replaced are within the limits of errors involved in estimating national areas and combining them to give regional and global figures.

Grainger (2008) notes discrepancies between successive assessments, and identified three main sources of error: (a) national forest surveys based on subjective expert assessments, (b) projection errors from the methodology used to ensure a common reporting year for all countries, i.e. using extrapolations forward to the year of assessment (e.g. 2000 for FRA 2000) from the last national forest survey for each country from the year it was carried out, and (c) increasing aggregation of FRA statistics. He gives as an example of errors associated in the methodology for Venezuela (Figure 1). Actual forest inventory surveys were carried out in 1977 and 1995 – the FRA1990 assumed a linear decline in forest cover from the 1977 survey based on the inventory prior to that and estimated about 46M ha of forest in 1990. Two methods of extrapolation were available at the FRA2000 – (a) linear extrapolation between the two 1977 and 1995 surveys only, giving an estimated forest cover of about 50M ha in 2000, and (b) fitting a curve to the two surveys as well as the 1990 value calculated in the FRA1990, giving an estimated forest cover of about 60M ha in 2000. The difference in estimated values for 2000 between the two approaches was nearly 10M ha, or about 20% of the total forest cover.

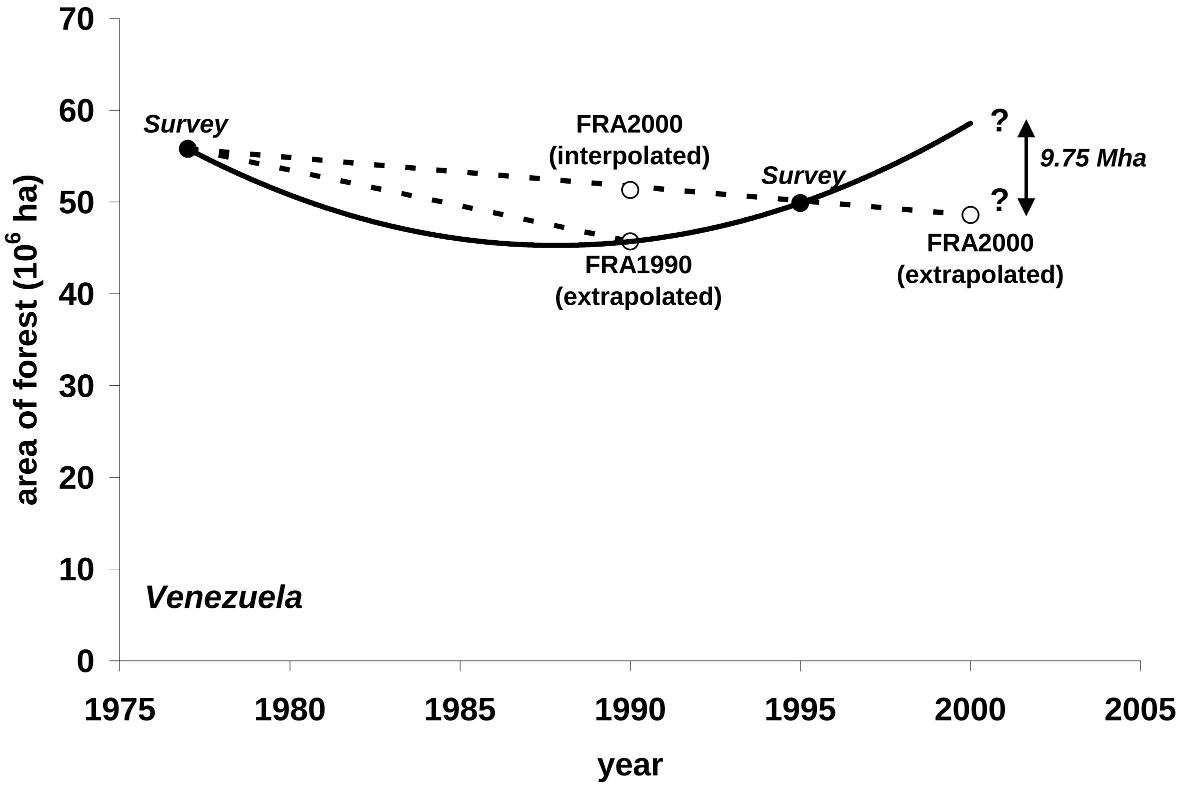


Figure 1: Potential errors in national forest cover for Venezuela depending on method of extrapolation used.

Availability of imagery data

Table 2 summarizes the most available data. LANDSAT satellite data with nearly complete global coverage are available at low or no cost for early 1990s and early 2000s, from the U.S. National Aeronautics and Space Administration (NASA) (https://zulu.ssc.nasa.gov/mrsid) or from University of Maryland's Global Land Cover Facility (http://glcfapp.umiacs.umd.edu/). These data play an important role in establishing historical deforestation rates. However, persistent cloud can be a major limitation to their use, especially in some regions of the tropics, e.g. in Central Africa and LANDSAT data are increasingly degraded as the satellite reaches the end of its useful life.Medium resolution data have been available for no cost since 2000. Other types of sensors, e.g. Radar and LIDAR, are potentially useful. Radar, particularly, can alleviate the substantial limitations of optical data in persistently cloudy parts of the tropics and has been demonstrated to be useful for mapping tropical forests (DeGrandi *et al.*, 2000; Rosenqvist *et al.*, 2000; Siegert *et al.*, 2001). Radar and LIDAR data have limited application to deforestation monitoring as their availability is not global and these sensors are not available onboard of a satellite. LIDAR observations provide information on the vertical structure of the forest by measuring returns from the signals emitted from the sensor; however acquisition is expensive and processing complex.

Table 2: Raw remote imagery data (modified from DeFries *et al.*, 2007).

Resolution	**Possible utility**	**Sensors (examples)**	**Availability**	**Costs**
Very high – RADAR sensors	Useful in project studies not yet widely used for monitoring; cloud free	LIDAR, ERS1/2 SAR, JERS-1, ENVISAT-ASAR ALOS PALSAR	ALOS – PALSAR since early 2009	High; Pilot areas free of charge
Very high < 5 m	Validation of small areas of results obtained with coarser sensors	QuickBird	2001 - 2006	Very high
		IKONOS	1999 - 2006	
High 10 – 60 m	Primary to identify change in tree cover, with 2->20 legend units for land cover types	Landsat	1972 – to date	Free for some years / bands Low/medium for historical data Medium/high for recent data
		SPOT HRV	1986 – to date	
		Others, e.g. AWiFs, LISS III, CBERS		
Medium 250 – 1000m	Monitoring of yearly changes in large clearings Locating hotspots for further investigation	MODIS (tree cover interpret-tation)	2000 – to date	Free
		SPOT vegetation	1998 – to date(?)	Free for research purposes if certain conditions are meet

The ALOS-PALSAR (Phased Array type L-band Synthetic Aperture Radar) has since early 2009 provided examples of the data quality that will become available. A major advantage is the cloud-free imagery, which is a big issue in the humid tropics (Figure 2). Data interpretation routines are still under development.

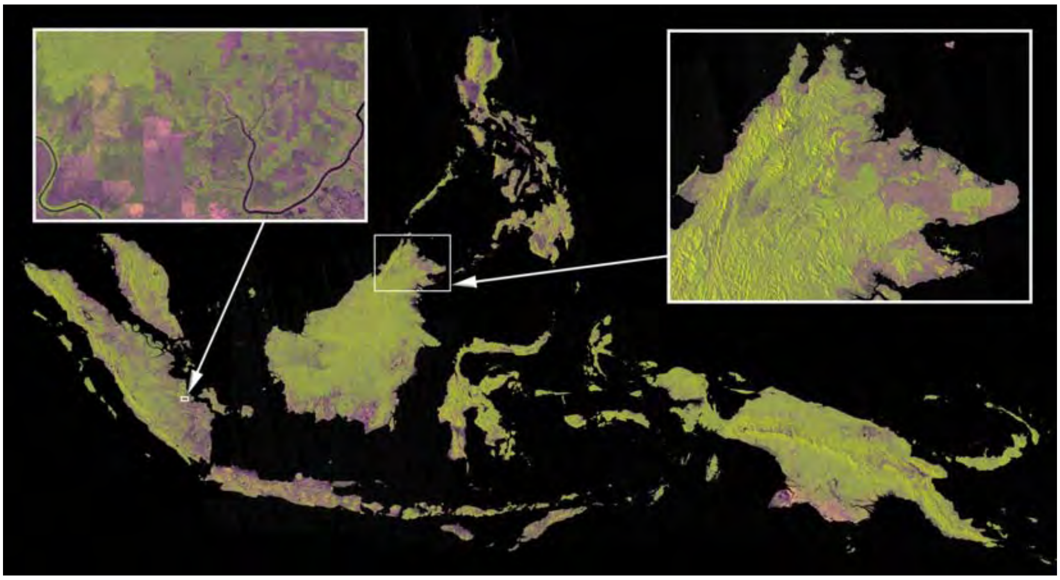


Figure 2: Example of the ALOS-PALAR imagery of Indonesia as a color composite of R= HH polarization, G=HV polarization, B=HH-HV polarization image. Greenish color shows a forest and purple colour shows deforest or not a forest area (http://www.eorc.jaxa.jp/ALOS/img_up/l_jkc_mosaic_fig1.htm)

It is important to have time series data for REDD+, and as there is considerable uncertainty in the coverage of tropical forests estimated from historically available information, more effort is needed to develop methodologies to create these from various and different sources (Herold *et al.*, 2008). This will require coordination of observations to ensure (a) coverage of all tropical forests in the future, and ii) use of data that are also partly missing. Brazil and India have respectively annual and biannual assessments of forest area changes based on satellite data. Other countries have not done this yet systematically, due to a requirement for capacity building and institutional development. Indonesia, for example, is carrying out land-use mapping exercises, including systematic mapping by satellite, but the available data are not yet sufficient or adequate for establishing reference emission levels or guiding future monitoring. Papua New Guinea is testing various methodologies, and assessing historical satellite datasets to track land uses and land-use changes and assess changes in forest carbon stocks. Mexico already has datasets for establishing a reference scenario and for analyses of historical trends of deforestation, and is currently establishing a nationwide land-use/land-cover change monitoring system, as well as incorporating the five IPCC carbon pools into the national forest inventory. Costa Rica already has a national accounting system based on reliable historical data to measure changes in forest cover and carbon stocks. For many other countries, however, the costs of high resolution data are currently a limitation in establishing monitoring systems.

Processed land cover data

Land cover mapping at any point in time provides a static figure of land cover, but does not on its own indicate change in forest area. It provides a baseline against which to assess future changes, and to help establishing forest areas that need to be monitored. When using a land cover maps to assess future change, consistent methodology and spatial resolution are needed for interpretation of results. Static forest cover maps used together with change detection studies provide the basis for establishing rates of change, and are particularly useful as a stratification tool in developing sampling approaches for forest change estimation (Mayaux *et al.*, 2005). The most important datasets are summarised in Table 3.

In the late-1990s global or pan-continental maps were produced at around 1 km spatial resolution from a single data source: the AVHRR sensor onboard the US NOAA satellites. In the early 2000s, new global land cover datasets were produced at similar resolution – 1 km – from advanced Earth observation sensors (VEGETATION on board SPOT-4 and SPOT-5 and MODIS on board the Terra and Aqua platforms). These products (GLC-2000 and MODLAND) were used for a spatial and thematic refinement of the previous global maps.

Table 3: Global land cover maps (Achard *et al.*, 2007)

Name of the map	**Resolution**	**Method**	**Sensor**	**Reference**
IGBP discover	1 km	12 monthly vegetation indices from April 1992 to March 1993	NOAA-AVHRR	(Loveland *et al.*, 1999)
University of Maryland (UMD)	1 km	41 multi-temporal metrics from composites from April 1992 to March 1993	NOAA-AVHRR	(Hansen *et al.*, 2003)
TREES	1 km	Tree cover mosaics of single date classifications (1992–1993)	NOAA-AVHRR	(Achard *et al.*, 2001)
FRA-2000	1 km	AVHRR updated from the IGBP dataset	NOAA-AVHRR	(FAO, 2001)
MODLAND	1 km	12 monthly composites from October 2000 to October 2001	TERRA MODIS	(Friedl *et al.*, 2002)
Global Land-Cover2000 (GLC-2000)	1 km	365 daily mosaics for year2000	SPOT-VGT Global	(Bartholome & Belward, 2005)
Vegetation continuous fields	1 km	Annually derived phenological metrics	NOAA-AVHRR	(DeFries *et al.*, 2000)
	500 m		TERRA MODIS	(Hansen *et al.*, 2003)
GLOBCOVER Global	300 m	6 bi-monthly mosaics from mid-2005 to mid-2006	Envisat MERIS	(Arino *et al.*, 2007)

More recently new global land cover datasets at finer resolution (250–500 m) have been generated from TERRA-MODIS or ENVISAT-MERIS sensors. Initial examples at this scale include the MODIS vegetation continuous fields (VCF) products depicting sub-pixel vegetation cover traits at a spatial resolution of 500 m (Hansen *et al.*, 2003). Currently, six years (2000–2006) of global VCF tree cover are now available and are being incorporated into various forest cover and change analyses.

A new 500 m version of the MODIS Land Cover product (Friedl *et al.*, 2002) has been generated. The GLOBCOVER initiative produced a global land cover map using the 300 m resolution mode from the MERIS sensor onboard the ENVISAT satellite. Data have been acquired from 1 December 2004 to 30 June 2006. This new product updates and complements the other existing comparable global or continental products (e.g. Eva *et al.*, 2004; Mayaux *et al.*, 2004; Stibig *et al.*, 2007). The total RMS error of the absolute geo-location of the ortho-rectified MERIS

FRS product is less than 80 m which is reckoned to be largely below 1/3 of the pixel size required for multi-temporal analysis. Bi-monthly, seasonal and annual mosaics have been created over a one year period (between mid-2005 and mid-2006). A global land cover map was generated from these mosaics from automatic classification tools using equal reasoning areas, and spectral and temporal characteristics of the mosaics (Saatchi *et al.*, 2007).

Accuracies of 80–95% [2]are achievable for monitoring with high resolution imagery to discriminate between forest and non-forest. Accuracies can be assessed through ground observations or analysis of very high resolution data (DeFries *et al.*, 2007). A statistically valid sampling procedure (Strahler *et al.*, 2006) can be used to determine the accuracy on a forest/non-forest map at a single time. Whilst it is difficult to verify change from one time to another on the ground unless the same location is visited at two different time periods, a time series of very high resolution data can be used to assess accuracy of identifying new deforestation. With commercially available software for automatic recognition of land cover types, accuracies of around 85% are feasible for legends of 15-20 classes in tropical forest margins.

Brazil and India have operational systems in place to monitor forest cover from remote data. These countries have receiving stations to acquire remote sensing satellite imagery (LANDSAT or TERRA data) and/or national satellites (IRS or CBERS). Other countries have carried out forest assessments using remote sensing products, e.g. Peru, Bolivia, and Indonesia. Key issues for other countries to set up similar systems are i) the access to data at a reasonable cost and ii) the set up of the technical infrastructure (hardware, software, and internet access).

Recognizing forest degradation

Forest degradation is the result of human activities that remove forest carbon stocks in excess of regeneration within the accounting unit. Degradation thus depends on the scale of the accounting unit, in both space and time. It can be defined at patch scale over a multi-year period (linked to a recovery period after logging, for example), or at landscape scale across a mosaic of patches that are in various stages of a management cycle. At national scale degradation refers to a sustained decrease in national forest C stock.

At a local level, degradation is often a precursor to forest conversion as areas that are selectively logged often increase access (and decrease in value the remaining standing stock), and result in clearing (Achard *et al.*, 2007). Monitoring of degradation is more technically complex than monitoring major shifts in local forest cover as differences in reflectance between forest and degraded forest are less evident than in the case of deforestation, and degradation patches are generally small compared with clearings (DeFries *et al.*, 2007). For these reasons, methods for monitoring degradation are not as well established as those for monitoring deforestation. Methods to identify forest degradation use high resolution data. Radar data can potentially detect degradation, though this needs further development (Saatchi *et al.*, 2007). Spatial patterns of log landings (patios for logging trucks and river landings) and identification of other infrastructure (e.g. roads and rivers used for transportation) has been a successful approach for identifying logging activity as indicator of degradation (Asner *et al.*, 2005). Detection of active fires using thermal data can also indicate presence of subsequent burn scars (Roy *et al.*, 2005). Results in the research domain have demonstrated capabilities for monitoring degradation and show promise for implementation in operational monitoring systems (e.g. Asner *et al.*, 2005; Mollicone *et al.*, 2007a). Annual monitoring may be needed to capture the dynamics associated with degradation. As is the case with deforestation monitoring, the key constraint is data continuity of high resolution imagery.

[2] Meaning that forest and non-forest can be distinguished with 80-95% probability of being correct.

Estimating carbon stocks and emissions

Converting biomass data to carbon stocks

Carbon emissions from deforestation and degradation are derived by multiplying the area of forest change (ha) with the change in C stock density (t C ha^{-1}) (Brown, 2002). Available forest inventories provide large volumes of data on trees across different forest types in many countries. These inventories can provide biomass values according to forest type and use, e.g. mature forest, intensely logged, selectively logged, fallow, etc. More use could be made of this data to provide C stock estimates.

Nevertheless many developing countries do not have sufficient forest inventories or are not making the best use of data that are available (Czaplewski, 2003; Chowdhury, 2006; Achard *et al.*, 2007; DeFries *et al.*, 2007). The FAO data provide default values for carbon stocks often stratified by main ecological zones (FAO, 2006), although the confidence intervals of these data are rather wide (Czaplewski, 2003; Chowdhury, 2006). Compilation of data from permanent sampling areas may provide estimates of carbon stocks for different forest types but depends on the design of particular scientific studies. A variety of methods and models have been developed using a combination of remote sensing observations, spatial databases of key factors that are related to forest biomass (e.g. precipitation, temperature, elevation, growing season length, and the like). A recent example was described by Saatchi *et al*. (2007) for the Brazilian Amazon. However these methods are not yet widely applied.

An EU-funded project just started in Indonesia is focusing on this type of data mining. Results so far demonstrate that there are extended tails of tree biomass distributions – at low frequency there are giant trees in the forest (with diameters above 3 m) – any one of such trees may contain the same amount of C as the assumed average for a hectare of tropical rain forest. Any ha-plot that contains such a tree may be double or triple the average value. Even if only one in twenty ha plots contains such a giant tree, they can already represent 5% of the total C stock. Yet the frequency of large trees is poorly recorded. Efforts in data mining with current database and statistical techniques are likely to be highly rewarding in reducing uncertainty in emission rates.

A recent re-calculation of emissions from deforestation in Brazil came out at 15% lower than previous estimates(Ref??), based on more detailed information on the wood density of the types of forest actually converted. Uncertainties in the allometric equations used to convert tree diameter (and height) data into biomass and C stock estimates are therefore significant . A recent synthesis of published data showed that wood density information is indeed important. ICRAF has an on-line database of wood densities at http://www.worldagroforestrycentre.org/sea/Products/AFDbases/WD/.

Deriving carbon stock densities from remote sensing data

There are currently no standard procedures and methods for measuring forest biomass through remote sensing data at regional and/or national scales, as the remote sensing signal that is based on leaf area index (LAI) saturates at LAI 3-5, which may represent anything between 35 and 350 t C ha^{-1}.

Pilot studies using airborne LIDAR data and very high resolution optical data have been used in a sampling approach to estimate biomass of different forest types (e.g. Drake *et al.*, 2003; Brown *et al.*, 2005). Very high resolution digital optical data can be used to identify individual trees in the forest canopy though there is currently no way to scale up this type of information to the national level. New tools for automatically delineating tree crown areas in complex tropical forests are under development. These methods are currently costly. They may eventually provide a more cost effective than traditional large field-based forest inventories, but not sufficiently developed for widespread operational use (DeFries *et al.*, 2007).

Estimated national carbon stocks

There are now emerging a number of other published data sets on national forest C stock. Gibbs *et al*. (2007) have summarised five of these (Table 4) by the ratio of highest to lowest estimates. In 90% of cases the ratio is less that a factor 5 though values up to 8 occur. Bhutan where the ratio is 60 appears to be an outlier. All estimates are based on widely accepted methods.

Table 4: Overview of published national C stock estimates (Mt C) (based on Gibbs *et al.*, 2007).

		Based on compilations of harvest data			Based on forest inventory				
	Country	(Olson *et al.*, 1983 ; Gibbs, 2006)	(Houghton, 1999; DeFries *et al.*, 2002)	(IPCC, 2006)	(Brown, 1997; Achard *et al.*, 2002; Achard *et al.*, 2004)	(Gibbs & Brown, 2007b; Gibbs & Brown, 2007a)	Ratio highest/ low-est	% of total based on lowest estimates for all	% of total based on highest estimates for all
1	Brazil	54,697	81,087	82,510	82,699	—	1.5	34.201	26.662
2	D.R. Congo	22,986	22,657	36,672	24,020	20 416	1.6	14.167	11.823
3	Indonesia	13,143	25,547	25,397	16,448	20,504	1.9	8.218	8.236
4	Bolivia	6,542	9,541	9,189	2,469	—	3.9	1.544	3.076
5	Venezuela	6,141	9,202	7,886	2,326	—	4.0	1.454	2.967
6	India	5,420	8,997	5,085	7,333	8,560	1.8	3.180	2.901
7	Papua New Guinea	4,154	8,037	7,075	5,160	—	1.9	2.597	2.591
8	Angola	7,811	6,702	11 767	7,215	3,557	2.2	2.224	2.518
9	Peru	7,694	11 521	13 241	2,782	—	2.8	1.740	2.481
10	Central Afric. Republic	4,059	3,176	7,405	3,524	4,096	2.3	1.986	2.387
11	Colombia	6,737	10 085	11 467	2,529	—	2.7	1.581	2.172
12	Zambia	4,295	3,423	6,378	3,725	1,455	4.4	0.910	2.056
13	Cameroon	3,721	3,454	6,138	3,695	3,622	1.8	2.160	1.979
14	Mexico	4,361	5,924	5,790	4,646	—	1.4	2.727	1.910
15	Rep of the Congo	3,458	3,549	5,472	3,740	4,739	1.6	2.162	1.764
16	Myanmar	2,843	5,182	4,867	4,024	4,754	1.8	1.778	1.671
17	Mozambique	4,567	3,749	5,148	4,068	1,894	2.7	1.184	1.660
18	Malaysia	2,405	4,625	4,821	2,984	3,994	2.0	1.504	1.554
19	Gabon	3,063	3,150	4,742	3,315	4,114	1.5	1.915	1.529
20	Nigeria	1,805	1,377	3,952	1,510	1,278	3.1	0.799	1.274
21	Guyana	2,494	3,742	3,354	923	—	4.1	0.577	1.206
22	Paraguay	2,831	3,659	3,063	1,087	—	3.4	0.680	1.180
23	Tanzania	2,716	2,221	3,400	2,409	1,281	2.7	0.801	1.096
24	Ivory Coast	1,047	750	3,355	830	1,238	4.5	0.469	1.082
25	Surinam	1,793	2,753	2,330	663	—	4.2	0.415	0.888

26	Philippines	869	1,765	2,503	1,213	1,530	2.9	0.543	0.807
27	Thailand	1,346	2,489	2,215	1,923	2,104	1.8	0.842	0.802
28	Ghana	880	612	2,172	678	609	3.6	0.381	0.700
29	Madagascar	1,043	1,055	2,114	1,116	1,796	2.0	0.652	0.682
30	Ecuador	941	1,379	2,071	351	—	5.9	0.219	0.668
31	Guinea	854	598	2,051	664	973	3.4	0.374	0.661
32	Cambodia	1,008	1,800	1,222	1,334	1,914	1.9	0.630	0.617
33	Laos	718	1,523	1,388	1,163	1,870	2.6	0.449	0.603
34	French Guiana	1,097	1,683	1,588	403	—	4.2	0.252	0.543
35	Vietnam	774	1,632	1,546	1,169	1,642	2.1	0.484	0.529
36	Nicaragua	930	1,395	1,275	972	—	1.5	0.582	0.450
37	Liberia	506	515	1,302	543	707	2.6	0.316	0.420
38	Honduras	852	1,268	1,123	901	—	1.5	0.533	0.409
39	Uganda	536	434	1,237	479	429	2.9	0.268	0.399
40	Guatemala	787	1,147	923	823	—	1.5	0.492	0.370
41	Ethiopia	183	153	553	168	867	5.7	0.096	0.280
42	Benin	410	260	792	292	262	3.0	0.163	0.255
43	Panama	509	763	685	549	—	1.5	0.318	0.246
44	Costa Rica	471	704	593	493	—	1.5	0.295	0.227
45	Sierra Leone	136	114	683	123	240	6.0	0.071	0.220
46	Kenya	314	320	618	339	163	3.8	0.102	0.199
47	Togo	252	172	510	192	145	3.5	0.091	0.164
48	Sri Lanka	302	509	296	400	138	3.7	0.086	0.164
49	Equat. Guinea	304	313	474	330	268	1.8	0.168	0.153
50	Nepal	246	393	369	337	334	1.6	0.154	0.127
51	Malawi	290	246	391	267	152	2.6	0.095	0.126
52	Guinea-Bissau	204	145	381	161	78	4.9	0.049	0.123
53	Belize	198	318	261	218	—	1.6	0.124	0.103
54	Senegal	171	141	228	153	86	2.7	0.054	0.074
55	Bangladesh	65	137	93	92	158	2.4	0.041	0.051
56	El Salvador	105	153	108	117	—	1.5	0.066	0.049
57	Bhutan	13	29	121	22	2	60.5	0.001	0.039
58	Brunei	58	112	115	72	40	2.9	0.025	0.037
59	Burundi	69	51	43	55	9	7.7	0.006	0.022
60	Rwanda	45	45	36	48	6	8.0	0.004	0.015
61	Gambia, The	7	7	11	7	6	1.8	0.004	0.004
	Total	198,276	246,884	276,120	212,291	81,614	235	100	100

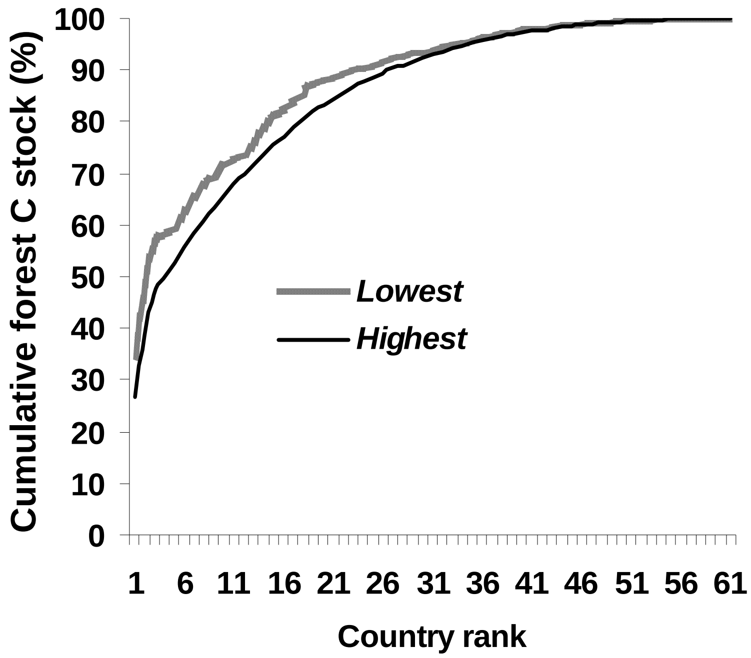


Figure 3: Cumulative tropical forest C stock by country rank, based on Table 4.

These data underline the importance of time series consistency in the estimation method applied (to avoid estimated differences in carbon stock arising from methodological choice). Taken together, the data indicate that three countries (Brazil, DR Congo and Indonesia) probably contain among them about 50% of total forest C stock. If seven other countries are added, about 67% of all tropical forest carbon stock is found in a total of ten countries, with a further 51 countries accounting for the remaining 33%.

Estimated national GHG emissions

The Climate Analysis Indicators Tool (CAIT), developed by the Climate, Energy and Pollution Program of the World Resources Institute (WRI), provides a comprehensive database of greenhouse gas emissions data (including all major sources and sinks) and other climate-relevant indicators (http://cait.wri.org/).

CAIT consists of a set of tools:

- CAIT (online) operates through a web-based interface, and includes a wide variety of climate-relevant data and indicators.
- CAIT-UNFCCC is a basic interface for viewing and analyzing official GHG emissions data submitted by UNFCCC Parties to the Convention Secretariat.
- CAIT-U.S. is an interface for viewing data, indicators and policy development related to USA.
- CAIT-V&A is an interface for viewing data and indicators related to countries' vulnerability and adaptive capacity (V&A).

The CAIT database contains data from 1850 up to 2000 on CO_2 emissions from land-use change and forestry, based on the analysis of Houghton (2003b; 2003a). More recent estimates of carbon fluxes from land-use change and forestry were released in 2008 covering the period 1850-2005 (Houghton, 2008).

Sources of uncertainty

Ambiguity of forest definitions

A large part of the variation in Table 4 is due to different forest definitions. To make sense out of the multitude of data on deforestation rates or emissions associated with deforestation and/or degradation, one needs to understand the multitude of operational definitions that underlie these estimates.

Considering an overall landscape, carbon can be stored in natural forests as traditionally conceived (forests with trees), and also in agroforestry systems containing both trees and crops. The latter do not necessarily qualify as a forest: they may be *trees outside forests*. In many countries, clear-felling followed by replanting is considered as a forestry operation. There may therefore be *forest land without trees*; this should be temporary destocking but there may not be a time limit for replanting to occur. The implication of this is that to get a proper estimation of forest carbon stocks one needs a clear forest definition, consistently applied, and a system to measure the actual carbon stock dynamics. Without this there is considerable latitude for differences in carbon stock estimates that are simply a function of different definitions or methodological choice. The most consistent system would be to estimate carbon stock changes and emissions across the landscape because this would capture not only agroforestry systems, but also knock-on effects of forestry policies on other land uses. In practice this may not be achievable in the medium term, because of the additional methodological challenges. The best approach is likely to be application of an agreed methodology, most likely the IPCC Good Practice Guidance, in a consistent manner to capture the full carbon stock dynamics associated with human activity in forest ecosystems. Consistent application includes consistency with respect to forest definitions. Practicalities of data collection and differences between ecosystem characteristics mean that forest definitions need not necessarily be the same in all countries, but they should be consistently applied, and if REDD+ is to be efficient in securing actual emissions reductions the coverage of carbon stock dynamics needs to cover all carbon pools and activities significantly affected by initiatives to reduce emissions from deforestation and forest degradation. Coverage needs to extend to all activities, whether sustainable or not, so that contributions to emissions and removals can be taken into account.

Ambiguity in pools included/excluded

Another source of variability in the data reflects the different carbon pools included in the assessment. The IPCC methods generally recognize five pools: three pools of biomass (aboveground trees, aboveground understory, roots), necromass above the soil (dead wood and litter) and soil organic matter. Much of the forest inventory data, however, refers only to tree biomass (e.g. the estimates in Figure 4).

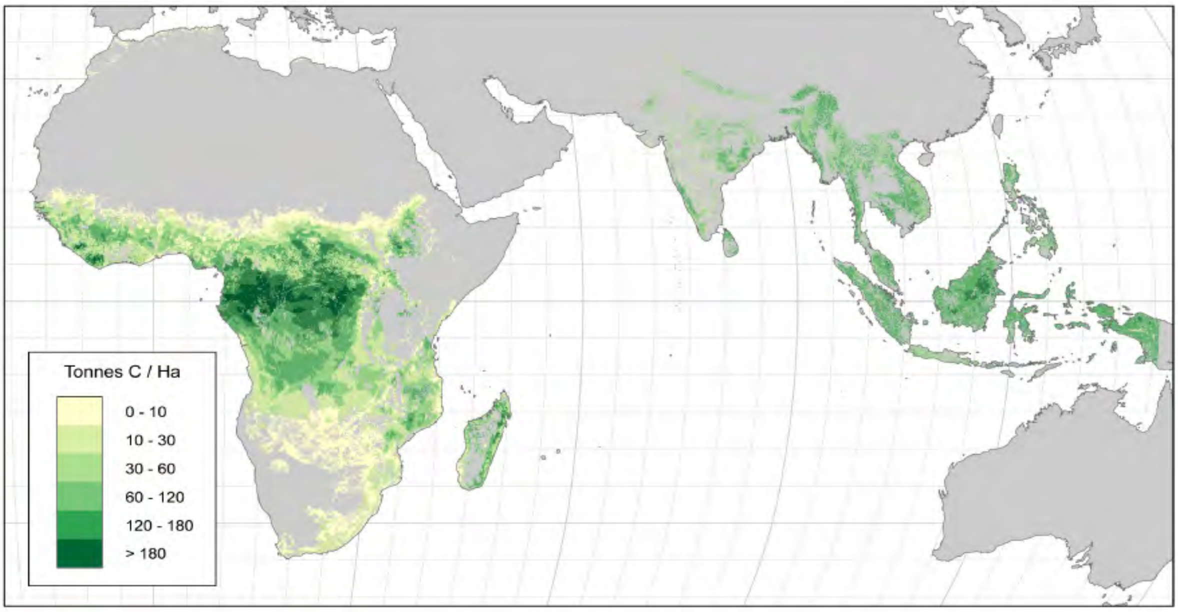


Figure 4. Forest biomass carbon maps for Africa and Southeast Asia produced by using regression-based models to extrapolate forest inventory measurements (Gibbs *et al.*, 2007).

The other pools can be estimated by various methods. Under natural forest conditions the standing stock of tree necromass will be 10-20% of tree biomass (what takes 100 years to grow takes 10 years to decompose), but after selective logging operations tree mortality can be high and a necromass value at 30-40% of remaining biomass is common. Understory vegetation (usually including trees <5 cm stem diameter) is usually less than 5% of the total. Shoot:root ratios are usually assumed at 4:1 for humid tropics with lower values in more seasonal climates and higher values on very wet soils. Collecting tree roots is hard work (e.g. Smit *et al.*, 2000) but the pool size is 10-20% of the total biomass, and uncertainties in estimates of this pool can easily be 50%.

Soil organic matter data have been compiled for the soils of the world (Batjes & Bridges, 1995), but there is still debate on the relevance of deep soils and the tree roots that transfer C to them. Generally an exponential distribution of soil C along with that of fine roots shows that the highest C% can be found in topsoil, but total content depends on soil depth, a property that is poorly known. For two situations soil C changes below 30 cm depth will be specifically important:

- Peat soils (and the soils that have shallow peat on the surface but are not classified as peat.
- Soils as studies in the eastern Amazon (and of uncertain prevalence globally), with appreciable measured C fluxes at the depth of 1-5 m.

<u>Forest quality</u>

The nationally-reported forest data that are the basis for the FAO Forest Resource Assessment reflect the institutional perspective of foresters rather than actual forest cover. The operational definitions have shifted over time, making time-series unreliable or misleading – see above on the importance of consistency. Recent data include changes in forest quality (estimates of increase or decrease in growing stock), degradation, as well as forest area. The data reported by tropical countries show a considerable spread (Figure 5). This spread may in part reflect the different nature of forest conversion. In Brazil, nearly all forest conversion is based on clear-felling followed by conversion to pasture with few, if any, trees. In Indonesia, a gradual loss of large and smaller trees takes place before final conversion, resulting in a comparatively high forest degradation rate, both in absolute terms and in relative to the rate of deforestation.

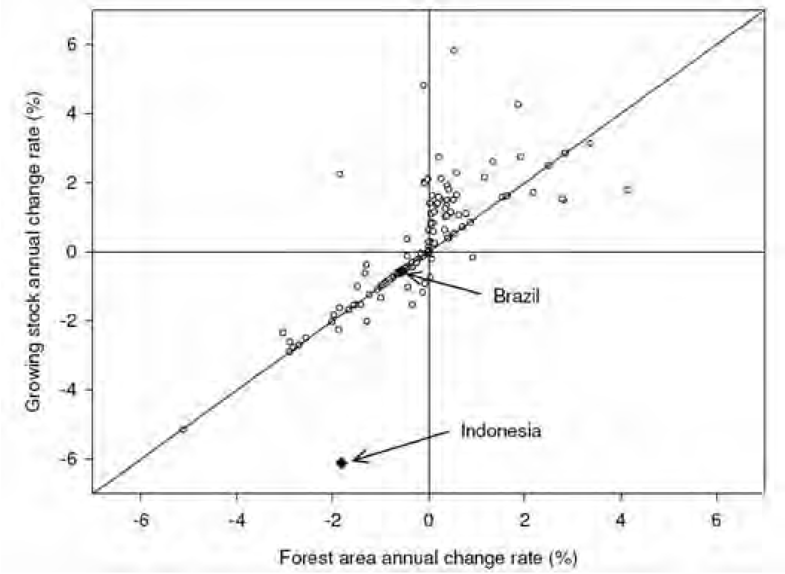


Figure 5: Comparison of forest area change ('deforestation') and loss of growing stock ('degradation') in nationally reported forest data in the FAO forest resource assessment (Marklund & Schoene, 2006); the position of Indonesia indicates much stronger 'forest degradation' than 'area-based deforestation', while globally the two indicators are more strongly correlated.

The estimates of changes in areas of growing stock are ambiguous as estimates of forest degradation, as logging may seriously set back terrestrial C stock without affecting the area of growing stock. There is no acceptable short cut to full C accounting as a basis for any REDD+ discussion. This is why inventory reporting to the UNFCCC has full coverage, consistent with the IPCC Guidelines. Reporting is also complete under the KP, though countries have some choice about the forestry and other land-use activities which count towards their commitments.

Peat soils

A specific issue in the countries with the highest emission estimates from the land use sector is that a large share of these emissions may be from peat areas. If brought together as 'forest + peat' emissions these values may stand, but if eligibility considerations under any international agreement require their separation, the lack of clarity in the forest definition will once again play havoc, e.g. if areas of previously forested peat are deforested and reclassified into a non-forest category, the emissions may be removed from an international agreement focussed on REDD+. Quoting an Indonesian example once more: the area designated in the early 1990's for the 'one-million hectare rice' in Central Kalimantan was taken out of the 'institutional' forest category, and a considerable part lost its forest cover before 2000. Under current drainage, these lands will continue to emit large amounts of CO_2 into the atmosphere, but reducing such emissions (probably one of the lower hanging fruits for emission reduction) may not be part of REDD+. Nevertheless, the Australian-Indonesian Forest Climate partnership has focussed on emission reduction in this area as a REDD+ pilot, and linkage to broader sectoral agreements should in any event be feasible.

Full carbon accounting and landscape-wide emissions

Following the LULUCF (or the more recent AFOLU) guidelines of the IPCC.

$$\Delta C = \sum^{n}_{i} A_{ij} [\Delta C\_Biomass_{ij} + \Delta C\_Necromass_{ij} + \Delta C\_Soils_{ij}] / T_{ij}$$

The basic equation for changes in terrestrial C stock refer to changes in area between any of *n* land use categories, weighted by the typical C stock (in biomass (aboveground (trees + understory vegetation) + roots), necromass (dead wood, litter layer) and soil (soil organic matter and/or peat). If only two land use categories are considered ('forest' and 'non-forest'), this collapses into a discussion of deforestation (change in area) and degradation (change in C stock per unit of forest).

Given the huge variation in C stock values within the forest category (from less than 50 to around 300 t C ha^{-1}), it is important to use appropriate carbon densities. A classification that allows for multiple types of land cover within and outside of the 'forest' category should be superior in providing accounting and accountability.

The IPCC national GHG accounting protocols distinguish three levels:

Tier 1 – using default values for C stock estimates for land cover categories,
Tier 2 – using country-specific values for C stock estimates for land cover categories,.
Tier 3 – using more detailed gain + loss estimates.

The advantages of whole-system accounting for net anthropogenic emissions of greenhouse gases, in accordance with IPCC guidelines, is increasingly recognised (Cowie *et al.*, 2007): *Ideally, the accounting approach should cover all significant biospheric sources and sinks, avoid biased or unbalanced accounting, avoid leakage, and require no arbitrary adjustments to remedy unintended consequences*.

The following example illustrates the differences between these approaches. In a study that included forest areas in Asia, Africa and Latin America, emissions were calculated using an IPCC Tier 2 whole landscape C accounting approach (Dewi *et al*. in prep). Comparison of these figures with changes in forest cover only (i.e. the horizontal difference between pairs of filled and unfilled symbols) gives only a weak correspondence between emission estimates and changes in forest cover (Figure 6). Emissions were lowest for the province of Lampung in Indonesia (which lost most of its forest cover before the 1990s) at 2.5 t CO_2 ha^{-1} y^{-1}, and tenfold higher for the province of Jambi (also on Sumatra), with substantial peat areas. Similarly, despite estimated net emissions of 10 t CO_2 ha^{-1} y^{-1}, forest area at the Cameroon site actually showed an increase over the time period (the open circle is to the left of the closed one in Figure 6).

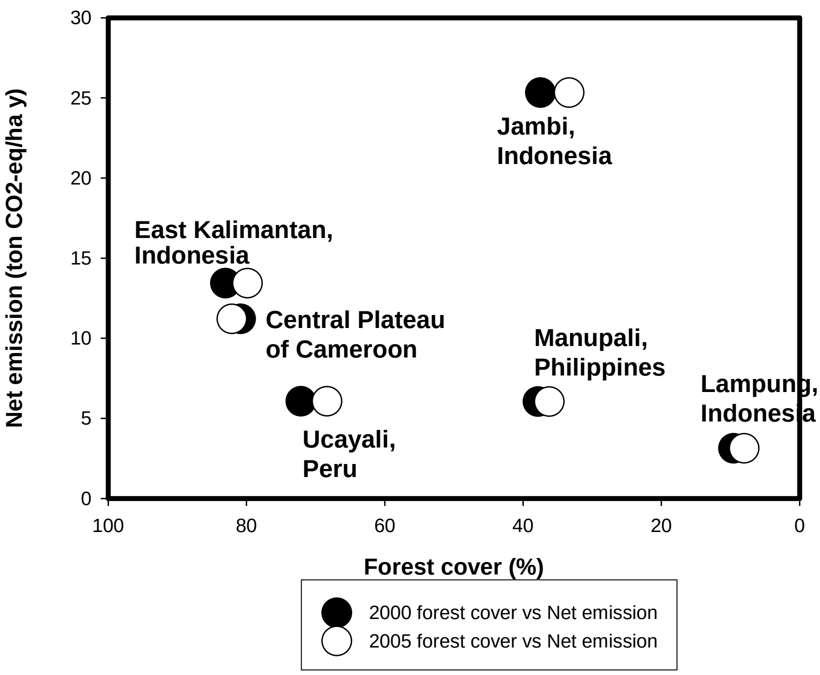


Figure 6: Relation between net emissions (t CO_2eq ha^{-1} $year^{-1}$)) and forest cover at start and end of accounting period for the ASB benchmark areas in Asia, Africa and Latin America, demonstrating the low predictive value of deforestation (horizontal shift between closed and open circle)in relation to emissions (Dewi et al., in preparation).

Uncertainties in data such as presented in Figure 6 are considerable, and derive from classification errors in the interpretation of remote sensing images (these may be 10-15% at pixel level, depending on the procedure used), uncertainty on the mean C content per land cover category based on limited numbers of samples, and biases (systematic error) in C stock estimates. The first two uncertainties may rapidly decrease with scale (as land cover classification errors may be symmetrical and increasing number of replications decreases uncertainty of the mean). However, problems of bias cannot be solved simply by increasing the sample size; gathering more data would only gather more biased information.

Chapter 3: Understanding the causal link between trends in deforestation and forest degradation rates, and the underlying drivers

Introduction

Understanding the trajectory that a country is on in terms of deforestation, and the driving factors bringing this about, is crucial to the design of equitable baselines for REDD+. Mather (1992) used the term *forest transition* to describe the changes in forest cover that occur as societies undergo industrialisation and urbanisation, with forest cover declining to a minimum, before it slowly increases and eventually stabilises (Figure 7). In the first stage, the forest is relatively undisturbed, with poor infrastructure and market access making it inaccessible for commercial exploitation (Angelsen, 2007). A set of triggers starts the deforestation process which is accelerated by a number of positive feedback loops which lead to the second stage, the *forest frontier*. Eventually, high levels of deforestation bring about forest scarcity which slows deforestation rates, leading into the third *forest and agricultural mosaics stage*. Finally, in the fourth stage, forest cover may begin to increase again, which is usually explained by two possible pathways – the *economic development* route, or the *forest scarcity* route (Rudel *et al.*, 2005). In the *economic development* route, increasing urban development results in higher earning capacity in the towns and cities, drawing labour from the surrounding rural areas. This relative depopulation of the countryside means that fewer people are making their livelihoods from the land, and landowners therefore gradually switch from labour intensive agricultural production to less labour-demanding activities such as forestry, so that forest cover increases, although this is through plantation planting rather than regeneration of indigenous forest. In the *forest scarcity* route, the declining forest area leads to a shortage of forest products in relation to the demand for these from both urban and rural areas, leading to price rises for these products, which in turn leads to increased tree planting, again leading to an increase in forest cover due to plantation forestry. A third route, suggested by Boucher (2008) and related to the first two, is the development in tropical countries of independent environmental movements and political pressures that lead to reductions in deforestation. This has already occurred in recent years in several countries, for example, Costa Rica and Brazil. Thus, to some extent, tropical countries are beginning to reduce deforestation for their own reasons, without waiting for the development of REDD+ mechanisms to fund the effort from abroad.

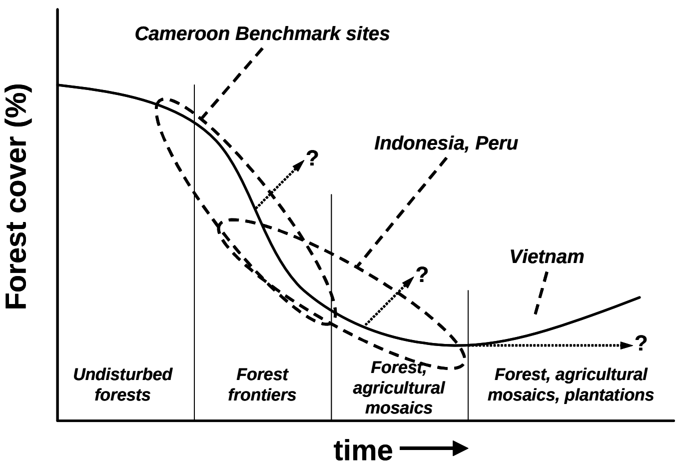


Figure 7: Forest transitions (adapted from Angelsen (2007)). Dotted arrows with question-marks indicate possible deviations from this trend (see text for details).

Whatever the mechanism, the forest transition pattern describes well the pattern that has occurred in Europe and North America over the past two centuries, and there are also signs of a similar pattern in a number of tropical countries (Rudel *et al.*, 2005). Rudel (1998) noted that on average about half of the initial loss is gained during the recovery phase. However, both the slopes (speed for deforestation and reforestation) and the turning point (minimum forest cover) may vary, and, indeed, Angelsen (2007) asserts that policies can have an important role in shaping both the slope and turning point, and that the forest transition model allows an understanding of the basic forces at work so that appropriate policy measures can be designed according to the stage in the transition and the drivers in operation.

The study of Rudel *et al*. (2005), in which the FAO Forest Resources Assessment 2000 dataset was used to look at trends in forests in a number of countries, found that not all deforestation leads to a transition – in several countries, urban wage rates did not attract the rural population into the towns, nor was there a sufficient demand for forest products, so that the resulting poverty trap aggravated deforestation. In some countries, civil wars and the breakdown of governance resulted in increased deforestation rates, while in others (e.g. Indonesia, Cameroon, Brazil) forest governance was weak and vested interests were strong, so that transitions had not occurred. They found that per capita income and the extent of forest cover at the national level (as indicators of the economic development and forest scarcity pathways, respectively) were able to explain some of the variation between countries, and suggested that accounting for other factors, such as level of corruption, could improve these prediction of deforestation rates. Thus, despite the large number of published studies, there is still much uncertainty about the causes of forest loss and forest poverty and about effective policy responses (Chomitz *et al.*, 2007). Chomitz *et al*. (2007) gives some examples of policy measures that have not always had the desired effect due to a partial understanding of the forces at work. High prices for timber, for example, can stimulate sustainable management of plantations and secondary forests, but they can also provoke mining of old growth forests. Improving agricultural technology and hence crop yields can relieve pressure on the forests, but can sometimes also encourage more deforestation if the surpluses generated are used for additional forest clearing (Angelsen & Kaimowitz, 2001). Higher farm incomes may also attract more migrants in the forest region, resulting in more cleared land for cultivation. Thus, although the general trend shown in Figure 7 can often be discerned at the national level, variation in the balance between these various feedbacks in a local context can mean that the trajectory followed at a specific location can deviate significantly in direction from this overall trend (Perz, 2002), as illustrated by the dotted arrows in Figure 7.

While global level drivers are undoubtedly important, local conditions, incentives and constraints determine where and why deforestation occurs. Geist & Lambin (2001; 2002) as part of the LUCC (Land Use and Cover Change) project have devised a widely used framework for analysing causes of deforestation, by distinguishing between direct (proximate) causes and ultimate driving forces, noting that deforestation and degradation are not homogenous processes throughout the tropics (Figure 8). Regional differences mostly come from varying mixes of economic, institutional, technological, cultural, and demographic factors underlying the direct causes of deforestation (i.e., underlying driving forces or indirect causes). Understanding these complex feedbacks and local deviations is needed for designing equitable baselines for REDD+.

For this objective a literature review of the drivers of deforestation in some Asian, South and Central American and African countries was carried out. Given the time and resources available, this review is by no means exhaustive and does not claim to be a definite account of drivers of deforestation. It gives a broad overview of the main drivers in each of these three regions. The section firstly presents summaries of drivers for each of the three regions, Asia, South and Central America and Africa. Maps of regional deforestation rates were sourced from Source data: © ESA / ESA GlobCover Project, led by MEDIAS-France (Arino *et al.*, 2007).

When collating the material the group decided it would be useful to organise it into a set of country fact sheets providing information on historical drivers of deforestation at the country scale for a selection of countries from each region followed by a more detailed analysis of current drivers of deforestation. Time periods in the historical analysis vary depending on the information available. These country fact sheets are given in Annex 1 of this report.

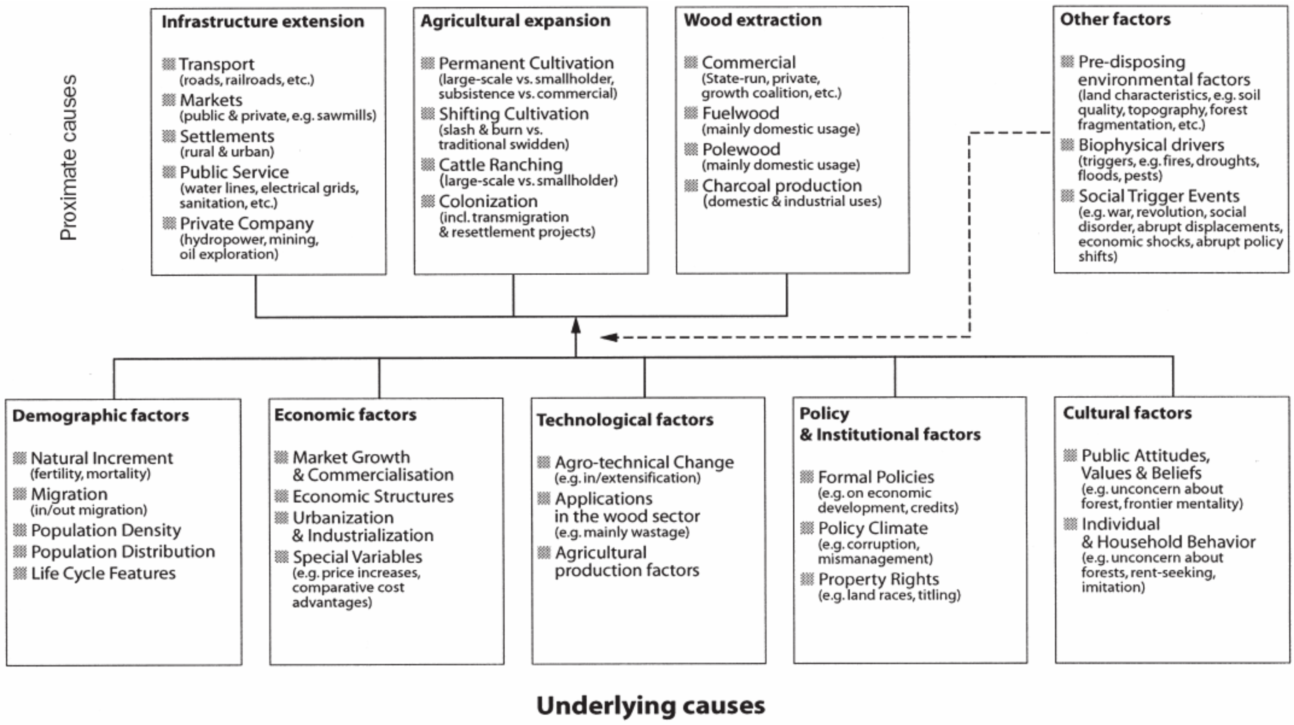


Figure 8: Framework developed by Geist & Lambin (2002) for analysing drivers of deforestation.

Drivers of deforestation in South and South-east Asia

Forests in South and South East (SE) Asia are mainly tropical in nature, spreading across India, Nepal, Sri Lanka, Bangladesh, Myanmar, Thailand, Cambodia, Lao PDR, Vietnam, Indonesia, Malaysia, Philippines, and the islands of New Guinea. The tropical forests in Asia account for 18% of the total tropical forests in the world (Laurance, 2007) and are home to millions of people and habitat for many rare plant and animal species. Out of the 25 world biodiversity hotspots identified by Myers *et al*.(2000), four of them are located in the tropical Asia. The appearance of European (and later American) colonial powers in the region heralded an era of increased deforestation in many Asian countries, especially in SE Asia. After independence, deforestation rates dropped very slightly or even increased due to, amongst other factors, national development objectives, sometimes paired with ineffective and weak governmental institutions and corruption. In an increasingly globalised world, global demand for natural resources became increasingly important as a cause of Asian deforestation.

In the past few decades, large areas of these tropical forests have been removed for various reasons. The relative rate of tropical deforestation in Asia is twice as high (0.8-0.9%) as the rate in Latin America or Africa (Laurance, 2007). Forest rich countries in S.E. Asia are generally under the threat of deforestation, whereas the forest poor South Asian countries have relatively stable forest cover with the exception of Nepal and Sri Lanka. Therefore, this report focuses mainly on changes in forest cover and associated drivers in SE Asia.

Natural forests in many SE Asian countries (Thailand, Vietnam, Singapore, Philippines) have been largely deforested in the last few decades. Countries such as Indonesia, Malaysia, Myanmar, Lao PDR, Cambodia and Papua New Guinea, who still have a large cover of forest are currently undergoing deforestation. The relative rate of annual deforestation is highest in Philippines (2.1% y^{-1}) followed by Indonesia (2.0% y^{-1}), Cambodia (2.0% y^{-1}) and Myanmar (1.4% y^{-1}), with slower rates in Malaysia (0.7% y^{-1}), Lao PDR (0.5% y^{-1}), Papua New Guinea (0.5% y^{-1}) and Thailand (0.5% y^{-1}). The Philippines have low forest cover (24%) and a high annual relative rate of deforestation. In absolute terms, annual deforestation is highest in Indonesia (18,710 km^2 y^{-1}) followed by Myanmar (4660 km^2 y^{-1}), Cambodia (2190 km^2 y^{-1}), the Philippines (1570 km^2 y^{-1}), Malaysia (1400 km^2 y^{-1}), Papua New Guinea (1390 km^2 y^{-1}), Lao PDR (780 km^2 y^{-1}), Thailand (590 km^2 y^{-1}) and Nepal (530 km^2 y^{-1}). Figure 9 shows the range of deforestation rates across SE Asia.

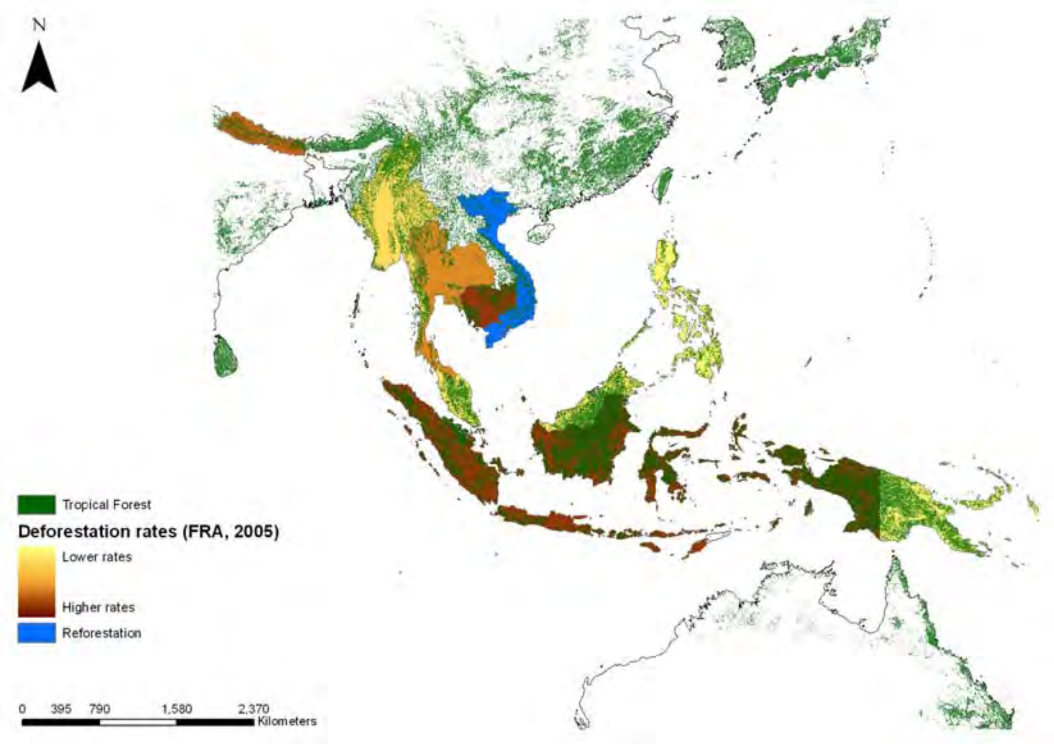


Figure 9: Map of main deforestation areas in Asia

Some countries show similarities in the type of drivers causing deforestation (e.g. expanding oil palm plantations in Malaysia and Indonesia; institutional factors in Papua New Guinea and Indonesia). However, a considerable degree of heterogeneity of forest cover, deforestation rates, and direct and underlying drivers exists across the whole region. The table below serves to illustrate this for three countries that differ both in present forest cover, deforestation rates and drivers.

Figure 10: Forest cover, deforestation rates, ands drivers of deforestation for Papua New Guinea, Indonesia, and Vietnam.

Country	**Papua New Guinea**	**Indonesia**	**Vietnam**
Forest cover 2005 (%)§	65	48.8	39
Deforestation rate km2 y-1 (2000-2005)§	- 1,390	-19,000	+ 2,400
Deforestation rate (% of forest cover y-1) (2000-2005)§	-0.5%	-2%	+ 2%
Direct drivers$	• Forest conversion for commercial and industrial timber production • Agricultural expansion for subsistence purposes • Mining • Forest fires • Clearing of forests for commercial crop plantations	• Forest conversion for palm oil • Forest concessions for wood extraction • Forest conversion for industrial timber production • Illegal logging • Clearing for subsistence and small scale farming	Deforestation: • Agricultural expansion and plantations • Shifting cultivation • Infrastructure development • Illegal logging Reforestation:

		• Fire	• Land allocation program • Intensification of agriculture
Underlying drivers#	• Institutional factors (corruption for logging concessions) • Demographic factors • Poverty • International demand for timber	• Economic uncertainty • International demand for palm oil, other cash crops and timber • Poverty • Public policy and institutional factors (weak institutions and corruption)	• Economic factors • Poverty

Notes: §FAO (2006); $ various sources, see country profiles; #(Wertz-Kanounnikoff *et al.*, 2008)

Government forest and national development policies, international market demand for forest commodities, and poor governance are among the main underlying causes of deforestation in the region – an overview of the historical change in forest cover and its drivers are given in the more detailed ‘fact sheets’ for a selection of countries in the region. There may be lack of recognition of the value of forest stocks and the flows of ecosystem services they provide, and the role of forests in strengthening socio-cultural systems rarely accounted for.

The major deforestation drivers are **agricultural expansion** and **logging**. Increase in area of oil palm and other cash crops such as rubber and coffee are two of the direct drivers linked to agricultural expansion. Growing demand for timber, pulp and paper driven by the economic interests of private companies (driven by rising global demand), and weak institutions and corruption in the governmental sector are also associated with illegal logging activities. Increasing population numbers and poverty in many of Asian countries increases the dependency of people on the forest for their livelihoods. This is especially true for indigenous groups of people and ethnic minorities, many of whom practice shifting cultivation for subsistence purposes and use fuel wood as their primary source of energy. Forest fires that open up forest areas for economic activity constitute another cause of deforestation in S.E. Asia. While forest fires occur naturally in some areas, human-induced fires can often spread uncontrolled, especially in years with unfavourably dry weather conditions (e.g. El Nino years).

The broad picture sometimes conceals large regional differences in deforestation rates and forest cover – for example, Java vs. Kalimantan in Indonesia, or Peninsular Malaysia vs. Sabah and Sarawak in Malaysia. These are described more in the individual country reviews in Annex 1.

Drivers of deforestation in South and Central America

South and Central America are home to the largest area of contiguous tropical forest left on earth, the Amazon Basin, the global significance of which is, in terms of biodiversity and climate regulation, well recognised. Any discussion of drivers of deforestation in the area is therefore going to be dominated by activities in the Amazon Basin. In addition, the region is home to the world’s largest area of seasonally dry tropical forest, areas of mountain forests and Atlantic forests.

In the 2000-2005 period, FAO statistics showed the highest rates of deforestation, on a percentage of national forest lost per year basis, were; Hondurus (-3.1%), Nicaragua (-1.3%), and Guatemala (-1.3%). Unsurprisingly, the country losing the largest area of forest per year during this period was Brazil, which lost 31,030 $km^2\ y^{-1}$. This was more than the total amount lost per year in the other top 10 deforesting countries in Latin America added together. The only country in the region to show significant reforestation during 2000-2005 was Costa Rica which gained 30 $km^2\ y^{-1}$, or 0.1 % of its total forest area annually.

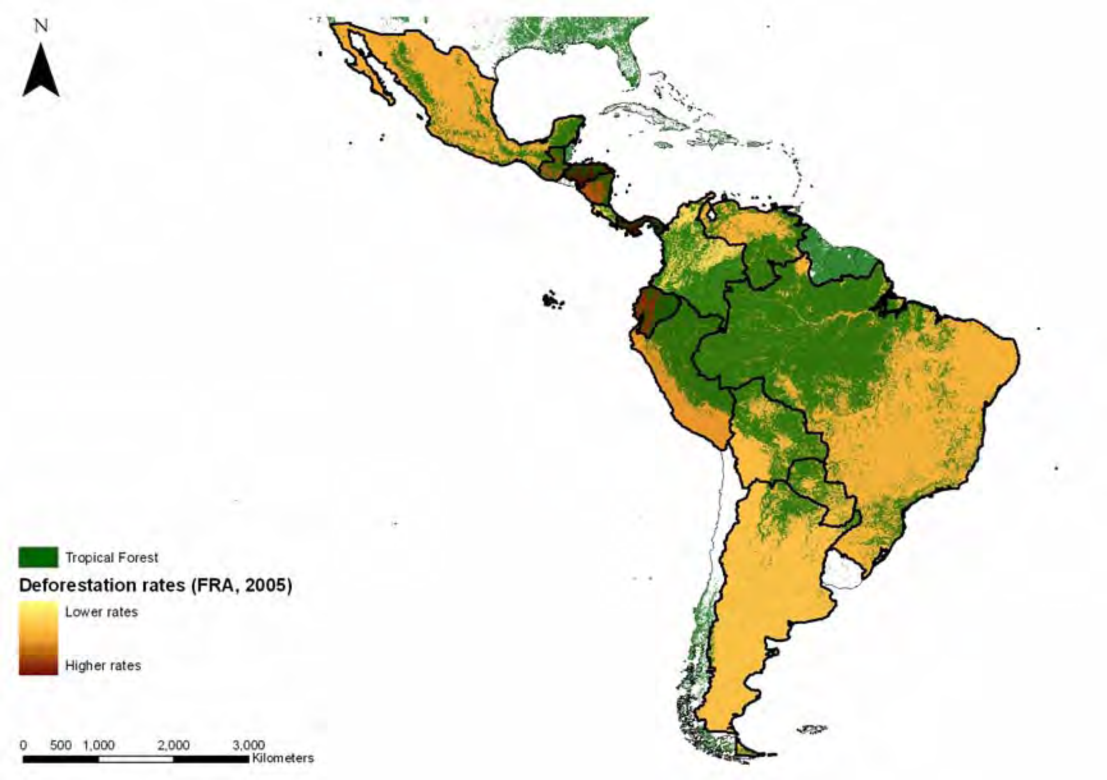


Figure 11: Map of main deforestation areas in South and Central America

The present population of Latin America is 500 million and is predicted to increase by 50% by 2050 (Grau & Aide, 2008). This will increase domestic demand for food, further threatening the region's forests. However, drivers of deforestation vary across the region. In recent years, global **demand for agricultural products such as beef and soybean** and associated **infrastructure development** have overtaken **subsistence activities** and **demand to supply domestic markets** as the main drivers of deforestation (Grau & Aide, 2008). **Timber extraction** also plays a minor role, as does mining in some countries. An overview of the main drivers of current deforestation in South and Central America are given below. The historical change in forest cover and its drivers are given in the more detailed fact sheets for a selection of countries in the region.

Up until the last two decades, deforestation in S & C America came mainly as a result of traditional shifting cattle ranching and cultivation, often driven by government colonisation programs and subsidies (Grau & Aide, 2008). Today pasture still predominates as the main land use following deforestation in S & C America, however mechanised agriculture to supply land for export crops such as soybean is an increasingly important driver.

In the Brazilian Amazon, a modernized cattle industry with a well-established export market continues to drive deforestation across the arc of deforestation. However, with Brazil set to become the world's leading soybean producer, deforestation for cropland accounts for ~ 17% of large scale forest clearance, a figure which is rising rapidly, especially in the state of Mato Grosso. In Argentina the situation is similar, with cattle production still the main driver of deforestation in the seasonally dry Chaco forest (Grau *et al.*, 2008), but with agricultural areas (especially for soybean production) expanding rapidly (Zak *et al.*, 2008). In similarity to Brazil and Argentina, Bolivia and Paraguay are also experiencing conversion of forest to crop land with their seasonally dry forests with flat terrain being most threatened (Grau & Aide, 2008). Likewise much of the forest destruction in Mexico can be attributed to agricultural expansion for cash crops in addition to pasture (Bray *et al.*, 2004).

Much of the soybean and maize produced in S & C America supplies demand from China and Europe. Global demand for these and other products (for example bananas from Ecuador and coffee from Peru) is therefore a major driver of deforestation in the region. South and Central America is placed in a difficult position, having global importance both in terms of biodiversity and food production. In some of the less stable states in the region, production of illegal crops such as coca and opium poppies are also significant drivers of deforestation, especially in the humid slopes of the Andes (Grau & Aide, 2008). It has been estimated that as much as 24% of deforestation in the Peruvian Amazon can be attributed to coca production (Moran, 1993).

Despite the dominance of export agriculture as a deforestation driver in the region, agriculture for local and national markets still plays a significant role in forest destruction. In many cases small scale farmers, out competed by large scale commercial growers sell cleared land then move on to clear new areas.

Deforestation is closely linked to access and the building of roads (Soares-Filho *et al.*, 2006). Rates of deforestation in S & C America, although high, are curbed by the limitations of the current transport network. Road construction which has led to significant deforestation includes the building of the BR163 in Brazil which goes from Cuiaba in Mato Grosso to the port of Santarem in Para. The road cuts through the heart of the Amazon. Plans to pave the entire length of the road under the Avança Brazil project will lead to increased deforestation, other things being equal (Fearnside, 2002). The Initiative for Integration of Regional Infrastructure in South America (IIRSA) program is an initiative involving 12 Latin American countries which will link up transport, energy and telecommunications projects. It has the potential to accelerate deforestation considerably (McCormick, 2007).

Timber extraction plays a relatively minor role as a cause of deforestation in the Amazon region compared with other drivers, but it is still significant. Extraction may be illegal, for example (Barreto *et al.*, 2006) estimated that 40% of Brazil's timber harvest comes from illegal sources. Selective logging is a major source of forest degradation throughout the region (Asner *et al.*, 2006), and has caused the near-disappearance of some species in certain countries (Escobal & Aldana, 2003).

Gold mining has been associated with the Amazon for a long time (Kirby *et al.*, 2006). Mining causes forest degradation, often through the large scale use of toxic chemicals. Venezuela, Peru, Bolivia and Ecuador are all experiencing deforestation as a result of exploration for oil (Finer *et al.*, 2008). Fire is a significant cause of deforestation in S and C America. It is usually instigated by humans, occurring along road networks and in areas next to settlements (Cochrane & Barber, 2008). Many global climate models predict a drying out and a warming of the Amazon region in the coming decades with some estimates as high as 10°C in 2100 (Cox *et al.*, 2004). Climate change and subsequent incidence of fire are therefore likely to increase in importance as drivers of deforestation in the region in the future.

Since the mid-2000s, the Brazilian government has made considerable efforts to reduce deforestation through the creation of more than 20 million hectares of parks and indigenous reserves (Nepstad *et al.*, 2006). Smallholder organisations have also been important in creating a mosaic of protected areas, particularly in Pará state. This, together with changes in economic trends, has reduced national deforestation rates by an estimated 50% from 2004 levels.

Drivers of deforestation in Africa

African forest cover in 2005 was estimated at 6.35 million km^2, approximately 16% of the global forest area. Net annual forest loss was about 40,000 km^2 for the period 2000–2005 accounting for almost 55% of the global reduction in forest area. Forest cover in Africa is distributed unevenly among the different sub regions and countries (FAO, 2006). Following the Amazonian forests, the forests of the Congo Basin in Central Africa constitute the second largest area of dense tropical rainforest in the world, stretching from the coast of the Gulf of Guinea in the west to the mountains of the Albertine Rift in the east, and covering about seven degrees of latitude on either side of the equator. Since 1990, forest cover in Africa has been declining significantly, although there are a few

African countries in which forest cover is increasing or marginally improving, particularly the "low forest cover" countries of Northern Africa (FAO, 2006).

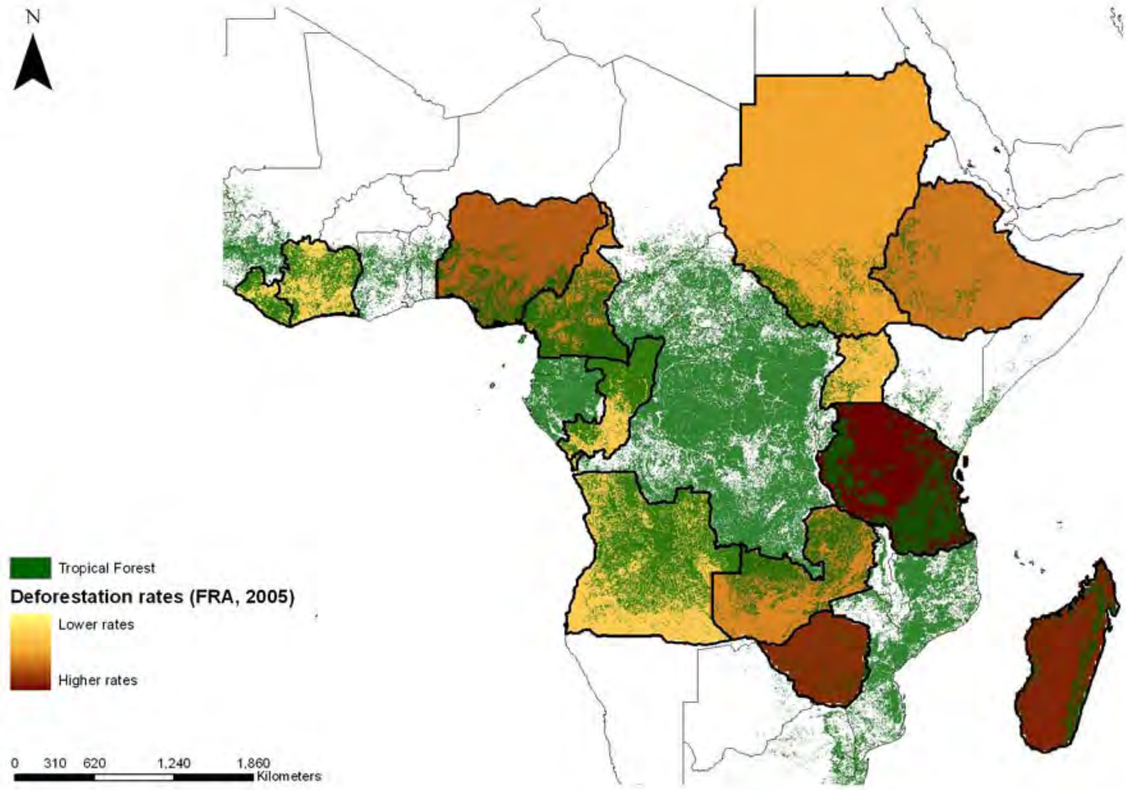


Figure 12. Map of main deforestation areas in Africa.

Conversion of forests into agricultural land is the main direct cause of deforestation in most African countries. Case studies from the Democratic Republic of Congo, Zambia, Cameroon and Madagascar suggest that shifting cultivation is leading to accelerated deforestation, although some studies question the dominant narrative amongst policy experts, non-governmental organizations and many scientists, that the practice of shifting cultivation is a principal cause of deforestation in tropical Africa (Jarosz, 1993; Ickowitz, 2006). Expansion of agricultural land for cash crops, such as sugarcane in Uganda, coffee and cocoa in Cameroon, maize in Madagascar, *khat* in Ethiopia, or oil palm in the Democratic Republic of Congo, is also an important driver of deforestation in Africa. Such agricultural practices are associated with population growth, migration due to war and structural adjustment policies imposed from externally.

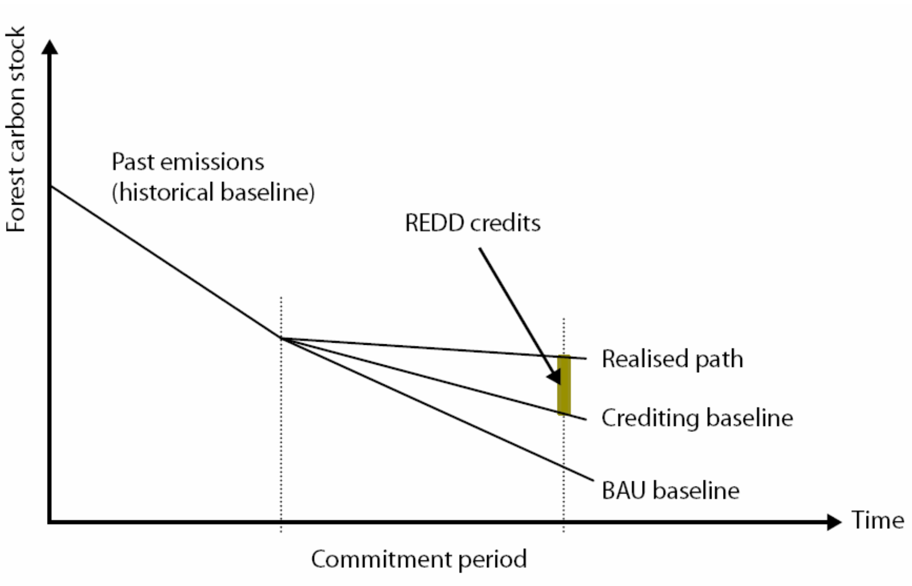
Logging, either legal or illegal, has been identified as being destructive to the tropical forests of Africa as it is the most important cause of forest degradation. Although selective logging removes only a small percentage of trees, it may trigger large scale deforestation through migration which leads to extensive agricultural practices. In the Democratic Republic of Congo (DRC), for example, a deal was struck with a logging corporation controlled by the Zimbabwean Army and Forestry Commission, in exchange for Zimbabwean President Robert Mugabe's pledge to help the DRC defeat rebels in the eastern part of the country. Logging is also important in Gabon, whose population is highly urbanised due to oil revenue, with little pressure from subsistence agriculture. With the drop in oil prices, however, pressure from logging may increase. The heavy dependency of most of the African population on fuelwood for energy also increases pressure on forest resources. Since the end of the war in the Republic of Congo in 2003, for example, production of charcoal and firewood has become profitable in the southern part of the country.

Chapter 4: Methodologies for establishing country-specific REDD+ reference emission levels

Introduction

Essentially the problem of estimating baselines boils down to being able to predict what deforestation rates or emission rates would have been in the absence of measures to reduce deforestation or forest degradation. There is significant experience in setting baseline levels for mitigation in other sectors (e.g. energy, landfill gas, etc.), and for afforestation and reafforestation , which may have relevance for avoided deforestation baselines, though these are baselines at the project, rather than the national level.

Although the determination of REDD+ baselines is often thought of as being a technical issue, it is important to appreciate that, as the particular baseline choice will have a big impact on benefits a country will receive from emission reduction credits based on the interpretation (which may involve negotiation) of principles such as *common but differentiated responsibilities* and *relevant national circumstances*. In this context, Angelsen (2008, p5) usefully distinguishes between three types of baseline: (a) the *historical baseline*, which is the rate of deforestation and degradation (or the corresponding GHG emissions from these) over a certain time period in the past; (b) the projected *business-as-usual (BAU) baseline*, which is how emissions from deforestation and degradation evolve in the absence of any REDD+ activity and is the benchmark from which the impact of REDD+ measures that were implemented can be assessed , and (c) the *crediting baseline*, which is the level at which REDD+ payments would start. The difference between the BAU baseline and the crediting baseline reflects the degree of own action by the country. Determining *BAU baselines* is in principle a technical issue, whereas agreeing and setting *crediting baselines* probably will be more a matter of negotiation.



Pirard & Karsenty (2009) consider three main categories of REDD+ baseline: (a) predicted based on sophisticated models, (b) extended based on historical trends with or without adjustment factors, or (c) negotiated based on existing carbon stocks at the start of the crediting period. Baseline estimation approaches in the first two categories are not very reliable because of the unpredictability of deforestation drivers (e.g. international commodity prices) and the complexity of interactions between them , while those in the third category are clearly subject to political pressures with a risk that objectives are eventually inflated (Combes Motel *et al.*, 2008).

Review of existing baseline methodologies

Project-specific baselines

Early approaches to estimating baselines were *project-specific*, focusing on changes in land-use and carbon densities within a defined project area (Sathaye & Andrasko, 2007). Despite the development of the *Greenhouse Gas Protocol for Project Accounting* for estimating project-level GHG savings (WRI/WBCSD, 2005), there is still considerable variation in the actual methodologies used to estimate project-specific baselines, which can include the use of satellite images, transition matrices, and/or simple extrapolation of historical trends. In CDM afforestation and reforestation projects, for example, three methodologies are stipulated: (a) historical or actual changes in carbon stocks (e.g. the Costa Rican Protected Areas Project, Busch *et al.*, 1999), (b) changes in carbon stocks brought about through an economically attractive land-use change (taking into account barriers to investment), and (c) changes in carbon stocks brought about by the most likely land use change at the time of the start of the project. Chicago Climate Exchange (CCX) Forestry Offset Projects, on the other hand, used average annual emissions or uptake during 1998–2001 as the baseline for the commitment period of 2003-2010. Tipper (2008) additionally includes scenarios based on business plans (e.g. of agribusinesses in Belize), prevailing technology or practice (e.g. logging in Malaysia), and risk-based modelling – i.e. the likelihood of a particular land parcel being deforested depending on factors such as distance to roads, slope, proximity to agriculture, etc.

The *project-specific* approach for estimating baselines was found to work well for large contiguous projects, but it could be tedious for groups of heterogeneous small projects covering large areas (Sathaye & Andrasko, 2007). Other problems identified included the fact that different baselines could be used for almost identical projects within the same region, and the high costs involved in baseline estimation due to the need for it to be done for each project, which may limit the attractiveness of such projects to potential investors, particularly in the case of small projects. In relation to REDD+, the main limitation for project-specific approaches is that of leakage – there is the risk that any emission reductions within the project area lead to increases somewhere else in the country, or even internationally. However, project-specific approaches may have a role in the mechanism described by Prior *et al.* (2007), which is discussed below.

Regional baselines

Land use change is driven by socio-economic factors that operate at a broader scale than individual projects, leading to the development of *regional baselines*. Sathaye & Andrasko (2007) have assessed the usefulness of such baselines for various tasks in comparison to *project-specific baselines*, from which they have developed the concept of *Stratified Regional Baselines* (SRBs) which recognise heterogeneity in carbon density, land use change, and other key baseline drivers, but also aim to identify land use parcels with relatively homogeneous characteristics. They argue that regional baselines are more objective, standardised and transparent, and cheaper in that their cost can be spread over many projects.

As an example of this approach, Tipper & de Jong (1998) used satellite imagery to determine historical deforestation rates in Chiapas, Mexico, and found they varied from 0.4% yr^{-1} to 2.3% yr^{-1} over a 22-year period from 1974. To smooth these fluctuations, they suggested using an average of 1.6% per year over the whole region, and used this value to develop a regional baseline by simple extrapolation of this rate into the future. They subsequently refined the approach to take into account two variables – i.e. distance of a parcel of land from roads and from farms, thus making it more site-specific. In a comparison of the three methods (i.e. extrapolation of project-specific historic rates, use of a single regional average rate, and the average rate modified by the two variables, de Jong (2002) found that the first gave the lowest rates (through not taking local context into account), the second the highest rates (due to the project area having lower deforestation rates than the average), while the third was intermediate.

More recently, Tipper (2008) has proposed an approach to predict the likelihood that a specific forest-containing pixel on a spatial land use map will be deforested (and hence use this to estimate a BAU baseline, based on four attributes:

- Accessibility: Local actors able to reach the area. In gently undulating terrain with no major barriers this may be 10 km from existing roads; whereas in montane regions it may be 3 km from existing roads, tracks or settlements.
- Cultivability: Land can be used for subsistence or commercial crops. In areas where large scale farming is expanding practices this may be defined by soils suitable for ploughing or mechanised agriculture. In areas where subsistence agriculture is predominant it may include any soils capable of supporting a subsistence.
- Extractable value: Forest biomass has economic value. At least 50% of the woody biomass consists of material with economic value greater than the cost of extraction. This may include woodfuel/charcoal, timber, poles and forage.
- Unprotected: Not within national protected areas, or private landholdings where forest conservation laws are effectively enforced.

He has termed this the ACEU approach, using an acronym of the four attributes. However, it is not clear how the rules relating these attributes to the probability of deforestation would be parameterized, or how the model would be validated, although historical time-course data on the four attributes and deforestation rates could be used for the former. The approach would require reasonably detailed spatial data (road maps, soils, biomass estimation, protected area maps), which may not always be available in many developing countries, and there is also no guarantee that the relationships derived from the data will remain the same in the future (as with most forecasting approaches), or for that matter, be extrapolated to other regions. The approach should be tested to see the accuracy with which it predicts deforestation rates.

Bird (2008) proposes a simpler approach to estimating regional baselines, based on a restricted set of likely land use changes in a region. Noting that some land use conversions cause little change in carbon stocks, some land use conversions do not occur, and that other conversions (negative carbon stock changes) can be conservatively ignored, he argues that the only conversions that are significant in terms of positive carbon stock changes are grassland into forest, cropland into forest, and cropland into grassland. The likelihood of these conversions occurring is modelled using binomial probability theory. The approach still needs to be assessed in practice.

At a larger scale, Rametsteiner *et al*. (2008), estimated regional deforestation rates statistically using forest share, agricultural suitability, population density and economic wealth as independent variables. Sub-Saharan Africa was modelled to be responsible for about 50% of global deforestation emissions over the coming 20 years, while Latin America contributed 35% and Asia 12%, respectively.

Brown *et al*. (2007) compared three models using data from study areas in Latin America: Belize, Bolivia, Brazil, and Mexico to try to determine the most analytically feasible and credible approach to regional baseline estimation. The models they used ranged from simple extrapolations of past trends in land use based only on initial forest cover and on future population growth (model: FAC = Forest Area Change), to more complex models of land-use change driven by biophysical and socio-economic factors (models: LUCS = Land Use Carbon Sequestration, and GEOMOD). FAC was developed within the framework of the FAO Forest Resources Assessment Project in 1990-1994 to calculate changes in land cover for countries in which there were little or no data. The model assumes a logistic relationship between percentage non-forest cover and population density, and uses historical data on forest cover and associated population density to estimate the parameters of this relationship. It has the advantage that its data requirements are minimal, it is applicable to large regions, but it lacks spatial resolution, and also does not discriminate between urban & rural populations which caused some discrepancies between these outputs and those of the two other models. LUCS is also driven by population density, but, in addition, takes into account different land uses and managements – permanent, shifting agriculture, agroforestry, closed/open forests, plantations, and secondary forests. As the population grows, this places demands on these different land uses for production of food and fuelwood. The advantages of LUCS is its applicability to many scales, and its ability to model different types of land use and not just deforestation, but like FAC it lacks spatial resolution, and is also not very transparent for users, the model code and parameters being somewhat opaque (Brown *et al.*, 2007). GEOMOD was the most complex model used in the study, and attempts to simulate landscape dynamics in a GIS environment. It uses extrapolation of past rates of land use change, based on interpreted satellite imagery, and takes into account elevation, slope, soils, distance from rivers, roads, settlements to determine the spatial occurrence of land use change. The advantage of GEOSIM is that it is spatially explicit at a range of scales, but this means that it has large data requirements, and large number of parameters, many values of which can only be obtained by optimisation, which the model does by sorting many driver variables to find the best correlation to deforestation.

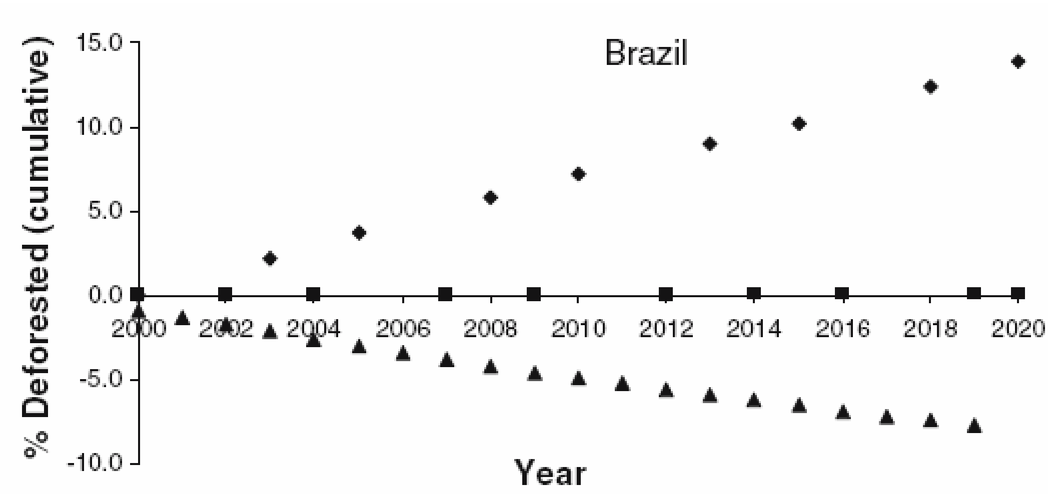


Figure 13: Cumulative % of initial forest area deforested for Brazil by each of the three models in Brown *et al.* (2007). Key: Diamonds: FAC; Squares: GEOMOD; Triangles: LUCS.

The comparison of models across six regions showed that each produced quite different deforestation baselines. In general, FAC, applied at the national administrative-unit scale, projected the highest amount of forest loss (four out of six regions) and the LUCS model the least amount of loss (four out of five regions). Perhaps more worryingly, for some of the regions, FAC predicted an increase in deforestation whereas LUCS predicted a decline {e.g. Brazil, Figure 13, \Brown, 2007 #5688}.

<u>Country-specific baselines</u>

Much of the discussion so far in relation to baselines for REDD+ purposes has been at the level of individual countries, as (a) data on forest cover is usually collated at the national level, (b) national governments are seen as the most appropriate entities for receiving funds from international sources of carbon finance, and (c) for making decisions and policies to reduce rates of deforestation, and (d) that problems of leakage would be minimised. As mentioned in the Introduction, Santilli *et al*. (2005) were the first to propose the use of national baselines, with reductions in deforestation rate below this rate being able to earn the country carbon credits at the end of a commitment period which could be sold on international carbon trading markets. The approach is not necessarily straightforward.

Firstly, long-term historical data on forests often do not exist. Even for countries where time series of deforestation data do exist, there can be substantial year-to-year variation. A proportion of this variation will be due to errors in the way that forest cover is measured and deforestation rates are calculated (Grainger, 2008), but a proportion is likely to be real, as deforestation is the multi-causal outcome of many different processes which in themselves may vary from year to year. Annual fluctuations can be smoothed by, for example, using running averages (e.g. last three years), but there may also be systematic trends over longer periods (e.g. 5-10 years) which may depart from past deforestation rates (Angelsen, 2008). If such discontinuities do exist, then there is a need to find out what has caused them, possibly limiting the data for baseline estimation to that from the inflexion point onwards (Sathaye & Andrasko, 2007). It has been suggested by some countries that at least five years of data be used, whereas other countries have suggested at least ten years, with recalculation of future emissions every three years (Herold & Johns, 2007).

Secondly, future deforestation rates will not necessarily be the same as those in the past, so pure linear extrapolation of historical deforestation data into the future may be simplistic. Apart from anything else, the rate of deforestation is often related to the amount of forest remaining and the ease of its extraction, and will tend to drop anyway as less and less forest remains and the cost of reaching that which is left increases (Skutsch *et al.*, 2007). The prevalence of the forest transition curve suggests that this will often be the case. Other factors driving deforestation are also likely to change, and for the BAU baseline to be realistic, relevant socio-economic and biophysical trends should be taken into account. At the national level, potential variables that have been shown to be influential include population density and growth, forest area, economic growth, commodity prices, governance variables, and location (tropical and regional) (Angelsen & Kaimowitz, 1999; Combes Motel *et al.*, 2008). More locally, distance to farms and roads, sawmill concentrations, export markets, etc. have been shown to be important (Sathaye & Andrasko, 2007), and the aggregate effect of proximity may therefore have a national effect. Having adjustable baselines to allow for changes in timber markets, forest laws, rates of deforestation, availability of new satellite data, etc. may be one way to address this (Sathaye & Andrasko, 2007).

Thirdly, if crediting baselines are too high, ‘hot air’ may be created, in which countries receive credits for no additional action, thereby devaluing the price of carbon. From one perspective this benefits both sellers and purchasers of carbon credits, as more credits can be generated, but it makes no difference to changing deforestation rates *per se* (FOEI, 2008), and increasing the volume or availability of offset credits without commensurate commitments makes it easier for developed countries to offset emissions instead of reducing their own emissions at home. On the other hand, if crediting baselines are too low, the financial inducement to reduce deforestation and degradation may be too small for countries to take it seriously. In both cases, the environmental integrity and credibility of REDD+ could be undermined (Angelsen, 2008). A balance needs to be found that is both effective in reducing emissions and acceptable politically.

Fourthly, consideration needs to be given those countries that have stabilized their forest stocks, and which argue, not unreasonably, for some sort of incentive needs to be given to maintain stabilization in the face of increased pressure to deforest, especially if the deforestation rate has been reduced elsewhere.

There have been attempts to address these issues. For example, a modification of the Santilli Compensated Reductions approach would use a target range instead of a baseline, in which lower and upper emission targets are defined, with countries receiving full carbon credits below the lower target (Schlamadinger *et al.*, 2005; FOEI, 2008, p22). This fraction diminishes as emissions increase above the lower target, which reflects the growing uncertainties concerning the real emission reductions compared to the baseline scenario. If emissions are above the upper target, credits are no longer issued.

Chomitz *et al*. (2007) took a simpler approach and suggested that the baseline could be based on a standardized estimate of the rate of increase in agricultural production, adjusted for an estimate of the rate of increase in agricultural productivity as well as the mean carbon content of forestland at the agricultural margin, with separate estimates being made for logging-related emissions and the rate of abandonment of current lands. Countries would be paid per tonne of carbon they store above the reference level from the start of the monitoring period, with the price being per tonne-year (i.e. the carbon price, $/tonne C multiplied by the annual interest rate).

More recently, it has been proposed that a Development Adjustment Factor (DAF) based on, for example, GDP per capita, be used. Angelsen (2008) has listed a number of arguments for this, which include:

1. the poorest countries are at an earlier stage in their forest transition curve (Figure 7), and therefore deforestation (and degradation) is likely to accelerate rather than slow down in a BAU scenario,
2. the capacity to implement REDD+ is likely to be inversely related to GDP per capita,
3. based on the UNFCCC principle of common but differentiated responsibilities, the REDD+ requirements should be lower for the poorest countries,
4. REDD+ should contribute to a transfer of resources to the very poorest countries because of co-benefits.

<u>Global baselines</u>

A problem with using historical data to estimate baselines is that countries with high forest cover but low deforestation rates are potentially penalised (da Fonseca *et al.*, 2007). However, avoiding deforestation requires both reducing high forest conversion rates and preventing forest conversion processes where they have not started, and arguably in the face of increased pressure. Achard *et al*. (2005) and Mollicone *et al*. (2007a) have therefore proposed the use of global baselines (GCR) as part of a two-tiered system using forest area and forest area changes as activity input data. Countries with high deforestation rates would be required to reduce their rates below a national baseline (NCR), whereas countries with low deforestation rates would only be required to keep their rates below a fraction – say 50% of the GCR. Countries would be categorised according to the ratio between the NCR and GCR (i.e. high: NCR>GCR/2, low: NCR<GCR/2). Degradation (as opposed to deforestation) is addressed by subdividing forested area into two further categories – *intact* (i.e. primary or pristine) and *non-intact* forests (intervened). They identified six criteria to define the intact forest area: (a) situated within the forest zone; (b) larger than 50,000 hectares and with a smallest width of 10 kilometres; (c) containing a contiguous mosaic of natural ecosystems; (d) not fragmented by infrastructure; (e) without signs of significant human transformation; and (f) with a natural fire regime. Carbon densities of the intact sub-category are taken from the literature (e.g. Achard *et al.*, 2004; Houghton, 2005), while those of the *non-intact* forests were taken to be half of the intact forests. Examples of how this approach would be applied to Brazil, the Democratic Republic of Congo, and Papua New Guinea are given.

Da Fonseca *et al*. (2007) categorise tropical forest countries into those with high forest cover but low deforestation rates (HFLD), those with high forest cover and high deforestation rates (HFHD), those with low forest cover and low deforestation rates (LFLD), and those with low forest cover but high deforestation rates (LFHD) (Figure 14). They make the point that if a recent historical reference rate is used as the basis for awarding carbon credits for reductions of emissions by deforestation, HFLD countries would have little potential for obtaining REDD+ credits, and would also have little potential to obtain reforestation credits under the Kyoto Protocol's Clean Development Mechanism that LFLD countries would have. HFLD countries would therefore have little incentive to maintain low deforestation rates, and indeed, deforestation reduced elsewhere could shift to these countries as they attempt to obtain income in other ways than carbon credits, so that overall net reduction in GHG emissions from deforestation would be less than it could be. To address this problem, they suggest the use of global baselines further to allow HFLD countries with high forest cover but low deforestation rates to benefit from 'preventive credits' if they kept their deforestation rates below a baseline pegged to the global baseline rate. If they exceeded this rate, they would forego receiving these credits. Such preventive credits should provide a barrier to new forest exploitation or policies that promote or allow deforestation.

	Low Forest Cover (<50%)	High Forest Cover (>50%)
High Deforestation Rate (>0.22%/yr)	*Quadrant I* e.g., Guatemala, Thailand, Madagascar High potential for RED credits High potential for reforestation payments under CDM Number of countries:44 Forest area: 28% Forest carbon (total): 22% Deforestation carbon (annual): 48%	*Quadrant III* e.g., Papua New Guinea, Brazil, Dem. Rep. of Congo High potential for RED credits Low potential for reforestation payments under CDM Number of countries:10 Forest area: 39% Forest carbon (total): 48% Deforestation carbon (annual): 47%
Low Deforestation Rate (<0.22%/yr)	*Quadrant II* e.g., Dominican Republic, Angola, Vietnam Low potential for RED credits High potential for reforestation payments under CDM Number of countries:15 Forest area: 20% Forest carbon (total): 12% Deforestation carbon (annual): 1%	*Quadrant IV - HFLD Countries* e.g., Suriname, Gabon, Belize Low potential for RED credits Low potential for reforestation payments under CDM Number of countries:11 Forest area: 13% Forest carbon (total): 18% Deforestation carbon (annual): 3%

doi:10.1371/journal.pbio.0050216.g001

Figure 14: Categorisation of tropical forest countries according to degree of forest cover and deforestation rate (from da Fonseca *et al.*, 2007).

Strassburg *et al*. (2008) took this further and proposed a hybrid system of incentives involving both individual national baselines and a global average baseline. Countries would receive two types of incentive – firstly, credit for reductions in deforestation rate below their own historical rates, and secondly for reductions below the global average. The combined incentive for a country would be the sum of these two incentives. The total amount of incentives available would be calculated as the Global Baseline Emission minus the actual Global Emissions for that year, multiplied by the price of carbon, which would then be distributed *pro-rata* to each of the countries according to the combined incentive. The relative importance of the two incentives could be adjusted by a factor (α), which at one extreme is similar to the Compensated Reductions proposal of Santilli (2005), and at the other scheme to the JRC proposal (Mollicone *et al.*, 2007a). Since both incentives are offered to all countries, so there is no need to categorise them into classes as the JRC proposal does (e.g. high- and low-deforesting countries). Moreover, as both incentives are simultaneously offered, both high and low deforesting countries are rewarded – a country with high deforestation rates will have an added incentive to go below the global average while low deforesting countries will also receive more if they reduce even further their deforestation rates

Other approaches

A workable mechanism has to be developed, and there are a number of issues that need to be resolved. Forest degradation is one of these. Whilst remotely-sensed and/or forest inventory data may be used to monitor changes in forest extent, and hence rates of deforestation, most countries do not have time series data of changes in the carbon density of forested areas caused by degradation, so that calculating baselines based on historical trends is difficult, though proxies linked to indicators of degradation could be developed. Alternative approaches obviating the need for baselines altogether have also been proposed. For example, Prior *et al*. (2007) proposed allocating a finite number of carbon credits to participating countries based on the amount of carbon stored in a country's forestry resources in a base year. A portion of these forest resources are put into a reserve, with the remaining forest areas outside the national reserve being put under permanent protection or management funded by the carbon credits received, and being eligible for generating further credits that can be traded in the global carbon market. Advantages claimed were that it allows both public and private entities in developing countries direct access to carbon finance if they establish protection systems over their forest resources, and that this finance was available up front rather than being paid at the end of a commitment period.

In their Compensated Successful Effort approach, Combes Motel *et al*. (2008) attempted to bypass the problems associated with estimating baselines by suggesting linking carbon finance to efforts rather than to results. They distinguished between structural variables (economic development, population, initial forest area, agricultural export prices), which a country can't do anything about, and domestic policies and measures which a country can do something about. The used an econometric model to predict the evolution of the structural variables, with the residuals between model prediction and observed deforestation rates assumed to be the policies and measures. They proposed that credits or debits be estimated *ex post* at the end of the crediting period so that changes in the structural variables over this period could be taken into account, and should also be relative to other countries. Inclusion of initial forest size as a structural variable would allow credit to be given to those countries that have not yet started to deforest, and to those that have already begun to reforest (e.g. Costa Rica).

Pirard *et al.* (2009) list other issues that need to be addressed, which include (a) issues with combining coarse resolution national baseline information with highly detailed remotely-sensed data, (b) large uncertainties in predictive baselines due to insufficient knowledge on the drivers of deforestation, particularly how some of these (e.g. agricultural commodity prices) will behave in the future, and (c) difficulties in relating specific public policies to reductions in deforestation rates. Like Combes Motel *et al*. (2008), Pirard *et al.* (2009) suggest that funds are made available as carbon finance for reinforcing multi- and bilateral instruments that relate to forest management in developing countries, with a focus on the correction of governance deficiencies.

Estimating reference levels for main deforesting countries

Datasets used

Chapter 2 summarises numerous data sets which contain forest-related information. However, it is difficult to find nationwide data with historical values at a global scale. The most commonly used data are from the Food and Agriculture Organisation of the United Nations and its Forest Resource Assessments (FAO, 2001; FAO, 2006). More recently a global land-use data set with an acceptable resolution (300m) was made available (GLOBCOVER, Arino *et al.,* 2007). While it is possible to derive forest cover information from the GLOBCOVER data set, some assumptions are needed about what is defined as forest and on how the classification was made. Analysis of drivers will likely show different permutations and combinations of drivers in different parts of the world – with the added complexity that the drivers themselves are likely to change and that they cannot be safely extrapolated into the future. Table 5 lists examples of potential explanatory variables available at the national level, though this does not include some interesting drivers such as proximity to road infrastructure. It would be useful to develop summary indices of local drivers like these that could be used in combination with national data.

Table 5: **Data that can be used in assessment of drivers of emissions and of opportunities for emission reduction**

	Name dataset	**Organisation responsible**	**Type of information**
Biophysical and Soil Data	SRTM	CGIAR-CSI	Digital elevation information
	FAO GeoNetwork	FAO	Different information provided with spatial dimension.
	EUSDAM	JRC- EU	World soil map
	ISRIC/WISE database		Maps and soil profile dataset
	IGBP-DIS		
	Soil map of the World	FAO-UNESCO	Soil map
	ORNL DAAC Soil datasets		Soil information
Demographic data	FAOSTATS	FAO	Population information and statistics including future projections
	Population data	WRI	
	Population data	CIESIN	
Economical Data	various	World Bank	Information on key economical statistics, such as GDP or GNI
	FaoSTATS	FAO	Information on production and income of different goods and services
Social Data	Corruption Index	Centre for corruption research	Information on the corruption level of different countries
	Human development Index	UNDP	Measure of the development of a country
Emission and C sequestration	Orbiting Carbon Observatory	NASA	
	Climate Analysis Indicator Tool	WRI	Information on the level of emissions in the past years due to land use changes and other sources.

Values for the forested area reported in the FAO datasets from 1948 to1963, the FAO Forest Resource Assessment (FRA) datasets from 1981, and the GLOBCOVER datasets are plotted below for the countries included in this report. The GLOBCOVER dataset has two scenarios based on which original land use classes were considered as forest. The first scenario includes the areas originally classified as broadleaved or coniferous forest (open, open to closed and closed). The second scenario also includes the areas originally classified as mosaic of forest with other wooded areas, e.g. shrub-land. Thus the values of the second scenario are always higher than the values of the first. Figure 15, Figure 16 and Figure 17 show the percentages of forest cover for each region for the four data sources. Considerable disagreement can be seen, even between the FAO and FRA values. It is therefore difficult to evaluate the results of the models using such data, as the variability is important and it becomes a question of which index to use. In the analysis which follows the FAO and/or the FRA data were used for consistency and comparison with previous studies (Grainger, 2008).

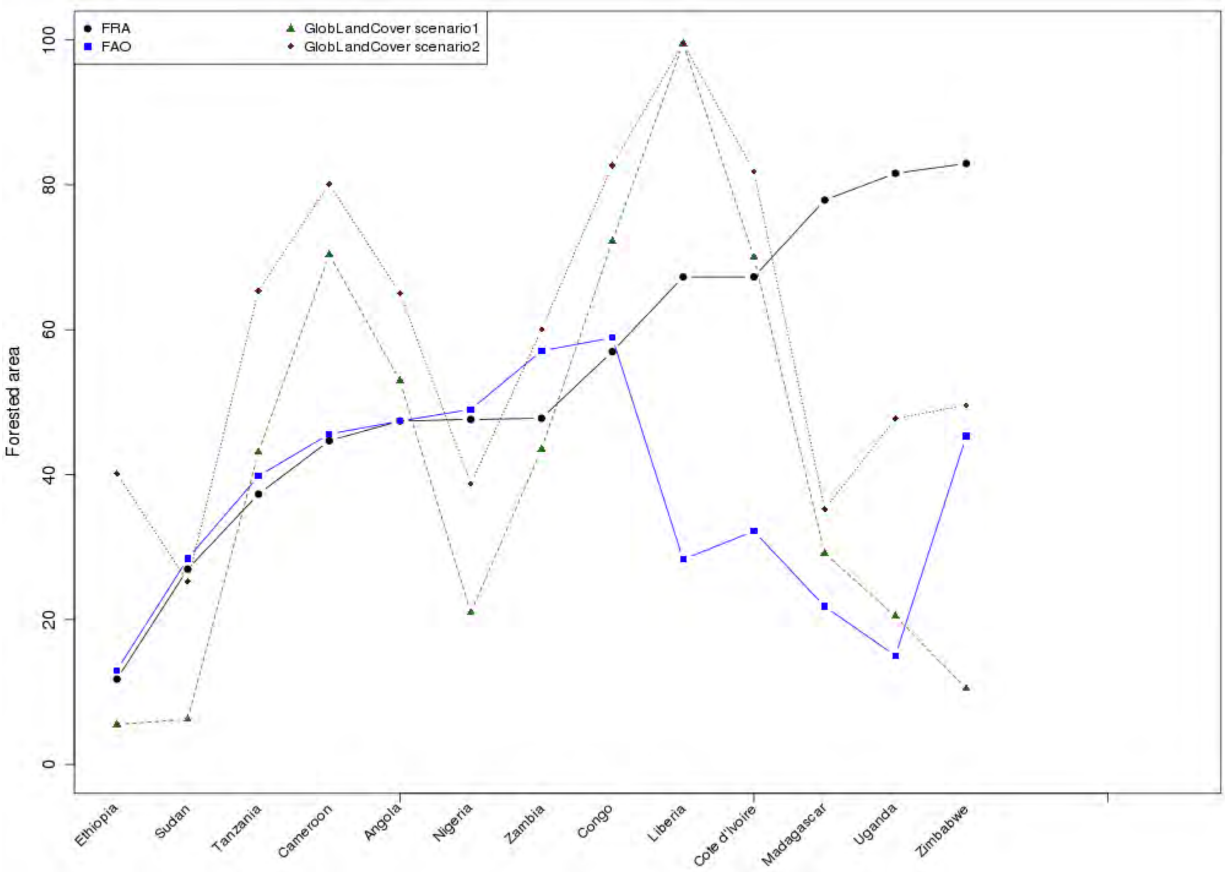


Figure 15 Africa: Plot of the forested area (%) according to different data sets

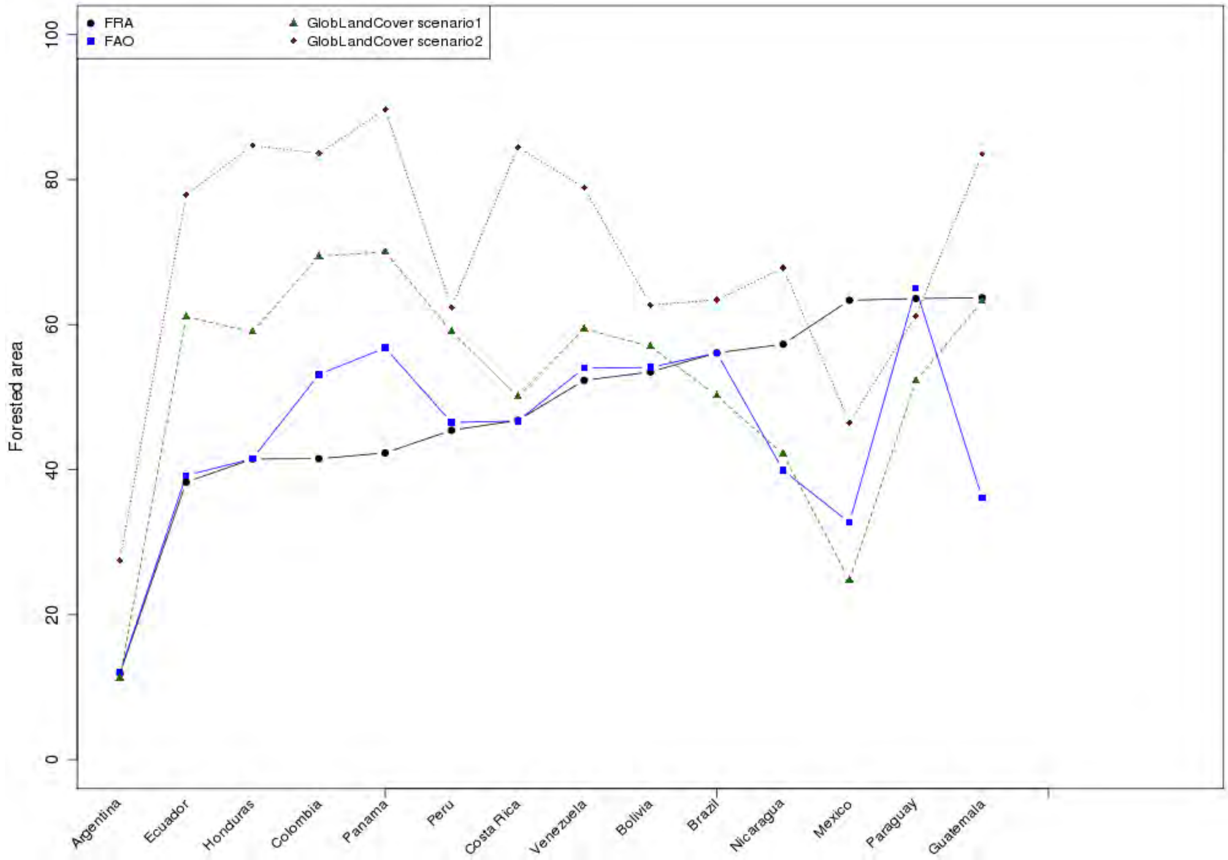


Figure 16 South America: Plot of the forested area (%) according to different data sets

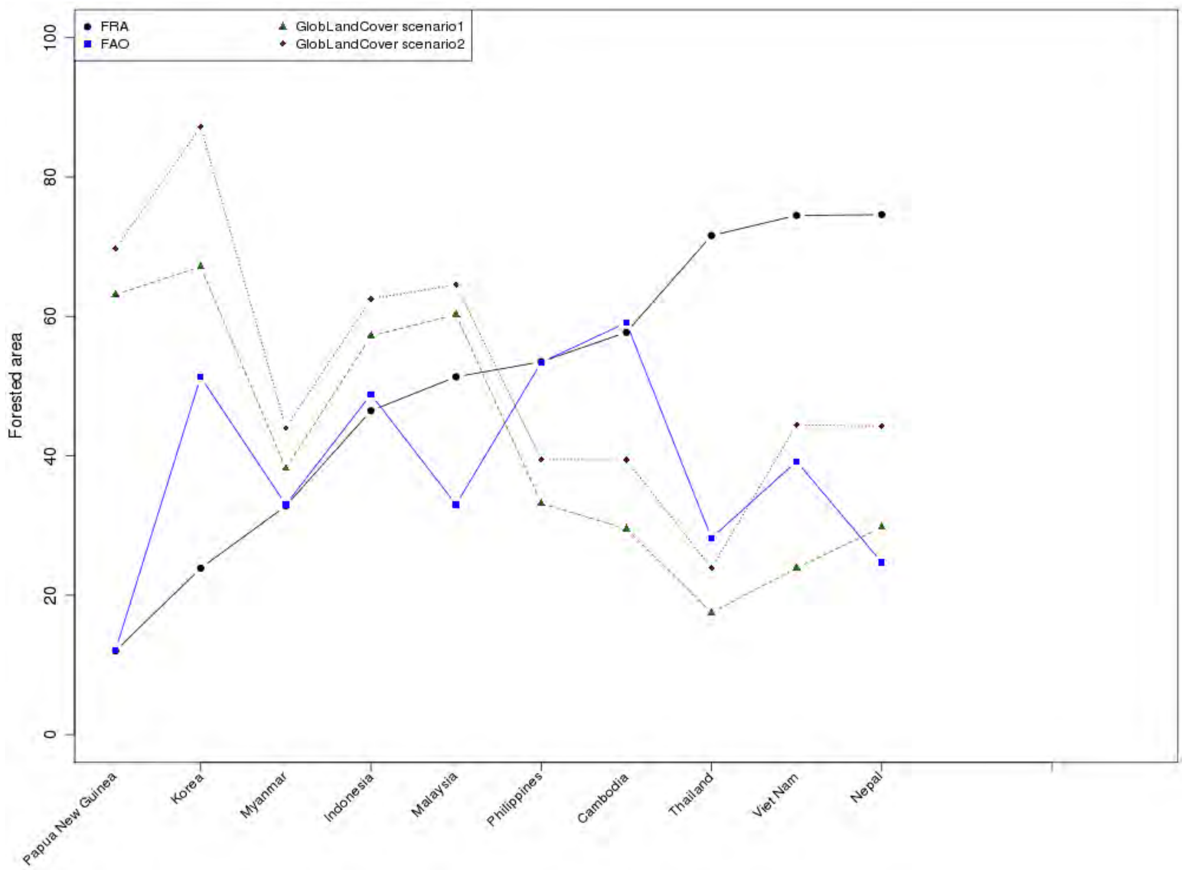


Figure 17 South-East Asia: Plot of the forested area (%) according to different data sets

Baseline models

Firstly, available FAO/FRA data were explored with linear regression methods. Various socio-economic variables were used as explanatory variables in order to try to increase the reliability of the model fit and of subsequent prediction. Among the variables examined information about the population (i.e. population density, % rural / urban population) was most significant. In Figure 18, the percentage of forested land (using the FRA values) is plotted against the population density showing a linear trend for the different countries considered. Only three historical data points were available for each country; which effectively precludes fitting any more complex a relationship than a straight line. With a large number of different countries, a standard linear regression approach is not appropriate; fitting a separate line for each country (the only sensible option given the evidence from Figure 18) is too inefficient, and the errors involved in fitting straight lines to three points are large. A better approach is to find a method to make more efficient use of the data, by pooling information across countries in some manner.

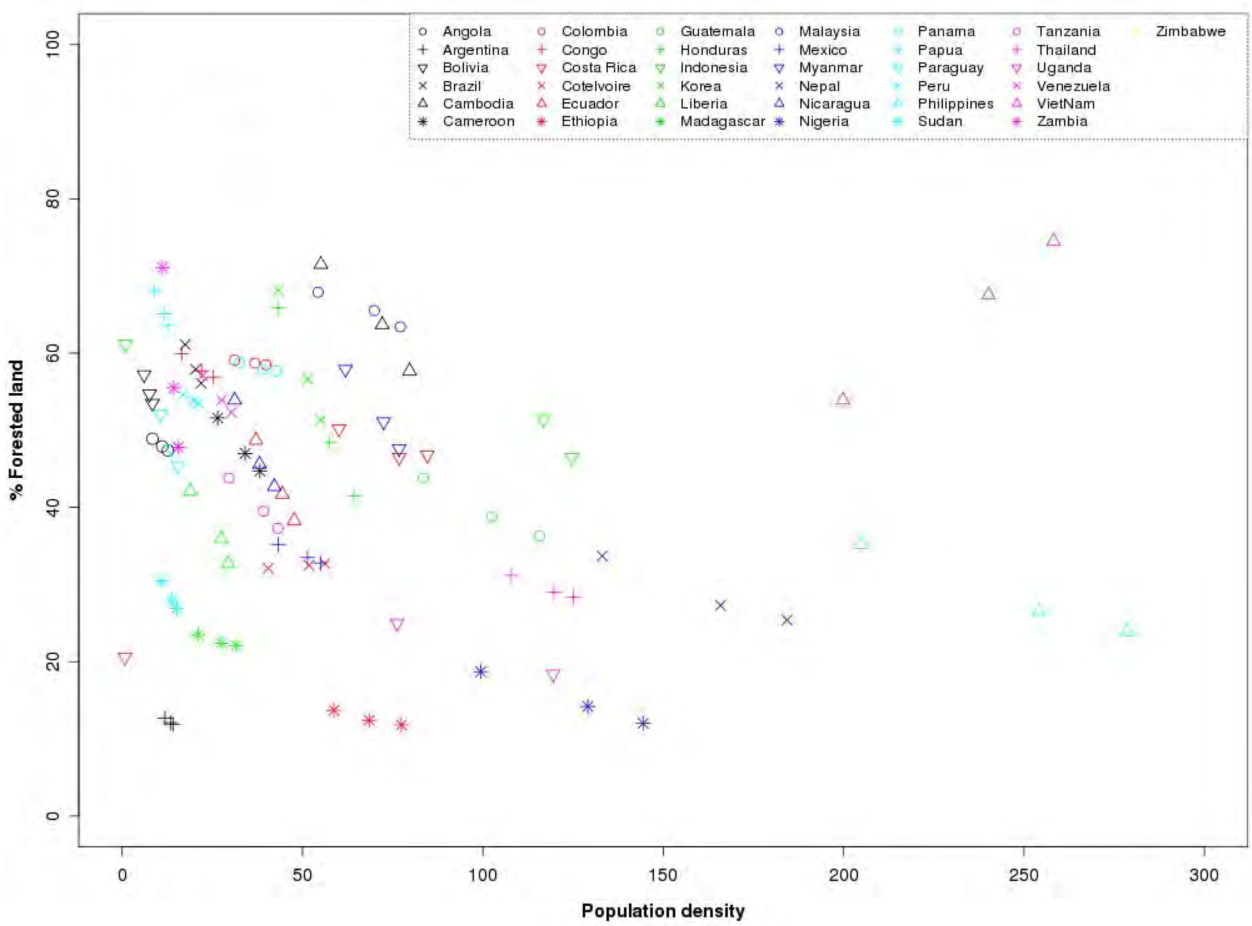


Figure 18: Scatterplot of forested area (%) against population density (pop./km^2) for the countries considered.

A linear mixed-effects model as described in Lindstrom & Bates (1990), was used to do this. Mixed-effect models describe situations where both fixed and random effects are present, making efficient use of data when similar relationships are to be fitted to multiple groups in a data set; in the current context the groups may be countries, continents, or some other categorisation. The efficiency gain is achieved by regarding the existence of common means (or in a regression situation, common slopes and/or intercepts) with random perturbations around those means explaining the differences between countries. Consequently, rather than having to find a regression intercept and slope for each country, we find a single common (average) intercept and slope and treat the deviations for each country away from the averages as another layer of residuals. The result is that many fewer parameters need to be estimated. We can extend the layering further: for example, rather than using a single common (average) intercept and slope for all countries, we could use a separate pair for each continent. Details on mixed-effects modelling can be found in Pinheiro & Bates (2000).

The models were first fitted having one layer for the countries, and then introducing a nesting involving a common (average) straight line according to groups composed of:

- geographical distribution based on continents
- similarity groups obtained via hierarchical clustering performed using two sets of variables:
    1. the forest set: including information describing the forest status[3] of the considered countries in 2005 according to the FRA dataset.
    2. the complete set: including the forest set and also socio-economics variables such as population description, GDP and growth rate.

The results of the clustering are presented in Figure 19 for the forest set and in Figure 20 for the complete set; the derived groupings (clusters) are shown via different shadings on the maps. The cluster classes were robust with very low measures of uncertainty for the individual classifications. Interestingly, the classes do not follow the geographical distribution of the considered countries, especially for the clustering based only on the forest set.

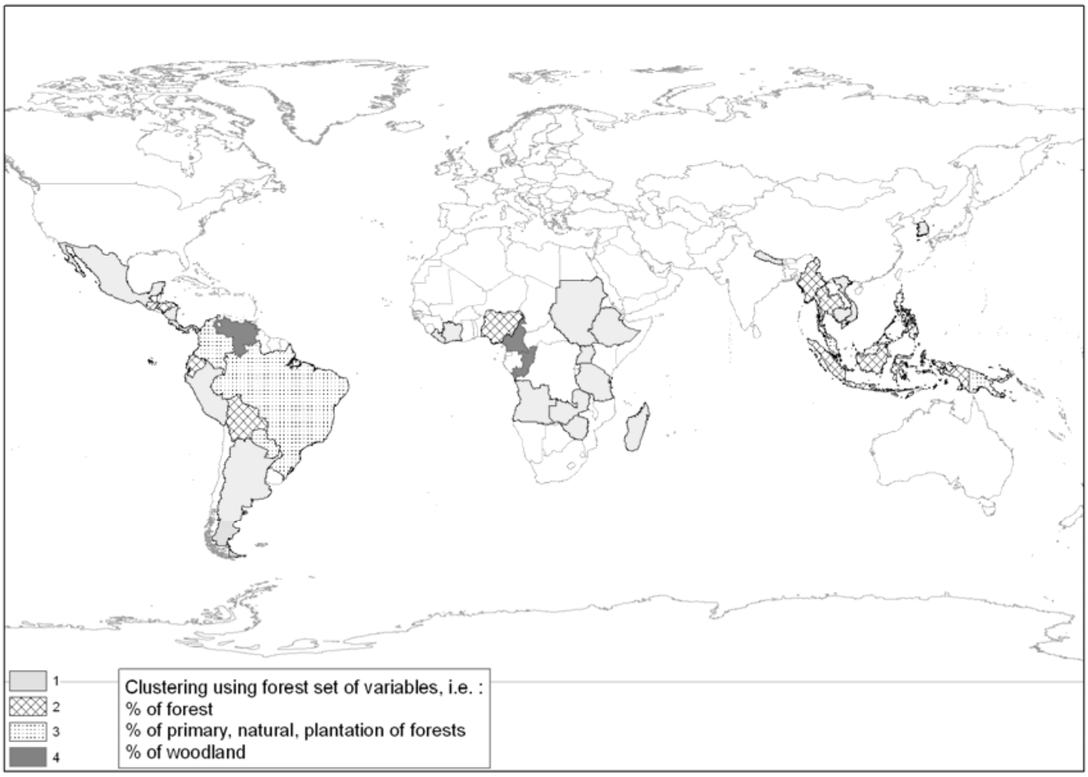


Figure 19. Hierarchical clustering using a set of variables describing the forest situation in the countries considered.

[3] Forest status refers to the amount of primary forest, natural forest and plantations

Figure 20: Hierarchical clustering using a set of variables describing the forest and the socio-economic situations in the countries considered. The different types of shading (and the numbers 1 to 4) represent the four different clusters obtained.

Mixed effects modelling

The variables included in the mixed-effect models are shown in Table 6, where × indicates the variables present in the corresponding model. These variables as well as projections for future years are available globally. Other drivers such as proximity to infrastructure were not included because data sets were not available.

Table 6. Indication of the tested models and variables included in each.

	Population density	**% Population that is rural**	**GDP**
Model 1	×		
Model 2		×	
Model 3			×
Model 4	×	×	
Model 5	×		×
Model 6		×	×
Model 7	×	×	×

The fitted models were compared in a pair-wise manner with likelihood ratio tests[4], and the resulting p-values are presented in Table 7. The most useful variable, as seen in Figure 18, has been the population density. The addition of the percentage of rural population appears to improve the fit of the model, i.e. model 1 versus model 4 gives a p-value slightly less than 0.05, so that the improvement is significant at the 5% level. Owing to the number of comparisons being made here, we should technically adjust the p-values to avoid finding spurious results favouring larger models by chance. However, this is unlikely to be a problem given that our main aim is prediction. The addition of GDP in the modelling did not significantly improve the fit of the models, e.g. model 4 versus model 7.

Table 7: P-values among the tested models. NA means that p-values could not be calculated because models have the same degrees of freedom.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Model 1	---						
Model 2	NA	---					
Model 3	NA	NA	---				
Model 4	0.0334	<.0001	<.0001	---			
Model 5	0.3848	<.0001	<.0001	NA	---		
Model 6	<.0001	0.8397	<.0001	NA	NA	---	
Model 7	0.1035	<.0001	<.0001	0.9200	0.0519	<.0001	---

Table 8: P-values for comparing models with a random effects term for country against an additional level of grouping, namely: continental; clustered groupings from the forest set; and clustered groupings using all variables. . An NA indicates the model could not be fitted.

		Continental	Cluster (forest set)	Cluster (all variables)
Country models	1	0.1237	0.9995	0.4768
	2	0.2110	0.4069	0.7009
	3	0.4816	0.6417	NA
	4	0.1431	0.8156	0.2763
	5	0.0991	0.9967	0.3963
	6	0.2141	0.4028	0.7079
	7	0.1392	0.8147	0.2758

The results of the test of hierarchical nested models are presented in **Error! Reference source not found.**, where the p-values shown result from (approximate) likelihood ratio tests comparing each of the seven fitted models with the same model having the addition of an extra layer of random

[4] One model can be compared with another by comparing twice the difference in their log-likelihoods with a X2 distribution; this provides a p-value for the test of the improvement in model fit being negligible. If the p-value is less than 0.05, we say the larger model of the two provides a statistically significant better fit. Otherwise, the smaller model (in terms of number of variables) is preferred.

effects, indicated by the column headings. In general this nested approach did not significantly improve the fit of the models. The geographical nesting shows slightly better results than the clustering, but this improvement is not statistically significant.

The tentative predictions to follow were based on model 4, without any nesting, so that only the percentage of population that is rural was used as a driver in subsequent modelling. The data on predicted population and percent of population that is rural were extracted from the FAOSTAT (FAO, 2009) database with long term (2010-2030) quinquennial series.

Predicted forest cover

In this study the population density and the percentage of population that is rural were considered, as output of the model analysis above. The results of the predicted forest cover based on the mixed-effect model considering these two variables are plotted for each geographical region in Figure 21, Figure 22 and Figure 23, with the error bars representing the uncertainty associated with each value. Individual country plots are given in Annex 2. The observed values in past years are represented with a solid blue line, the predicted values with a dotted blue line.

The plots show a high uncertainty mostly due to the poor quality and availability of input data. The measure of forest cover and its degradation, mainly from a remote sensing source, is a developing topic with many scientific institutions involved. Historical remote sensing data are available in different forms, from at least 1972. However, their elaboration requires further infrastructural efforts for most involved countries. The availability of data describing deforestation drivers is also a major problem. It is difficult to obtain detailed information, if recorded at all, besides population figures and some general economical parameters.

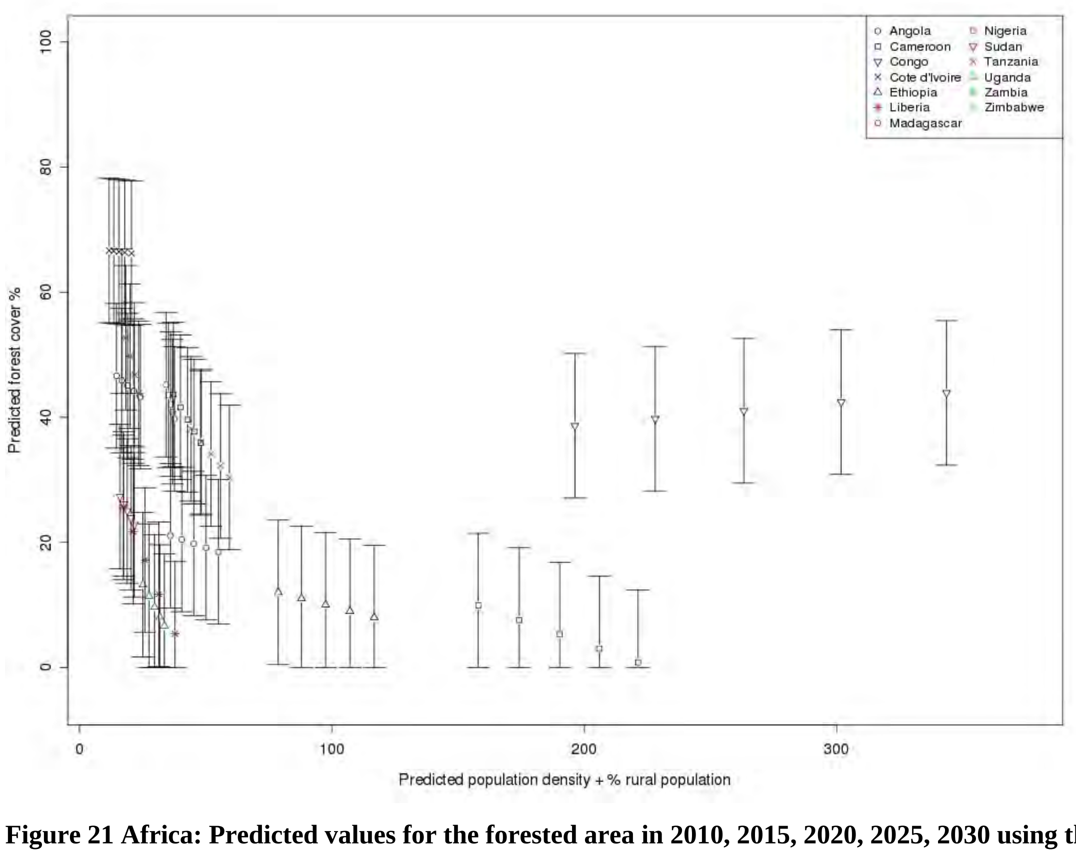


Figure 21 Africa: Predicted values for the forested area in 2010, 2015, 2020, 2025, 2030 using the density of the population and the percent of population that is rural as proxy.

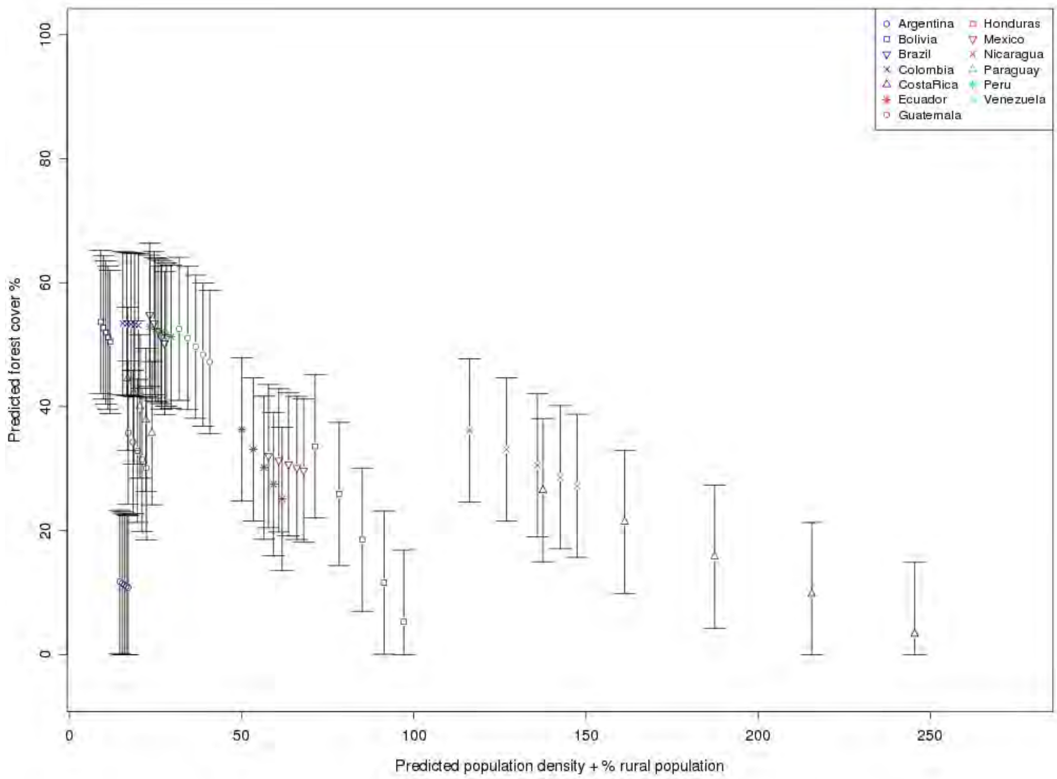


Figure 22 South America: Predicted values for the forested area in 2010, 2015, 2020, 2025, 2030 using the density of the population and the percent of population that is rural as proxy.

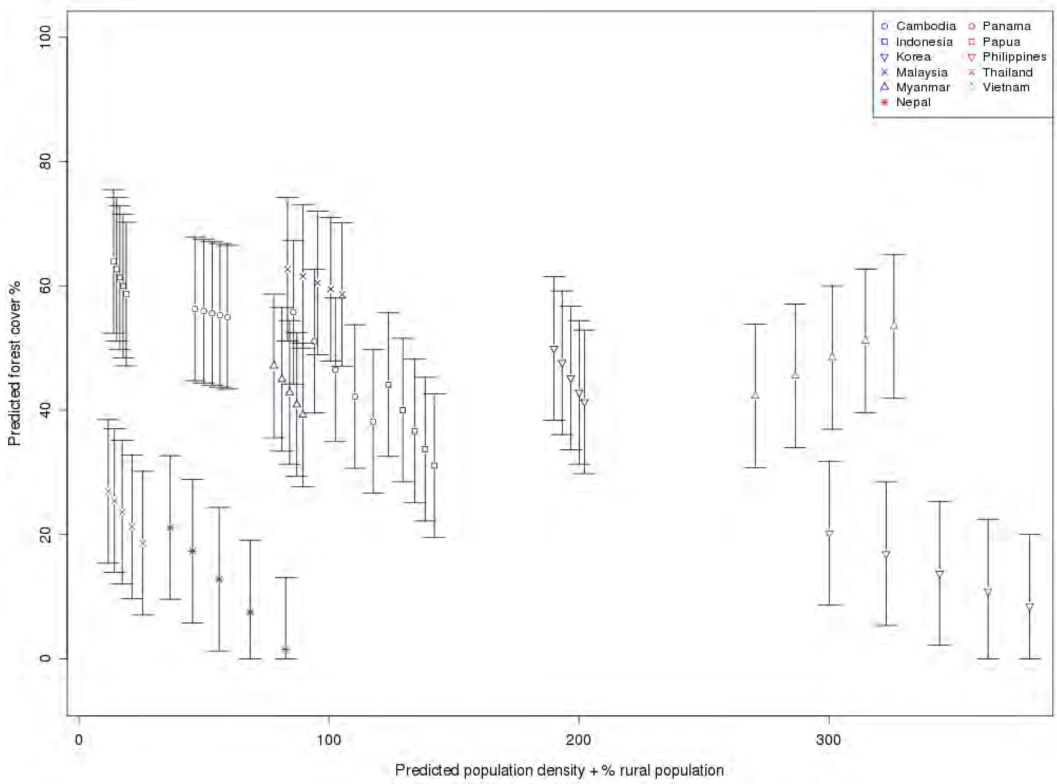


Figure 23 South-East Asia: Predicted values for the forested area in 2010, 2015, 2020, 2025, 2030 using the density of the population and the percent of population that is rural as proxy.

Chapter 5: Potential REDD+ demonstration projects

Introduction

Since the Conference of the Parties (COP13) in Bali, Indonesia, avoiding deforestation in the tropics has come to be recognized as a key component of a future climate change agreement. As a result, interest in REDD+ projects has increased rapidly. The aim of this study was to compile a list of REDD+ projects and national REDD+ readiness activities in order to examine commonalities and differences among these and REDD+ actors' involvement in different regions of the world. The list includes projects for which information was available up to March 2009.

REDD+ projects include activities that are implemented in a particular sub-national region or unit, i.e. national park, with the intention to reduce deforestation in that particular area. We believe that the analysis may be relevant to reducing emissions from REDD+ at the national level, especially as national emissions will not be reduced without local action – see discussion of effectiveness below..

We consider five criteria in the selection of potential demonstration projects: (a) *effectiveness* (real gains in CO_2e emissions need to be achieved), (b) *efficiency* (REDD+ must compete against other approaches to mitigation), (c) *fairness* (mechanisms that are considered to be unfair will have obvious political risks), (d) *sustainability* (one of the challenges of REDD+ is the temporary nature of the mitigation – commitment periods of 10-20 years are the minimal necessary requirement), and (e) *co-benefits* (i.e. benefits other than emission reductions, such as biodiversity conservation and water purification).

1. Effectiveness: There is a case to be made for a nested-scale approach to effective REDD+ projects. National-level accountability for year-to-year changes in aggregate carbon stock will help to circumvent problems of leakage and permanence. The effectiveness of national systems for forest resource inventory and assessment is therefore an important selection criterion. However, practical implementation of REDD+ will need to be devolved to levels of governance and ownership consistent with the devolved nature of forest ownership and governance. The effectiveness of forest governance and security of forest ownership are therefore additional criteria.
2. Efficiency: Projects should generate significant emissions reductions at relatively low cost. Studies by the ASB Tropical Margins Partnership have shown that there are substantial opportunities for this.
3. Fairness: Projects should be seen as fair – if they are not, then they may not be sustained and will be undermined in the long term.
4. Sustainability: For REDD+ projects to be sustainable, land owners should either have their claims to land bought out or shifted to alternative income generation practices that are consistent with maintaining high carbon stocks.
5. Co-benefits: With the large number of sites that have potential from a pure carbon perspective, there is great interest in sites where substantial co-benefits can also be produced, especially biodiversity conservation and protection of watershed services.

A Microsoft® Office Access 2003 database was created based on a literature review, web-based sources, face-to-face and phone interviews as well as short e-mail questionnaires, in order to gather a variety of data on emerging REDD+ projects and activities. Data collection was focused on the types of support offered by REDD+-engaged actors (institutions), the profiles of these institutions, the criteria by and reasons for which countries and sites have been selected for REDD+ activities and projects, and criteria used by national-level organizations in selecting sites for demonstration or pilot activities. As this field is rapidly evolving, this report can only offer a snapshot of the state of REDD+ project and national readiness activities at this point in time.

A subset of three countries Brazil, Cameroon and Indonesia chosen from the three largest remaining contiguous tropical forest areas in the world is discussed in more detail.

Data collection and analysis methods

Web-based research and interviews

Lists of REDD+ projects were assembled based on existing compilations of REDD+ readiness activities, online databases of forest carbon projects, project design documents (PDDs), as well as emails and interviews. Interviews with the initial group of interviewees also led to recommendations of new contacts.

Projects chosen to be included in this database were REDD+ projects or national readiness activities in planning or implementation stages within non-Annex I countries (as per UNFCCC definitions). Many projects presently being implemented have several different forest carbon components (i.e. afforestation/reforestation, forest restoration, sustainable forest management), but all have a clear deforestation component.

REDD+ project actors were categorized as: Bilateral/Multilateral Development Organization, Government, Local/Indigenous Community, NGO/Non-profit/Charity, Private Company, United Nations, University/Research Institution, and other.

Project data were also assembled primarily from PDDs, and web-based Project Databases, with interviews and e-mail responses used to fill in the gaps. The main focus of these questions was to ascertain the informal reasons for institutions' involvement in REDD+ projects in particular countries or regions (Questions 1 and 2, Table 9). The interviews were also used to obtain further information about additional REDD+ projects not listed on other databases, and to find out institutions future REDD+-related intentions (Questions 3 and 4, Table 9).

Table 9: Primary questions asked through e-mail, telephone or in person of members of institutions engaged in REDD+ projects and national readiness activities when this information was not available through online sources.

1. Why did your "Organization X' decide to implement a REDD+ project at the 'Project site'? Within the 'Project Region'? Within the 'Project country'? (In terms of location choice?)
2. Why do you think investors, (i.e. Investor X related to the project) wanted to invest in a REDD+ project within the 'Project Area'? Within the 'Project Region'? Within the 'Project country'? (In terms of location choice?)
3. Do you know of any additional REDD+ projects being implemented in this region? Country?
4. Does your organization have any intentions to implement further REDD+ projects in the region?

Interviews were a mix of face-to-face semi-structured interviews (for individuals in Cameroon), semi-structured phone interviews, and short e-mail surveys. A similar flexible set of questions was asked in all of these interview formats.

Answers to qualitative questions given or found on web-based sources, including: project activities, project co-benefits, actors' formal location choice criteria and actors' informal project or

REDD+ activity site location reasons, were recorded and then grouped into categories for ease of analysis.

<u>Access database</u>

The database was created in Microsoft® Office Access 2003 (Figure 24).

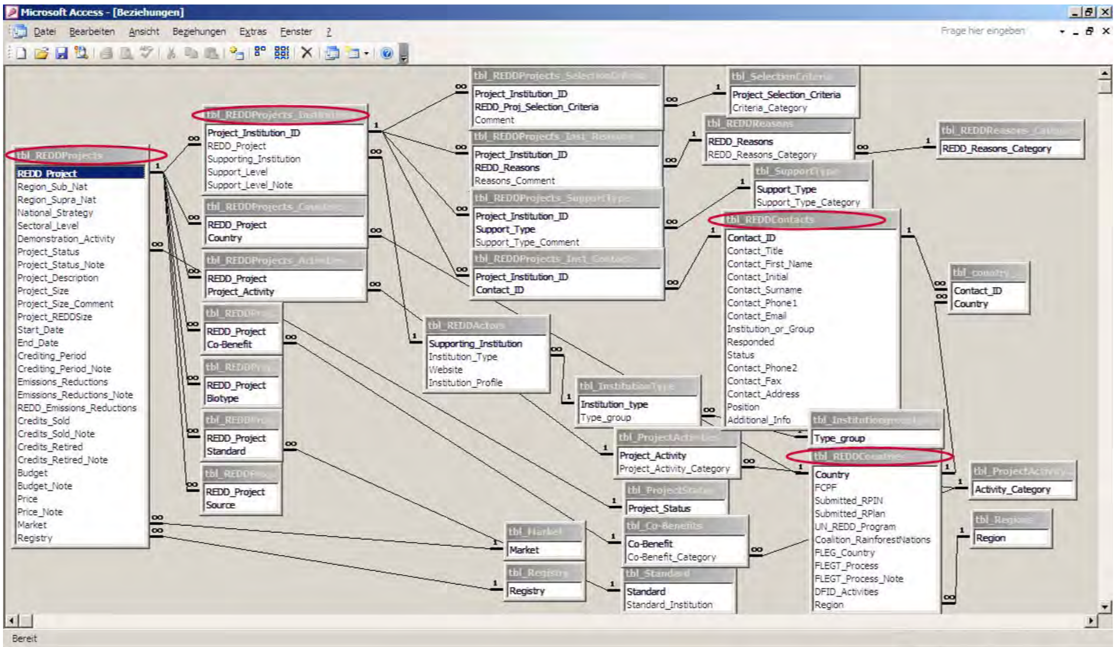


Figure 24. REDD+ Project and readiness activity Microsoft® Office Access Database structure. The key tables for relaying information are circled above: tbl_REDD+Projects, tbl_REDD+Projects_Institutions, tbl_REDD+Contacts and tbl_REDD+Countries.

The main mask of the database features input boxes for project information including project start date and end date, crediting period, emissions reductions ($MtCO_2e$), REDD+ emissions reductions ($MtCO_2e$), project size (ha), REDD+ component size (ha), credits sold, credits retired, carbon credit price ($A/ton), standards, whether the entry is part of a national-level strategy, sectoral-level readiness or a demonstration activity, project status, region (sub-national or supra-national), budget ($A) and budget details, market, and registry (Figure 25). For attributes that could have more than one entry, such as participating countries, biotypes, carbon standards, project activities and co-benefits, and project information sources, sub-tables were created (Figure 25).

Each project can also have an unlimited amount of actors associated with it, where data on each project-associated actor/institution is stored. This actor sub-form includes level of REDD+ support and details on the level of support provided by the institution. Each institution in turn has its own associated sub-tables for contact, type of project support, official location selection criteria and location selection reasons again allowing for multiple responses to the same initial question (Figure 26).

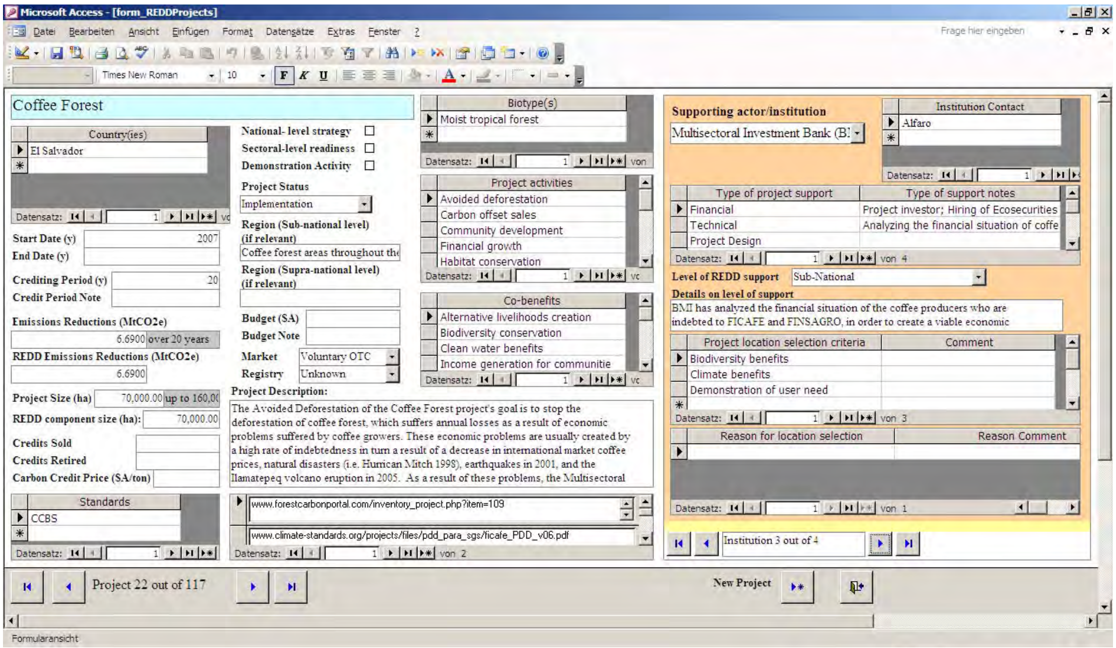


Figure 25. The main database mask displays all of the REDD+ Project or National REDD+-Readiness activity information as well as project-associated sub-forms, most notably the main sub-form, ‘Supporting actor/institution.’

Institution Information Sub-form

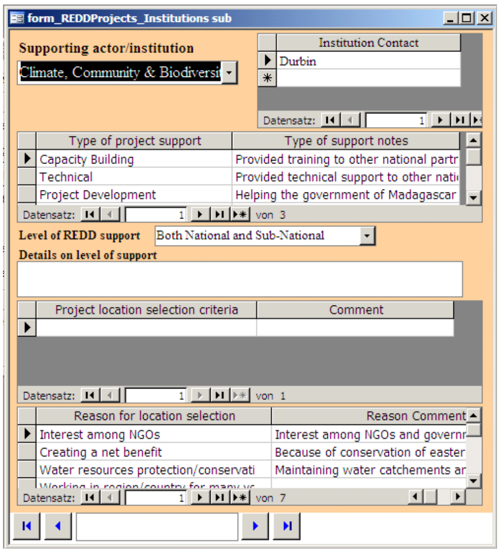
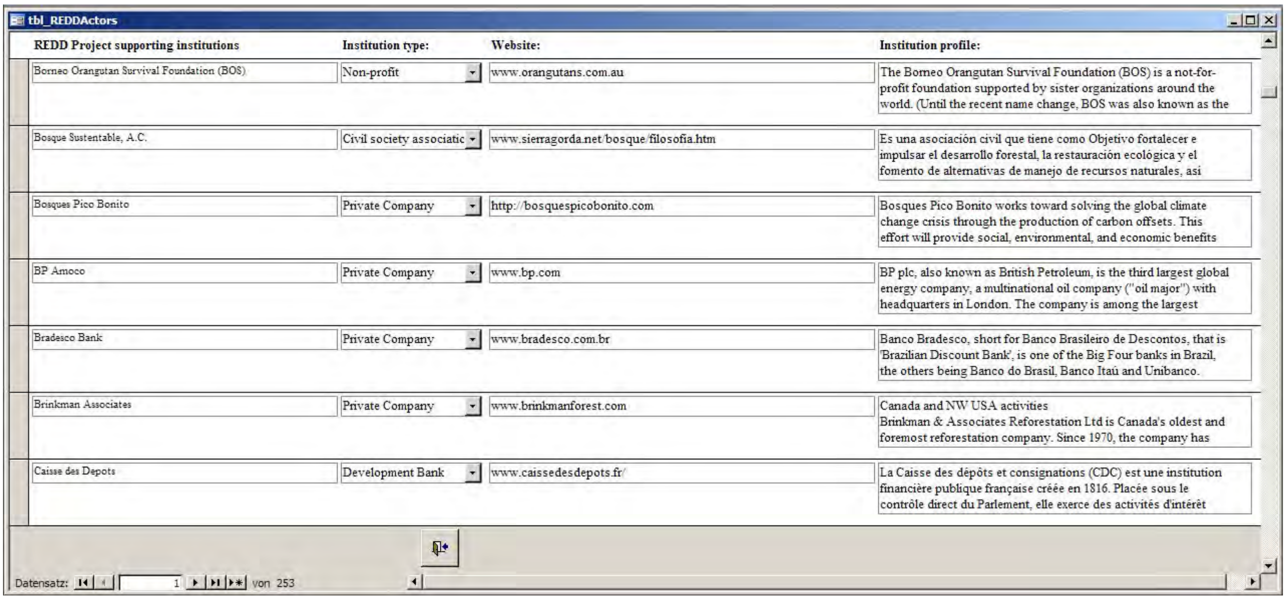


Figure 26. This sub-form mask displays Supporting actor/institution information and links to the Contact Information form through the Institution Contact sub-form.

Profiles of REDD+ actors and their websites were recorded separately (Figure 27). Information on contacts associated with each institution and project were recorded as well, in a separate form linked to the actor sub-form under contact (Figure 26; Figure 28).



tbl_REDDActors

REDD Project supporting institutions	Institution type:	Website:	Institution profile:
Borneo Orangutan Survival Foundation (BOS)	Non-profit	www.orangutans.com.au	The Borneo Orangutan Survival Foundation (BOS) is a not-for-profit foundation supported by sister organizations around the world. (Until the recent name change, BOS was also known as the
Bosque Sustentable, A.C.	Civil society associatic	www.sierragorda.net/bosque/filosofia.htm	Es una asociación civil que tiene como Objetivo fortalecer e impulsar el desarrollo forestal, la restauración ecológica y el fomento de alternativas de manejo de recursos naturales, así
Bosques Pico Bonito	Private Company	http://bosquespicobonito.com	Bosques Pico Bonito works toward solving the global climate change crisis through the production of carbon offsets. This effort will provide social, environmental, and economic benefits
BP Amoco	Private Company	www.bp.com	BP plc, also known as British Petroleum, is the third largest global energy company, a multinational oil company ("oil major") with headquarters in London. The company is among the largest
Bradesco Bank	Private Company	www.bradesco.com.br	Banco Bradesco, short for Banco Brasileiro de Descontos, that is 'Brazilian Discount Bank', is one of the Big Four banks in Brazil, the others being Banco do Brasil, Banco Itaú and Unibanco.
Brinkman Associates	Private Company	www.brinkmanforest.com	Canada and NW USA activities Brinkman & Associates Reforestation Ltd is Canada's oldest and foremost reforestation company. Since 1970, the company has
Caisse des Depots	Development Bank	www.caissedesdepots.fr/	La Caisse des dépôts et consignations (CDC) est une institution financière publique française créée en 1816. Placée sous le contrôle direct du Parlement, elle exerce des activités d'intérêt

Datensatz: 1 von 253

Figure 27. The REDD+ Actor form displays the REDD+-engaged institution's name, institution type, website and institution profile. As of this report's completion there are a total of 253 institutions engaged in REDD+ projects and/or national REDD+ readiness activities worldwide.

REDD+ Project Contact Information Sub-form

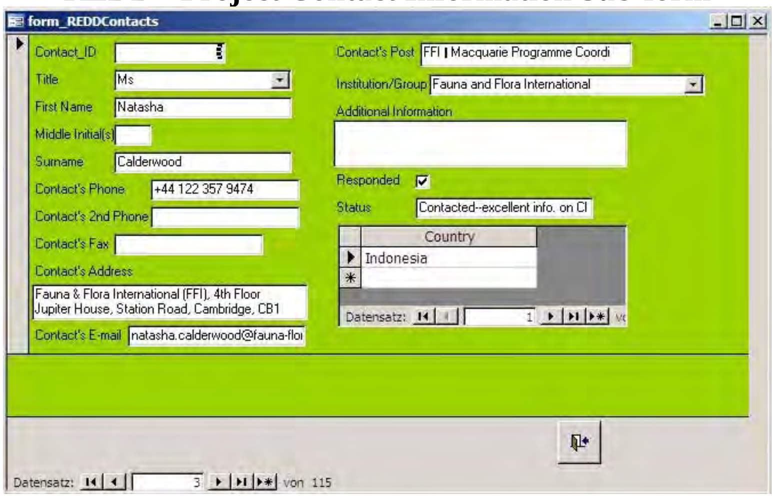


Figure 28. This form mask displays contact information, links to the actor table and country table, and contains additional contact information on individuals involved in REDD+-engaged institutions.

Results and Discussion: Emerging trends in REDD+

A total of 74 REDD+ projects and 53 national REDD+ readiness activities were included in the database, compiled according to the methods outlined above (Annex 1). Several interview respondents noted that they were in the process of planning or designing additional projects, but that detailed information on these projects was not yet publicly available.

Institutions engaged in the REDD+ process

Of the 253 actors/institutions involved or investing in REDD+ projects and national REDD+ readiness activities included in this database, 211 actors have been recorded as having involvement in REDD+ projects with 88 actors engaged in national REDD+ readiness activities. These 211 actors were divided into the following eight categories for ease of comparison: bilateral/multilateral development organization, government, local/indigenous community, NGO/non-profit/charity, private company, United Nations, university/research institution and other. Thus a wider variety of actors is engaged in REDD+ projects than in national REDD+ readiness schemes. Of the aforementioned institution categories, all eight groups of actors are involved in REDD+ projects; while five groups are involved in national REDD+ readiness schemes: bilateral/multilateral development organization, government, NGO/non-profit/charity, private company, and university/research institution (Figure 29; Figure 30).

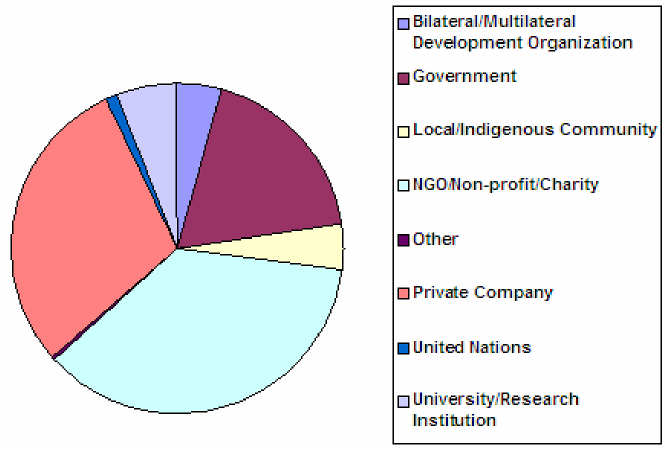


Figure 29. Share (%) of actor groups' involvement in REDD+ Projects.

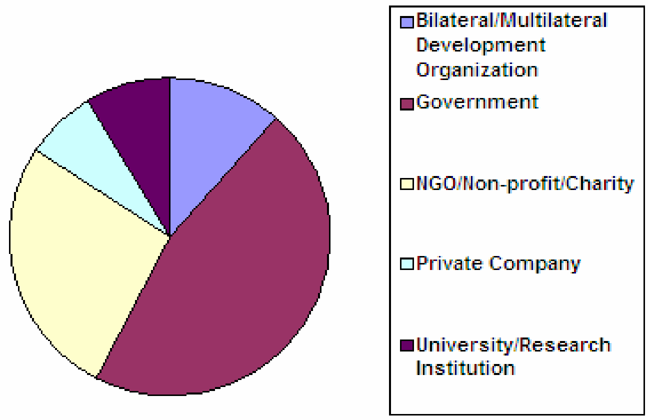


Figure 30. Share (%) of actor groups' involvement national REDD+ readiness activities.

Although five institution categories remain constant across REDD+ projects and national REDD+ readiness activities, the level of engagement of different institution types within these activities varies (Table 10).

Table 10: Share (%) of institution type involvement in REDD+ projects and national REDD+ readiness activities

Institution Category	Total share of actor involvement in REDD+ Projects (%)*	Total share of actor involvement in National REDD+ Readiness Activities (%) **
NGO/Non-profit/Charity	37.0	28.4

Private Company	30.8	4.5
Government	19.4	45.5
University/Research Institution	6.2	9.1
Bilateral/Multilateral Development Organization	4.7	12.5
United Nations	1.4	0
Other	0.5	0

*Based on a total of 211 actors involved in REDD+ projects;

**Based on a total of 88 actors involved in national REDD+ readiness activities

Distribution of REDD+ projects and national readiness schemes

Figure 31, Figure 32 and Table 11 show the distribution of REDD+ projects and national readiness activities by region and country as recorded in the database.

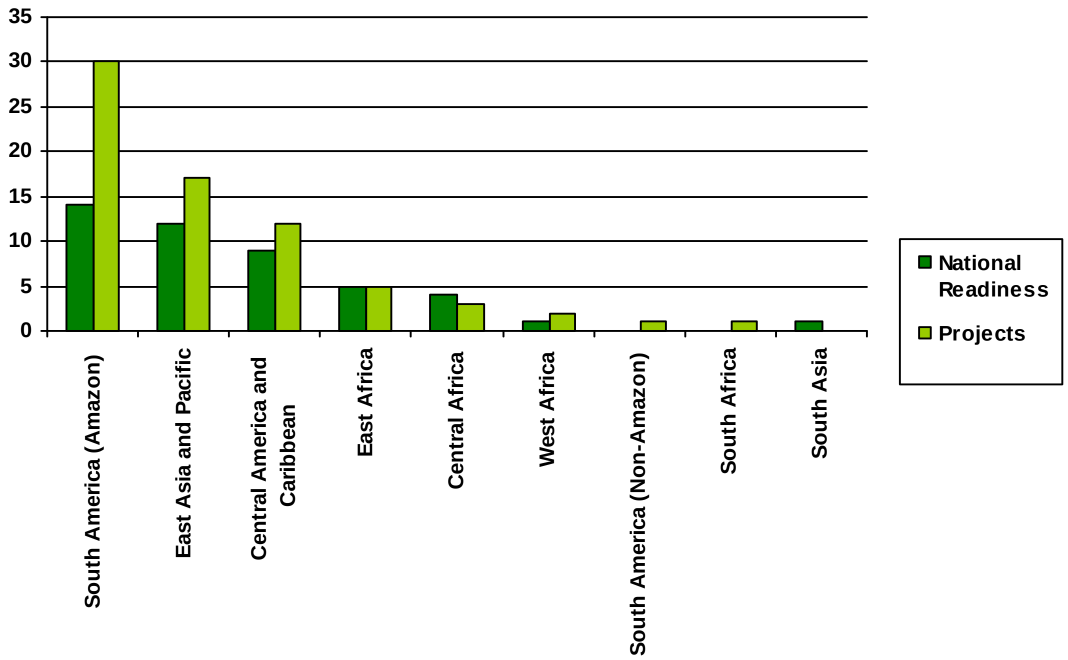


Figure 31. The distribution of REDD+ projects and REDD+ readiness activities by region.

Table 11: REDD+ projects and national REDD+-readiness activities by region

Region	REDD+ Projects	National REDD+ Readiness Activities	Project and Readiness Activity Total
South America (Amazon)	30	14	44
East Asia and Pacific	17	12	29
Central America and Caribbean	12	9	21
East Africa	5	5	10
Central Africa	3	4	7

West Africa	2	1	3
South Africa	1		1
South America (Non-Amazon)	1		1
South Asia		1	1
Total	**71**	**46**	**117**

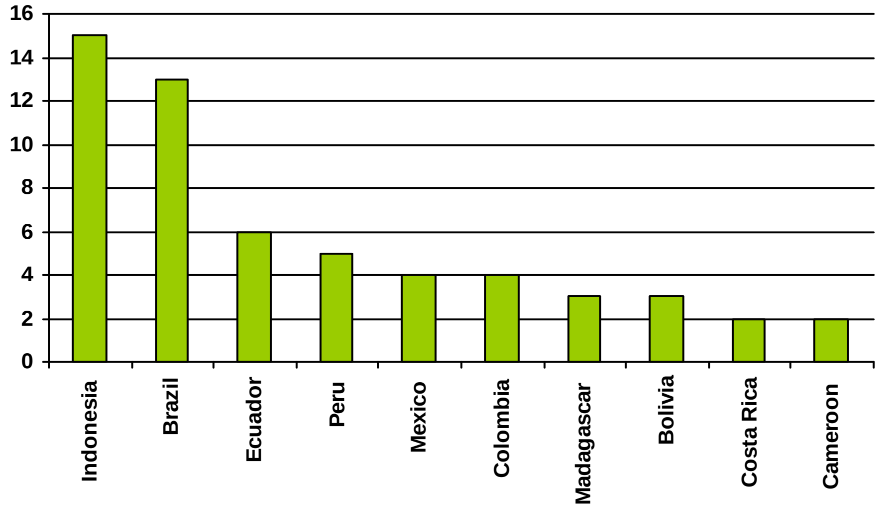


Figure 32. REDD+ project distribution across the 10-most selected countries for project implementation.

Figure 33 and Table 12 show the pattern of national REDD+ readiness schemes by region as included in the data-set.

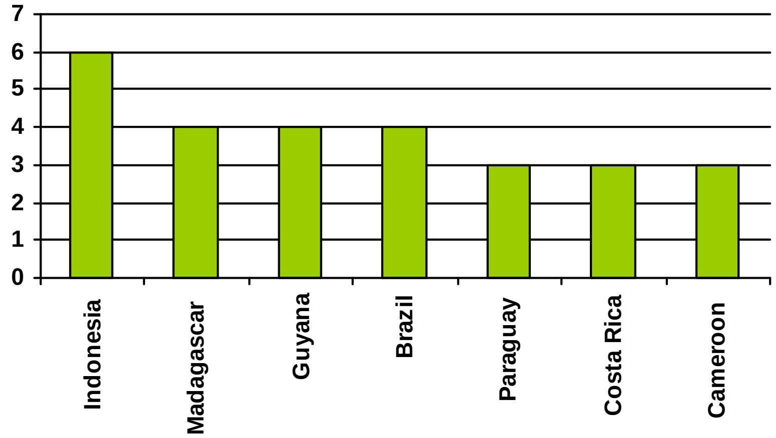


Figure 33. National REDD+ readiness activity distribution among the 7 most-selected countries

Table 12: REDD+ project and national readiness activity distribution among countries

Country	**REDD+ Projects**	**National REDD+ Readiness**	**Total**

		Activities	
Indonesia	15	6	**21**
Brazil	13	4	**17**
Ecuador	6		**6**
Peru	5	1	**6**
Colombia	4	2	**6**
Mexico	4	2	**6**
Bolivia	3		**3**
Madagascar	3	4	**7**
Cameroon	2	3	**5**
Costa Rica	2	3	**5**
Argentina	1		**1**
Belize	1	1	**2**
Democratic Republic of Congo	1	2	**3**
El Salvador	1		**1**
Ethiopia	1		**1**
Ghana	1		**1**
Guatemala	1	1	**2**
Guyana	1	4	**5**
Honduras	1		**1**
Ivory Coast	1		**1**
Mozambique	1		**1**
Nicaragua	1		**1**
Panama	1	2	**3**
Papua New Guinea	1	2	**3**
Philippines	1		**1**
Uganda	1		**1**
Venezuela	1		**1**
Paraguay		3	**3**
Lao PDR		2	**2**
Vietnam		2	**2**
Cambodia		1	**1**
Central African Republic		1	**1**
Gabon		1	**1**
Liberia		1	**1**
Nepal		1	**1**
Republic of Congo		1	**1**
Tanzania		1	**1**
Thailand		1	**1**
Vanuatu		1	**1**

Of 253 institutions listed in the database, the majority were involved in only one activity, while ten were involved in at least four (Figure 34).

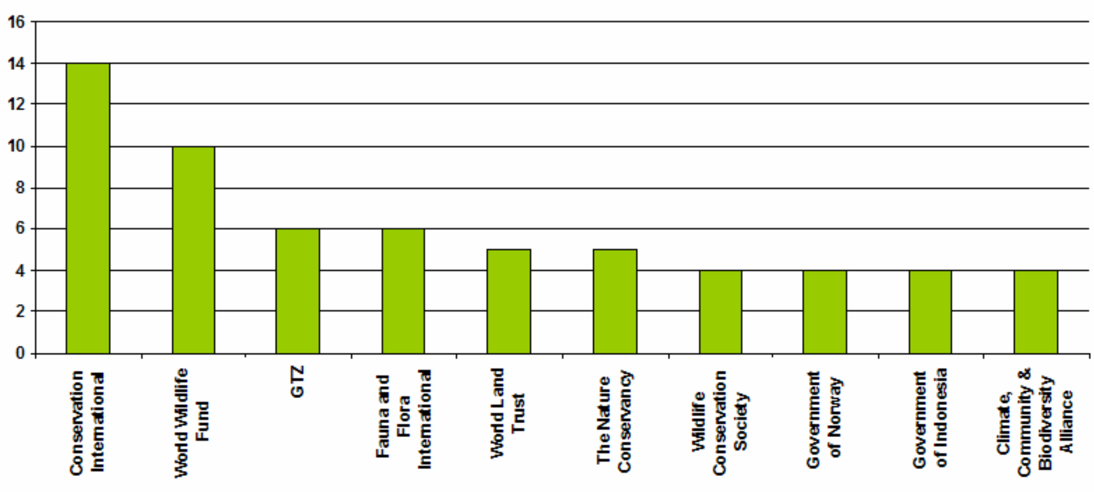


Figure 34. Amongst the 253 actors engaged in REDD+ projects and readiness schemes, ten were more heavily engaged and were involved in 4 or more activities.

From 14 projects in 15 countries where budget information was available, the mean for both REDD+ readiness and project activity budgets was $36,568,863.14 US, the minimum $394,080 US and the maximum $150,000,000 US (Table 13).

Table 13: Available budget information for REDD+ project and national readiness activities

REDD+ Project/National Readiness Activity	Budget ($US)	Country(/ies)
Ankeneny-Mantadia-Zahamena Corridor Project	$150,000,000	Madagascar
Juma Sustainable Development Reserve	$2,000,000	Brazil
Rio Bravo Climate Action Project	$5,600,000	Belize
ECOLAND: Piedras Blancas National Park	$1,100,000	Costa Rica
Tanzania REDD+ investment from Norway	$100,000,000	Tanzania
CBMAP II Panama	$9,245,000	Panama
Exelon Amazon	$1,500,000	Bolivia, Ecuador, Peru
Mekong Valley	$394,080	Cambodia, Lao PDR, Thailand & Vietnam
Amazon Fund	$100,000,000	Brazil
Kalimantan Forests and Climate Partnership	$30,000,000	Indonesia
Indigenous Amazon REDD+ Program	$2,324,004	Bolivia
Inhutani I in Mamuju	$66,801,000	Indonesia
Papua New Guinea-Australia FCP	$3,000,000	Papua New Guinea
Indonesia - Australia FCP	$40,000,000	Indonesia

Of the 68 combined project and national readiness activities with recorded start dates, the mean start date was 2005, with the earliest readiness activity, the PRODES and DETER land-cover monitoring satellites for Brazil, starting in 1989, and the most recent demonstration project, Mount Cameroon, destined to start in 2010 (Figure 35). The greatest number of activities (22) began in 2008 (after the December 2007 COP in Bali, Indonesia), with 11 a year previously, in 2007, and seven following in 2009 (Figure 35). However, it should be noted that 'start date' in the case of a REDD+ project is not necessarily well defined as projects begun with other purposes, such as national parks, often have been transformed into a REDD+ project or have added a REDD+ component at a later date. The earliest recorded end date for national REDD+ readiness activities was 2001, the latest 2058 and the mean end date, 2023.

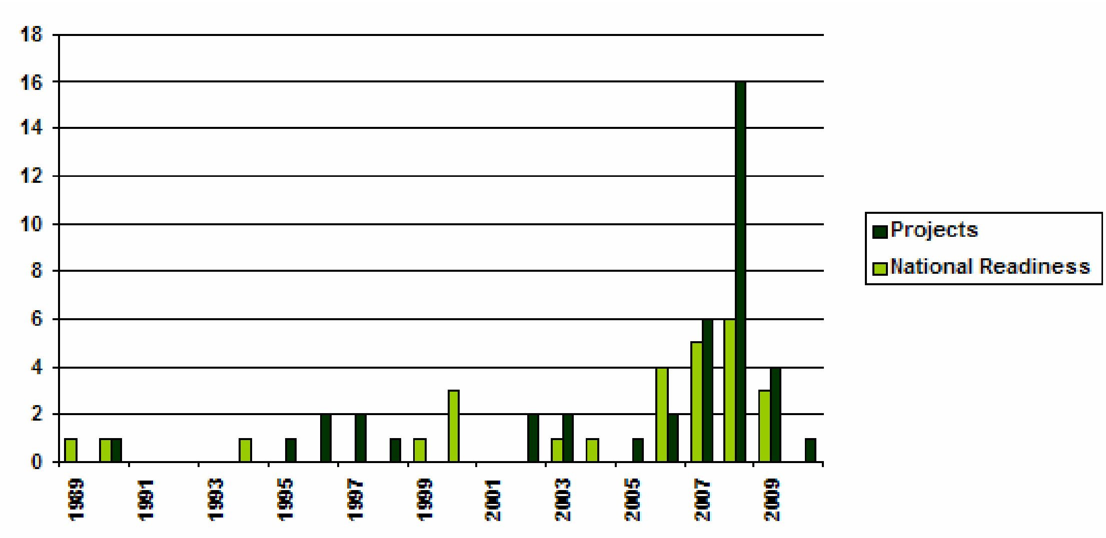


Figure 35. The recorded start dates for 68 combined project and national readiness activities point towards the greatest number of activities starting in 2008 (after the December 2007 COP in Bali, Indonesia), with the years 2006 and 2007 gearing up towards this event, and 2009 seeing a reduction in activities initiated.

Trends in actor involvement

From 2006 to 2008 the overall government share of REDD+ involvement has increased from 23% in 2006 to 34% in 2008 (Figure 36). Private sector involvement dropped during that time period from 29% of the share of actor involvement in 2006 to 22% in 2008.

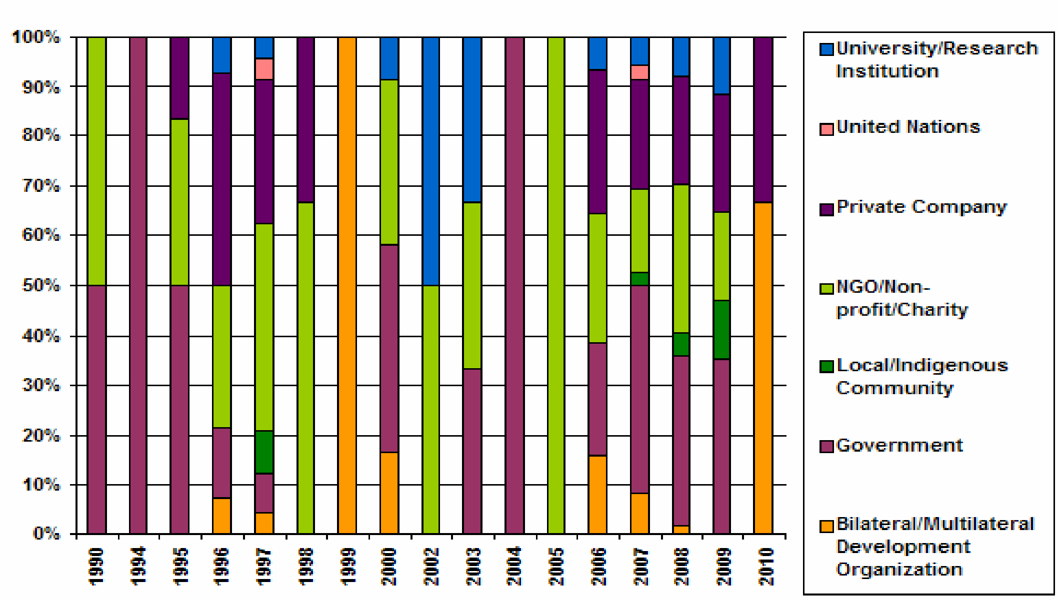


Figure 36. This graph displays the variation of relative proportions of REDD+-engagement of different types of actors over the years of REDD+ project and national readiness activities' inception. The United Nations category here does not include activities related to the UNREDD+ program.

<u>Carbon standards</u>

Out of 17 entries for carbon standards used by various REDD+ projects, the majority—seven used the Climate, Community and Biodiversity Alliance Standard (CCBS) (Figure 37). Following CCBS, two projects each used the Buyer's Standard, CDM, Seller's Standard and VCS.

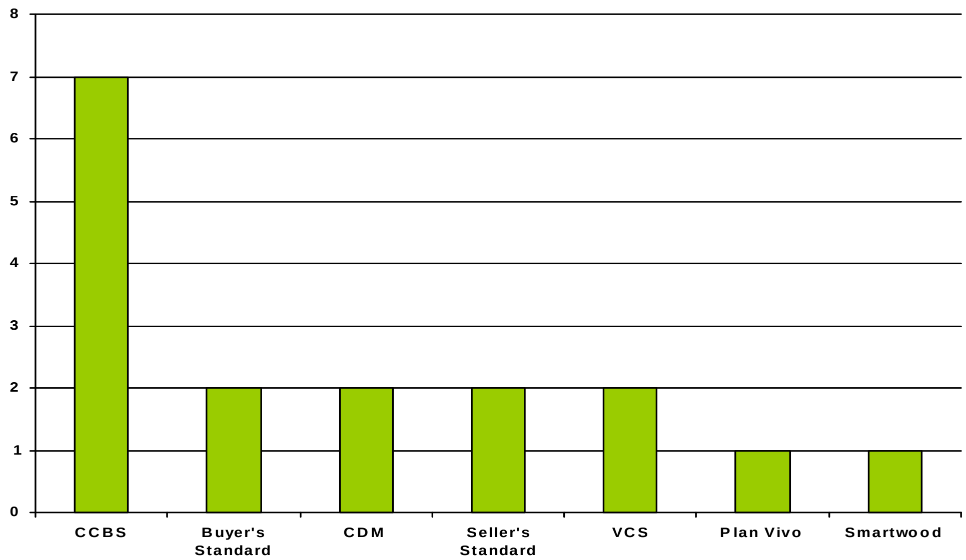


Figure 37. Of the standards employed by different REDD+ projects, the Climate, Community and Biodiversity Alliance Standard (CCBS) is the most commonly used.

REDD+ projects and national readiness schemes varied in terms of the types of activities they included and in terms of the co-benefits anticipated from implementation of these activities.

For the 71 REDD+ projects in the database, 256 activities were listed, and were placed into 17 categories (Table 14, Figure 38). Of these, the five most-frequently mentioned activities were, in order: capacity building/education 47 times, community development/improved livelihoods 32 times, avoided deforestation (directly) 31 times, biodiversity/habitat conservation 29 times, and sustainable forest/land/resource management 24 times.

Table 14: For 71 REDD+ projects, 269 activities were listed and then grouped into 17 categories.

REDD+ Project Activity Category	**Total**
Capacity Building/Education	47
Community Development/Improved Livelihoods	32
Avoided Deforestation	31
Biodiversity/Habitat Conservation	29
Sustainable Forest/Land/Resource Management	24
Afforestation/Reforestation/Restoration	17
Payments for Ecosystem Services/Carbon	15
Protected Area Creation/Enforcement	13
Stakeholder Processes/Community Planning	10
Baseline/Methodology Development	9
Combating Illegal Logging	9
Land-use Planning	9
Mapping/Identifying Land-Cover and Changes	9

Forest Carbon/Species Inventories	7
Forest Fire Management	4
Land Tenure Development	2
Ecotourism	2
REDD+ Project Activity Entries Total	**269**

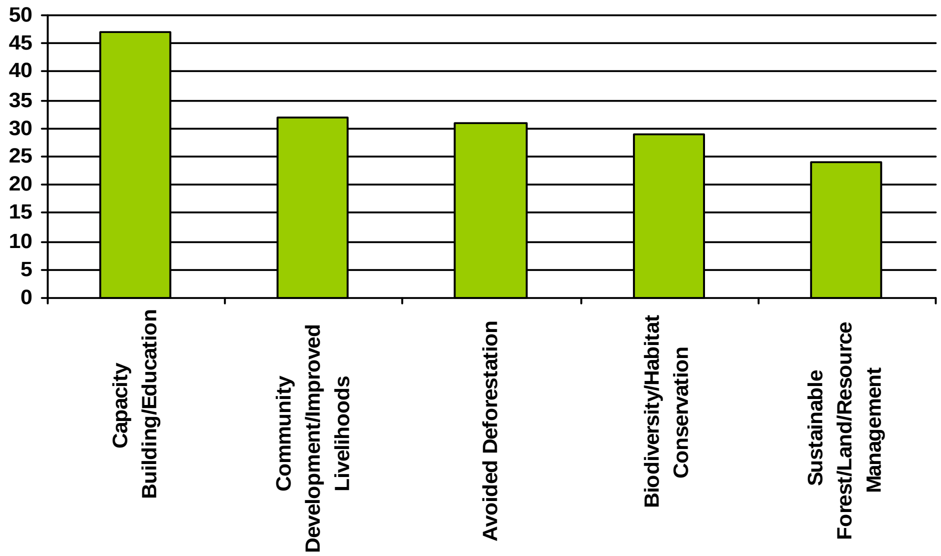


Figure 38. Capacity building/education is the first of 5 most frequently cited REDD+ project activity categories, based on a list of 17 categories formed from 256 activity entries associated with 71 projects.

Although there were fewer national REDD+ readiness entries in the database, and correspondingly fewer activities, the most frequently mentioned activities followed a similar pattern to the REDD+ project entries. For the 90 activities listed for the 46 national REDD+ readiness schemes in the database, 16 activities mentioned related to capacity building/education, twelve to avoided deforestation, ten to payments for ecosystem services/carbon payments, nine to community development/improved livelihoods and seven to biodiversity/habitat conservation (Figure 39; Table 15).

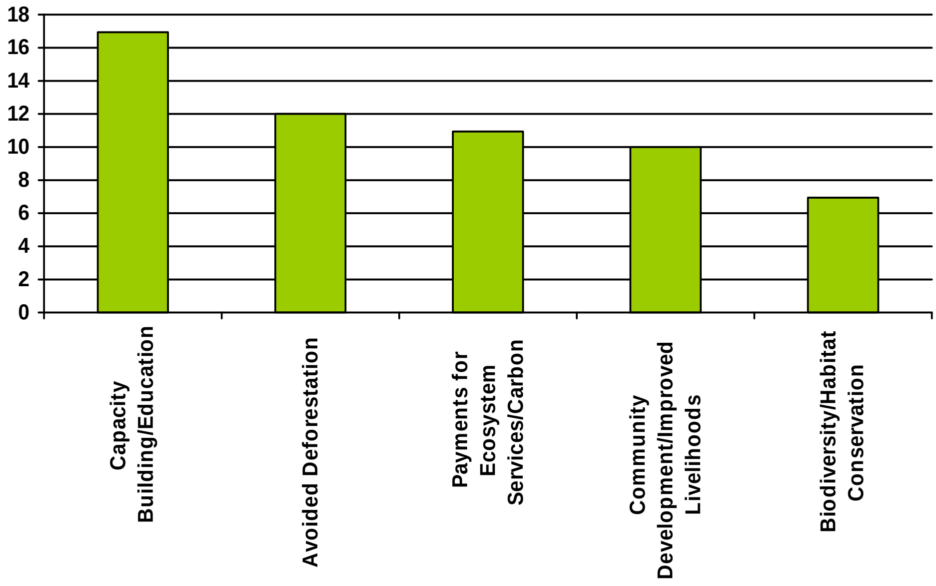


Figure 39. This graph displays the five most-cited national REDD+ readiness activity categories based on 20 categories formed from 90 activity entries for 46 national REDD+ readiness schemes.

Table 15: This table displays a ranked list of the 20 activity categories listed, based on a total of 90 activity entries for 46 national REDD+ readiness schemes.

National REDD+ Readiness Scheme Activity	**Total**
Capacity Building/Education	16
Avoided Deforestation	12
Payments for Ecosystem Services/Carbon Payments	10
Community Development/Improved Livelihoods	9
Biodiversity/Habitat Conservation	7
Baseline/Methodology Development	5
Forest Carbon/Species Inventories	4
Mapping/Identifying Land-Cover and Changes	4
Stakeholder Processes/Community Planning	4
Protected Area Creation/Enforcement	3
Sustainable Forest/Land/Resource Management	3
Combating Illegal Logging	2
Land Tenure Development	2
Land-use Planning	2
Policy Development	2
Afforestation/Reforestation/Restoration	1
Communications	1
Demonstration Activities	1
Ecotourism	1
Health	1
National REDD+ Readiness Activities Total	90

Along with national REDD+ readiness schemes' and REDD+ projects' activities, there were a range of responses associated with these activities anticipated co-benefits. For REDD+ projects, 110 co-benefits were listed and grouped into 14 categories (Table 16). Of these, the most anticipated co-benefits of REDD+ projects were: community development/improved livelihoods with 38 entries, biodiversity/habitat conservation with 32, water protection/clean water with twelve, capacity building/education with seven and soil conservation with four (Figure 40; Table 16).

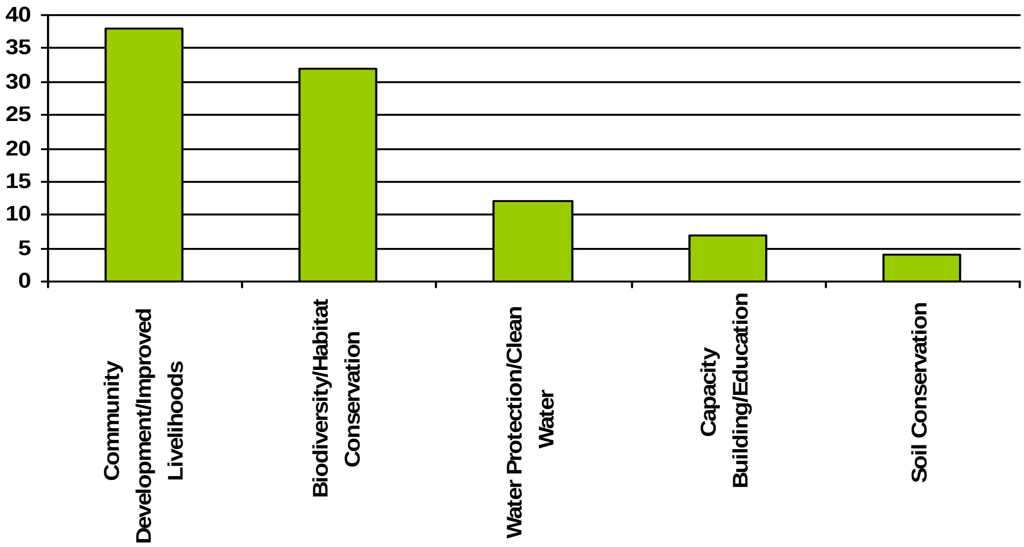


Figure 40. The five most-cited co-benefits of implementing REDD+ projects based on 110 entries. categories formed from 90 activity entries for 46 national REDD+ readiness schemes.

Table 16: Ranked list of the 14 REDD+ project co-benefit categories listed, based on a total of 269 co-benefits for 71 REDD+ projects.

REDD+ Project Activity Category	Sum
Community Development/Improved Livelihoods	38
Biodiversity/Habitat Conservation	32
Water Protection/Clean Water	12
Capacity Building/Education	7
Soil Conservation	4
Food Security	3
Land Tenure Development	3
Payments for Ecosystem Services/Carbon	3
Sustainable Forest/Land/Resource Management	3
Afforestation/Reforestation/Restoration	1
Forest Fire Management	1
Health	1
National REDD+ Readiness	1
Protected Area Creation/Enforcement	1
Total REDD+ Project Co-Benefits	**110**

Sixteen co-benefits were listed for national readiness schemes; these were grouped into 6 categories for national readiness schemes (Figure 41; Table 17). Of these six categories, biodiversity/habitat conservation was stated seven times, water protection/clean water four times, community development/improved livelihoods twice and capacity building/education, culture conservation and land tenure development once each (Figure 41; Table 17).

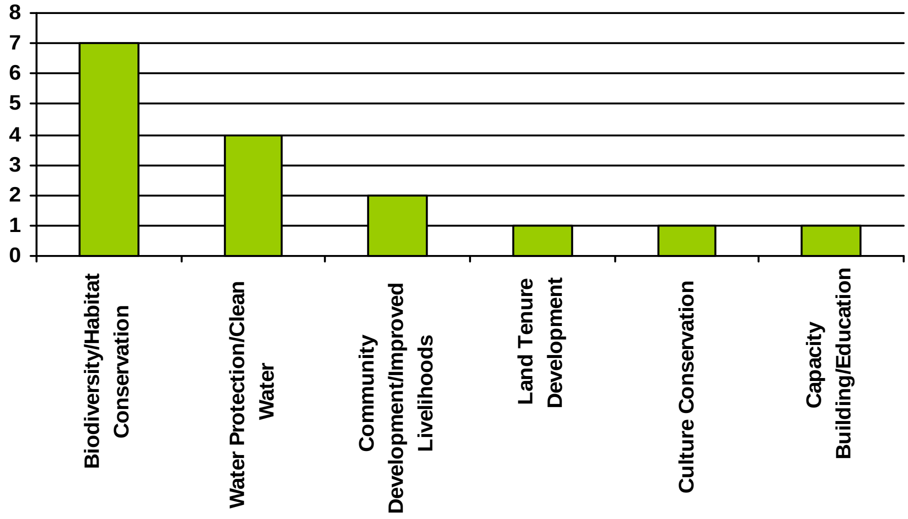


Figure 41. The six most frequently cited co-benefits of implementing national REDD+ readiness activities, based on 16 entries.

Table 17:The six most frequently cited co-benefits of implementing national REDD+ readiness activities, based on 16 entries.

Co-Benefit Category	**Total**
Biodiversity/Habitat Conservation	7
Water Protection/Clean Water	4
Community Development/Improved Livelihoods	2
Capacity Building/Education	1
Culture Conservation	1
Land Tenure Development	1
Total National Readiness Co-Benefits	**16**

Institutions' support given for REDD+ activities

For REDD+ projects, 232 support types were listed, and grouped into 20 categories. Of these, the eight most frequently cited types of REDD+ project support, were said to have been provided in at least ten of the REDD+ projects or national readiness activity cases listed. Financial support was the most common support type listed with 73 entries (Figure 42).

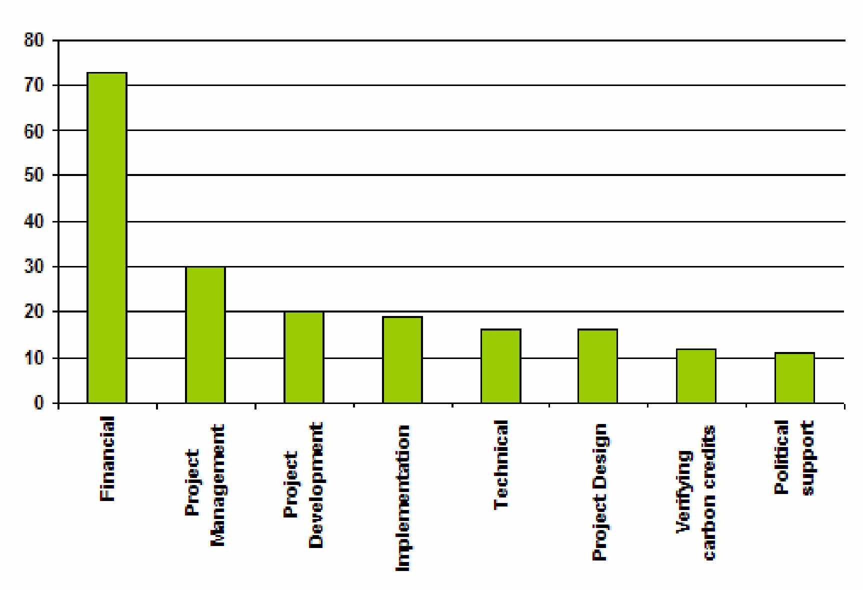


Figure 42. The eight most frequently cited types of REDD+ project support provided by REDD+-engaged institutions based on 232 entries.

There were 101 support entries for national REDD+ readiness activity support provided by REDD+-engaged institutions; these were grouped into 13 categories. Of these, the seven most frequently cited types of REDD+ project support, were said to have been provided in at least five of the REDD+ projects or national readiness activity cases listed. Similarly to the REDD+ project support types provided, financial support was the most common with 22 mentions (Figure 43).

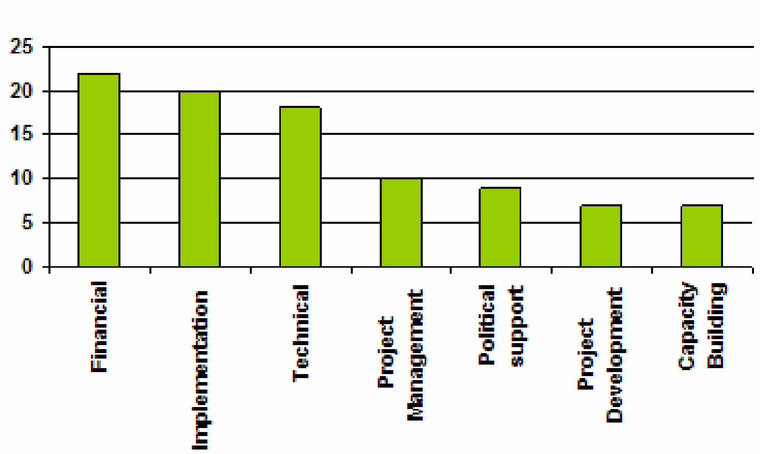


Figure 43. The seven most frequently cited types of national REDD+ readiness activity support provided by REDD+-engaged institutions based on 101 entries.

<u>Institutions' official criteria and additional reasons for REDD+ activity location selection</u>

Based on information drawn from project websites, online articles, phone and face-to-face interviews and e-mail correspondence, 81 criteria were assembled for REDD+ project and national readiness activity location selection. These criteria were then placed into 10 groups for ease of comparison: biodiversity benefits, business value, climate benefits, community benefits, cultural value, demonstration of user need, environmental value, medical benefits, threat of deforestation and water conservation value (Figure 44).

Official criteria for actors' involvement in REDD+ projects or national readiness activities within particular countries, or regions within countries, were varied (Figure 44). The three countries with the largest number of location selection criteria mentioned were Indonesia, Brazil and Madagascar (Figure 44).

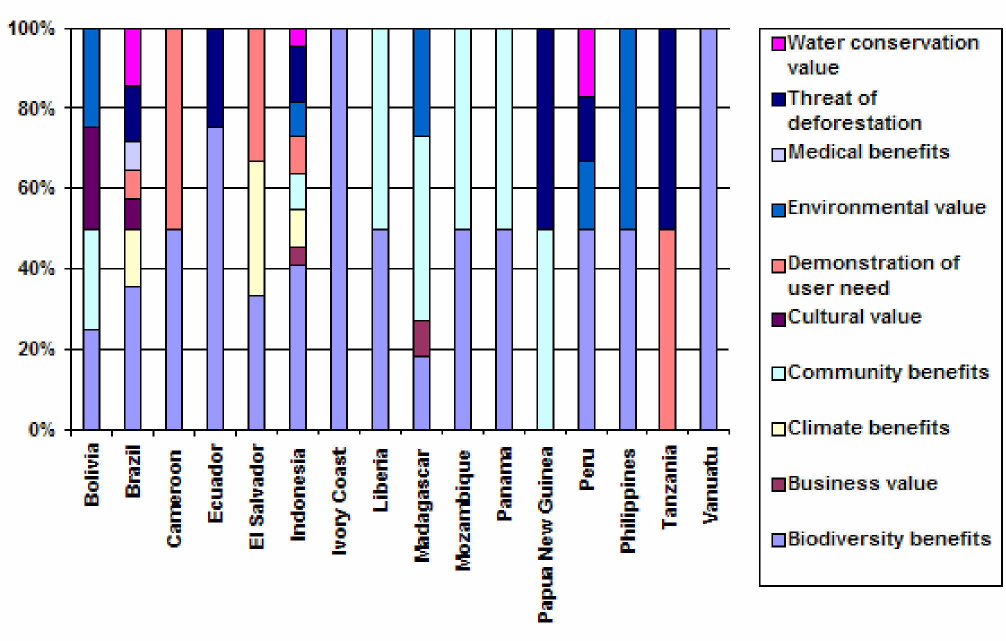


Figure 44. Official criteria cited by REDD+-engaged institutions as reasons for locating REDD+ projects or for engaging in national REDD+ readiness activities in particular countries from a total of 81 criteria responses for 117 entries.

There is another set of reasons that influence the location of REDD+ activity implementation. These 65 stated location reasons were divided into 13 groups for ease of comparison (Figure 45); they include: creating a net benefit, cultural value, financially viable, good governance/institutional setting, high conservation/biodiversity value, high level of deforestation, low level of deforestation, other parties interested (NGOs, Government), previous experience in related sectors/projects, prior relations with country/region/stakeholders, technical capacity, technical interest, and water resources protection (Figure 45).

The greatest variety of other reasons for REDD+ activity location selection were mentioned for: Cameroon, Guyana, Indonesia, and Madagascar (Figure 44). A larger variety of reasons for these countries could also have been influenced by a greater amount of interviews focused on these countries. Project placement could also be a result of institutions' perceptions of a project's likely future success; the World Bank states that for REDD+ projects to be successful there is a need for local environments that support project identification, preparation, consideration (World Bank, 2008).

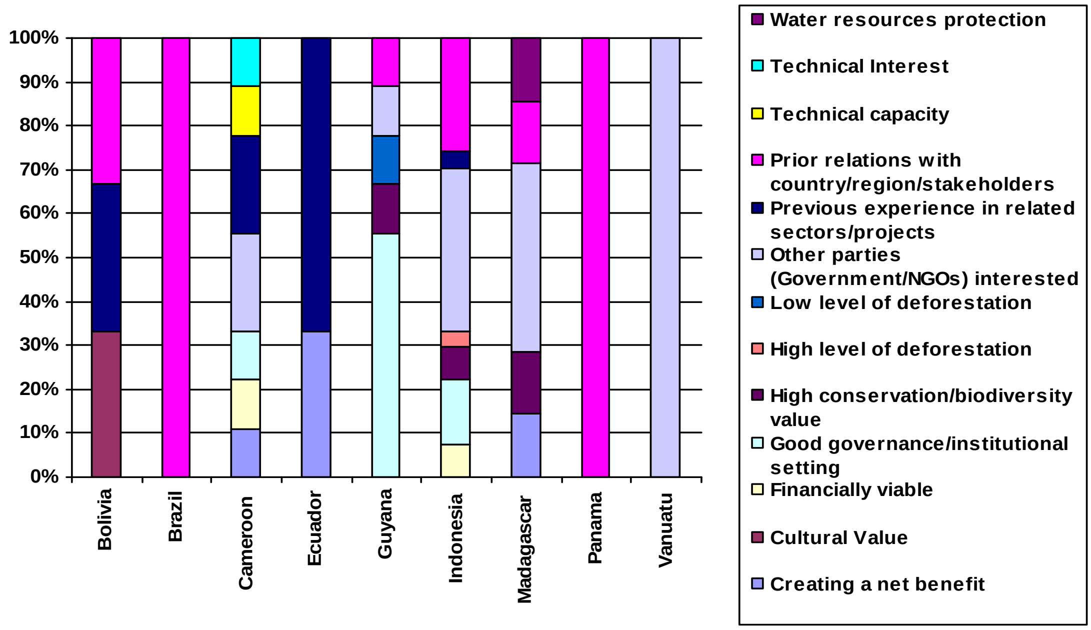


Figure 45. Informal reasons cited by REDD+-engaged institutions behind their location choices for REDD+ project implementation or for engaging in national REDD+ readiness activities in particular countries from a total of 65 reasons cited for 117 entries.

When examining criteria influencing REDD+ location selection between different groups of actors, NGOs emerge as having the most varied criteria for location selection (Figure 46). However, when examining informal reasons behind location selection for REDD+ activities, the private sector has the most varied collection of responses (Figure 47).

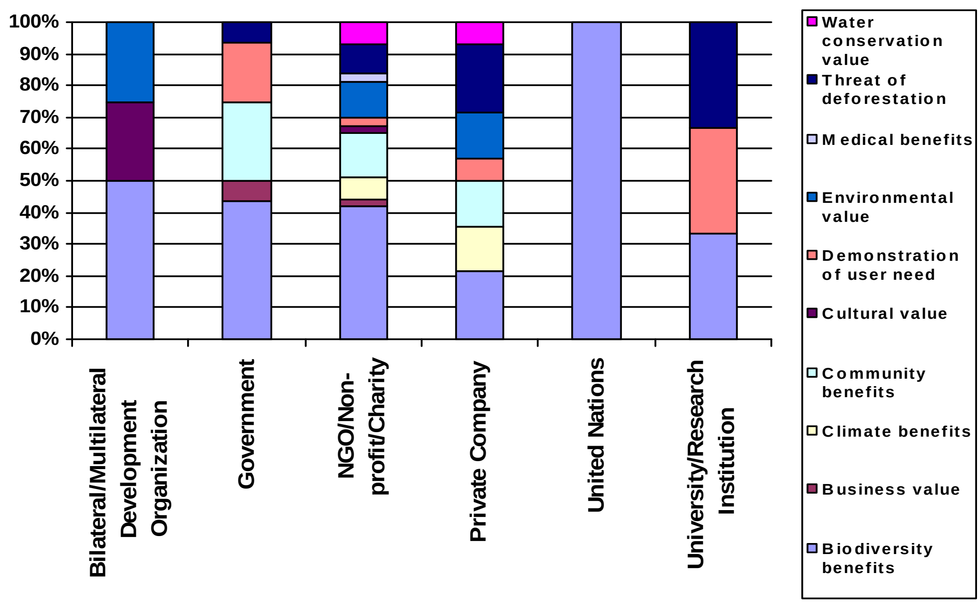


Figure 46. Different types of actors had different official criteria behind REDD+ project and readiness activity location selection; most notably, the NGO/non-profit/charity category had the most varied criteria for location selection.

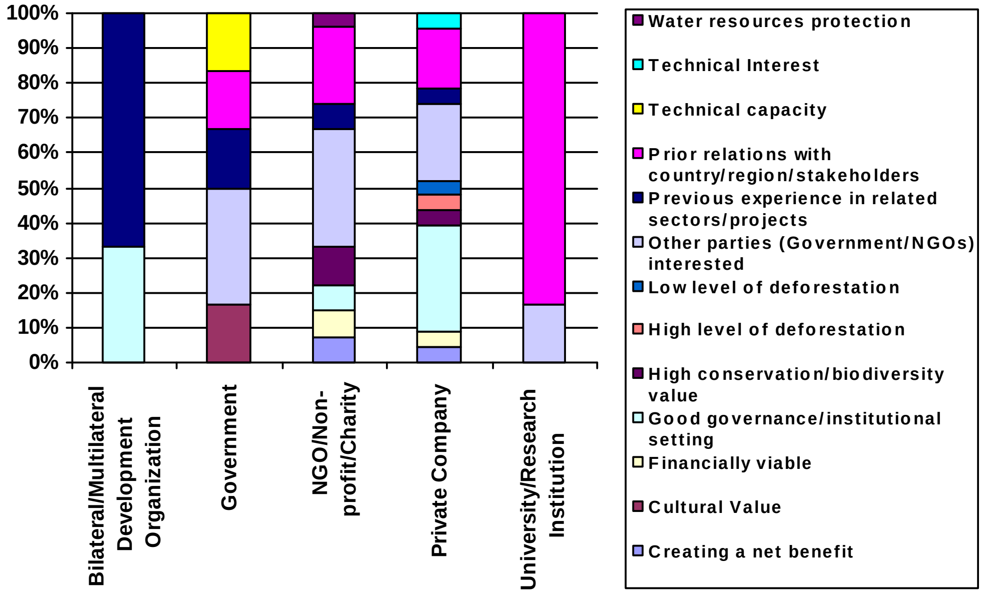


Figure 47. Different types of actors had different informal reasons behind REDD+ project and readiness activity location selection.

Overall, no matter which way one slices the criteria and reasons behind location selection of different actors across different countries, among official location selection criteria, biodiversity is the most commonly mentioned (Figure 44; Figure 46). Informally, the most commonly stated location selection reasons were prior relations with the country, region or stakeholders (Figure 45; Figure 47).

Summary

REDD+ projects and readiness schemes are varied in terms of their respective activities, expected co-benefits and reasons for being. Actors engaged in REDD+ had a variety of both official criteria and informal reasons for project and readiness locations varying from biodiversity value, to financially feasible, on to having prior NGO and government contacts in a particular region.

An analysis of the varied spectrum of REDD+ projects (71) and national readiness schemes (46) currently in place highlights that certain regions are in focus of activity. Indonesia stands out as having the most activity in terms of both REDD+ projects and national readiness activities. As for regions, the Amazon stands out as hosting the most projects and national readiness schemes. The reasons for this imbalance are not necessarily based on deforestation rates, comparative biodiversity and carbon values, but also on previous relationships between REDD+ engaged actors and local stakeholders, political relationships, financial viability, governance and perceived risk.

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Annex 1: Factsheets for major tropical deforesting countries

South-East Asia

Cambodia

Size of country:	0.18 million km^2
Forest cover before deforestation:	74 % (in 1965)
Present forests cover:	59.2% (in 2005)
Forest lost to date:	20% (during 1965-2005)
Current deforestation rate:	2190 km^2 y^{-1}, 2.0 % y^{-1} (during 2000-2005)
Emissions from Land-Use Change & Forestry:	56.1 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and the drivers of deforestation since large scale deforestation began in 1965

Time period	1965-1973	1973-1993	1990 - 2005
Deforestation rate (km^2 y^{-1})	765	1427	1666
Proximate drivers†	W,A	W,A	A,W
Underlying drivers	D,O,P	D,O,P	D, P
Activities	1. Wood export 2. War& political instability 3. Illegal logging 4. Subsistence activities/Shifting cultivation	1. Wood export 2. War& political instability 3. Illegal logging. 4. Subsistence activities/Shifting cultivation	1. Wood export 2. Government policy 3. Illegal logging 4. Subsistence activities/shifting cultivation 5. Mining 6. Tourism
References	(Kim Phat et al., 1999b)	(The World Bank et al., 1996)	FAO (2006a); CIFOR (2008)

†Letters shown alongside the proximate and underlying drivers relate to categories given in Geist & Lambin (2002) as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.

The forest cover in Cambodia increased until the middle of 20th century from 0.10 million km^2 in 1898 to 0.133 million km^2 in 1965 (Kim Phat & Uozumi, 1998). Thereafter, the forest area continuously declined due to many socio-economical and political reasons. Because of the Vietnam War, the forest cover declined to 0.127 million km^2 with an annual deforestation of about 765 km^2 during 1965-1973 (Table 1). The deforestation rate doubled (1427 km^2 y^{-1}) during 1973-1993 and the underlying causes were war (Khmer Rouge Regime 1975-1978, Communist Regime 1979-1989), political instability, fast growing population, and illegal logging (Kim Phat et al., 1999a).

2. Recent drivers of deforestation (1990 – 2005)

2.1. Wood export: Forest management in Cambodia is strongly influenced by regional dynamics of wood demand and supply. Depletion of forest resources in neighbouring countries has forced Cambodia to become a major wood exporter in recent years, with the annual log production increasing from 0.9 to 4.3 million m^3 during 1993 to 1997 (Kim Phat, 1999).

2.2. Government policy: All forests in Cambodia are owned by the national government. A forest concession system was introduced to Cambodia in early 1991. By 1997, the government has issued 28 concessions to different logging companies affecting 63,300 km^2 of total forest area (Kim Phat, 1999).
2.3. Illegal logging: Shortage of human resources, financial constraints, and government instability, especially along the borders with Thailand and Vietnam, has encouraged illegal loggers from inside and outside the countries to over-exploit forests. Global Witness (1997) reports illegal export of more than 1 million m^3 of forest products in 1997.
2.4. Subsistence activities/shifting cultivation: Deforestation also results from subsistence activities, such as collection of fuel wood and clearing for agriculture. Ethnic minorities in the north-eastern hill areas of Cambodia practice shifting cultivation, for their food security. The areas are farmed on average for eight months a year for on an average about three years.
2.5. Mining: Mining for gold, bauxite, and iron is increasingly a threat to Cambodia's forests. The government has recently introduced stricter legislation to govern small miners, including environmental provisions.
2.6. Tourism: Ankor, the most important tourist attraction in South East Asia, which is spread over about 400 km^2 is the part of a protected forest area in Cambodia. The unrestrained tourism has threatened surrounding forest by extensive construction of hotels and other infrastructure.

3. General information about Cambodia

Geographically, the kingdom of Cambodia is located between 13° 0′ 0″ N a latitude and 105° 0′ 0″ E longitude Cambodia is one of the smallest countries in Southeast Asia with a total geographical area of 181,035 km^2 and a population of over 13 million. The country is bounded on the north by Thailand and by Laos, on the east and southeast by Vietnam, and on the west by the Gulf of Thailand and by Thailand. About 59% of the land is covered by forest, which are of two main types, namely dryland and edaphic forests. Forests are one of the most important natural resources for the socio-economic development of the country. Legal and illegal logging driven by the wood demand in the neighbouring countries is one of the major reasons for deforestation in Cambodia.

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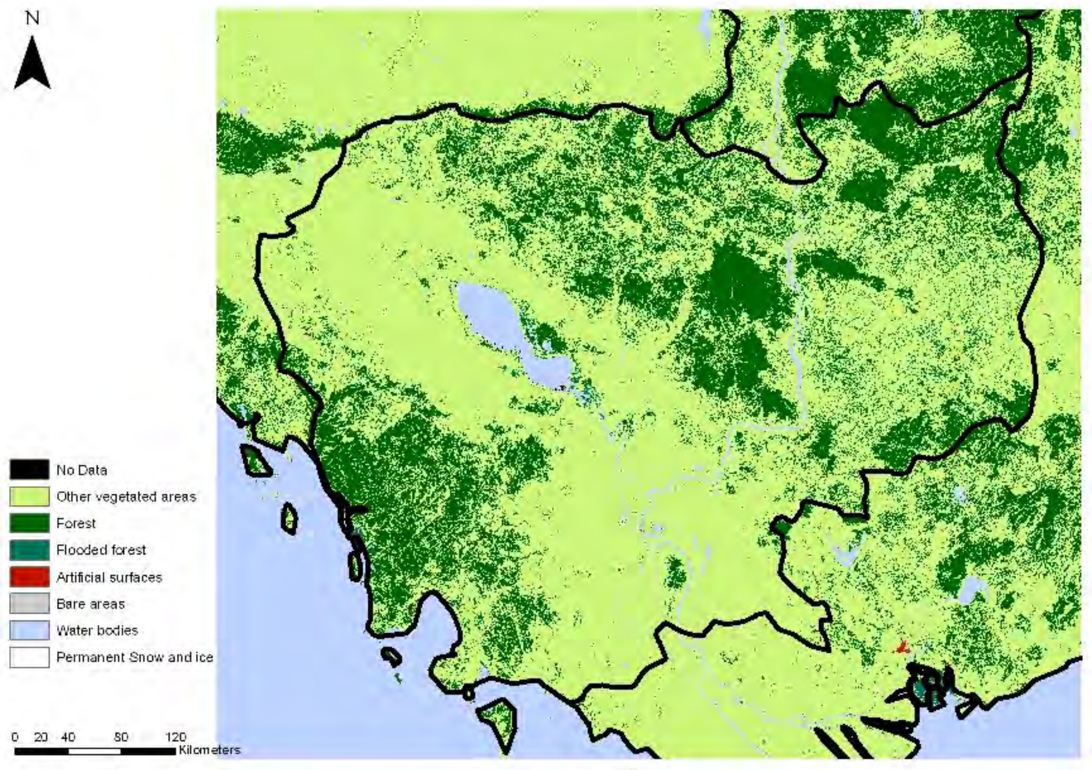
Figure 48: Map of Cambodia showing main areas of forest cover



Indonesia

Size of country:	1.92 million km^2
Forest cover before deforestation:	83% (in 1950)
Present forests cover:	48.8% (in 2005)
Forest lost to date:	41% (during 1950-2005)
Current deforestation rate:	18,710 km^2 y^{-1}, 2% y^{-1} (during 2000-2005)
Emissions from Land-Use Change & Forestry:	2,563.10 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and the drivers of deforestation since large scale deforestation began in 1950

Time period	1950-1960	1960-1970	1970 - 1980	1980 - 1990	1990 – 2005
Deforestation rate (km^2 y^{-1})	-	-	10000	17000	19000
Proximate drivers†	A	A, I	A,W	A,W	A, W
Underlying drivers	D, C	P, C	P, E, C	P,E,C	P,E
Activities	Traditional (slash and burn) and small scale farming	1.Transmigration program to outer islands (1960-99) 2. Traditional (slash and burn) and small scale farming	1. Government started issuing commercial logging concessions 2 Traditional (slash and burn) and small scale farming	1.Establishment of timber and crop (oil palm, cocoa) plantations; 2. Establishment of plywood industry. 3. Illegal logging. 4. Traditional (slash and burn) and small scale farming	1.Growth in plywood industry 2.Establishment of more timber plantations 3. Illegal logging 4. Establishing estate crops (oil palm) 5. Traditional (slash and burn) and small scale farming (rubber) 6. Fire (1994; 1997-98) 7. Economic uncertainty
References	FWI/GFW (2002)	Sunderlin and Kesosudamo (1996); Chomitz and Griffiths (1996); FWI/GFW (2002)	Sunderlin and Kesosudamo (1996); FWI/GFW (2002)	Sunderlin and Kesosudamo (1996)	FAO (2006a); FAO (2007); CIFOR (2008)

†Letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (2002) as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.

Drivers of deforestation through history (up to 1990)

Indonesia was almost completely forested up until 1900 (Mackinnon, 1997). In 1950, about 83% (1.59 million km^2) of the land area was under primary, secondary and tidal forests (Hannibal, 1950). During this period, the only driver for deforestation was agriculture (mainly rice cultivation) (FWI/GFW, 2002). The transmigration programme started in 1960 led to a widespread forest clearance in the outer islands (apart form the six major islands). By 1966, the forest cover had declined to 1.44 million km^2 (World Rain Forest Movement, 2001). Introduction of the Basic Forestry Law in 1967 (giving ownership of all the forests and its resources to the state) and the Forest Concessions and the Forest Product Levy in 1970 set a capital-oriented development policy, which resulted in the exploitation of forest resources (with an annual deforestation rate of 10000 km^2, Table 1). In 1980, though government restricted log export, set policies to promote plywood, pulp and paper industries. By late 1980s, the production capacity of pulp and paper industries has increased several times making Indonesia the world's ninth largest pulp producer and eleventh largest paper producer. The growth of these industries were at the expense of the existing forests with the deforestation rate increasing over the period (1980-90) to 17,000 km^2 y^{-1}. The expansion of these industries since then has created a level of wood demand that cannot be met by legally available forest resources, thereby encouraging illegal logging. Estimated deforestation rate during the 1990-2005 period through both legal and illegal logging was 19000 km^2 y^{-1} (FAO, 2005b; FAO, 2007).

2. Recent drivers of deforestation (1990 – 2005)

2.1. Forest concessions for wood extraction: One of the major proximate drivers of current deforestation is wood extraction through legal and illegal logging. Concessions issued to logging companies covered about one third of the total land area of 630,000 km^2 in 1995 (FAO, 1997). In 2000, the area reported under concessions was 550,000 km^2 (FWI/GFW, 2002). Most of these concessions were issued to companies during the Suharto regime in a non-transparent manner. Though the number and area of concessions is declining since 1995, nearly half the forests are still under logging concessions and are degraded or at the risk of degradation.

2.2. Forest conversion for industrial timber production: In 1980, the government allowed conversion of non-productive forest lands for timber production and provided subsidies to establish wood plantations in order to relieve the pressure on natural forests for timber and rehabilitate degraded lands. However, many concessions were established in still productive forest lands. About 22% of the land used for timber production was productive natural forest prior to plantation establishment (Kartodihardjo & Supriono, 2000). The underlying drivers for these proximate causes are economic demand for the wood arising from plywood, pulp and paper industries.

2.3. Illegal logging: Since legal logging through forest clearance concessions and timber plantations provided only less than half of the wood demand of the wood-based industries, the remaining was met mainly though illegal logging (FWI/GFW, 2002). Even though exact data are not available, it is estimated that about 50-70% of the wood supply is through illegal logging.

2.4. Forest conversion for establishing estate crops (palm oil): Palm oil is an important source of Indonesia’s export revenue. About 1.8 Mha of forests were converted to oil palm plantations between 1990 and 2000 (Wakker, 2000). World demand for palm oil is expected to rise by 40.5 million tons by 2020, which is nearly twice the production in 2000; Oil World, 2001).

2.5. Traditional (shifting cultivation) and small scale farming: Exact figures of the extent of forest clearing caused by shifting cultivation are not available, though estimates show that traditional farming is responsible for about 20% of total forest loss (Dick, 1991). Small-scale farmers normally clear secondary forest or degraded lands to grow food crops, trees or cash crops (rubber, oil palm), rather than primary forest. Recent data show that more than 80% of the rubber plantation area (Kartodihardjo & Supriono, 2000) and about one third of the oil palm area in Indonesia is under small-scale farming. Small-scale rubber planting has also grown significantly since 1997 (Sunderlin et al., 2000).

2.6. Fire: Exceptionally dry conditions caused by El Niño has led to uncontrolled wildfires in 1994 and 1997, with more than 5 Mha of forest burned in 1994 and another 4.6 Mha in 1997.

2.7. Economic uncertainty: Economic uncertainty and volatility experienced by small farmers may increase the rate of forest clearance as they turn to forests to quickly compensate their loss (Sunderlin et al., 2000). Increase in deforestation rate and weak policing of protected forests after the fall of Suharto’s regime in 1998 is one such example of the strong link between price changes and forest clearance.

3. General information about Indonesia

Indonesia is an archipelagic country lying between 6^o 08’N to 11^{o}15’S latitude and 94^o 45’ to 141^o 05’ E longitude. It comprises 17,435 islands with a total land area of 1.92 million km^2 (FAO, 2005a). Six thousand of these islands are inhabited although the five largest islands, Java, Sumatra, Kalimantan (part of Borneo), New Guinea (shared with Papua New Guinea), and Sulawesi hold about 95% of the total population of 215 million, according to 1990 census. About 49% of the country is occupied by forest and the major forest types range from evergreen to seasonal monsoon forests, savanna grasslands to mangrove forests. Wood extraction by legal and illegal logging is one of the major drivers of deforestation in Indonesia.

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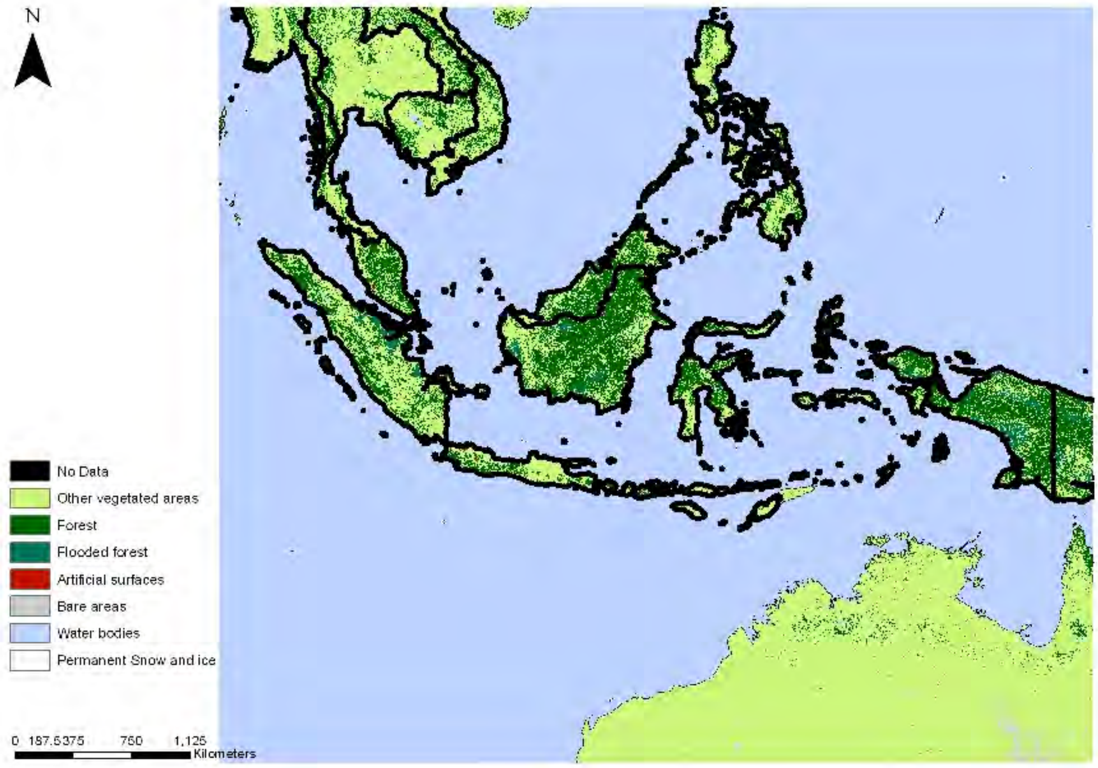
Figure 49: Map of Indonesia showing main areas of forest cover


N
No Data
Other vegetated areas
Forest
Flooded forest
Artificial surfaces
Bare areas
Water bodies
Permanent Snow and ice
0 187.5375 750 1,125
Kilometers

Lao People's Democratic Republic

Size of country:	0.237 million km^2
Forest cover before deforestation:	70% (in 1940)
Present forests cover:	42 % (in 2005)
Forest lost to date:	40% (during 1940-2005)
Current deforestation rate:	780 km^2 y^{-1}, 0.7% y^{-1} (during 1990-2005)
Emissions from Land-Use Change & Forestry:	23.6 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and the drivers of deforestation since large scale deforestation began in 1940

Time period	1940-1960	1960-1980	1980 - 1989	1990 – 2005
Deforestation rate (sq. km y^{-1})	922	1366	1294	781
Proximate drivers†	A	A, O	A, W, I	A, W,I
Underlying drivers	D	D	D,E, P	D, E, P
Activities	1.Shifting cultivation	1. Indo-China War 2. Logging 3. Shifting cultivation	1. Shifting cultivation 2. Logging 3. Illegal logging 4.Infrastructure development	1.Shifting cultivation 2. Logging 3. Illegal logging 4. Infrastructure development
References	Phantanousy (1994); World Bank et al. (2001)	FAO (1993); FAO (1995); Phantanousy (1994); Gilmour et al (2000); Mittleman (2001)	FAO (1993); FAO (1995); Anonymous (2000); Mittleman (2001)	FAO (2006a); Anonymous (2000); CIFOR (2008)

†Letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (2002) as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.

Drivers of deforestation through history (up to 1990)

The estimated forest cover in 1940 was 70% of the total area of the country. By the early 1960s, the forest area had been reduced to 64% (Phantanousy, 1994; World Bank et al., 2001), with an average annual deforestation rate of 922 km^2 yr^{-1} (Table 1). Shifting cultivation was the major driver of deforestation during this period. During the 1960's and 1970's, the Indo-Chinese war in the northeast, and heavy logging and shifting cultivation in the west, destroyed large areas of forest. In 1986, the Lao Government opened up the economy to foreign investors, which led to an increase in logging and timber exports in the following years. By 1989, the forest cover declined to 0.1117 million km^2 (47%). By 1991, wood export in the country accounted for 56 % of the total annual export and the logging rate reached 400,000-500,000 cubic metres per year. According to the Ministry of Agriculture and Forestry, the main causes of deforestation are logging, both legal and illegal, and shifting cultivation (MAF, 1996). Other reasons include new settlements, infrastructure development, and improper forest management practices.

2. Recent drivers of deforestation (1990 – 2005)

2.1. Shifting cultivation: In Lao PDR, shifting cultivation is one of the major drivers for deforestation, most of which occurs in the uplands of northern Lao PDR. About 20-40 % of the total population is partially or fully involved in shifting cultivation, which uses around 4000 km^2 of forest area annually (Fujisaka, 1991; Hansen, 1998). Rice is by far the most important crop and is farmed in monoculture or mixed with other crops on most of the cultivated area. However, deforestation due to shifting cultivation declined from 2459 km^2 y^{-1} in 1990 to 1158 km^2 y^{-1} in 1999.

2.2. Logging: National and provincial governments and the military are involved in logging. At the Government level, quotas are allocated on the basis of political favour, the capacity of the saw mills in the region, and in exchange for building infrastructure by the private companies (Anonymous, 2000). In 1992, long-term logging contracts were awarded to companies from Taiwan, Korea, Thailand and other countries. In 1994, the government gave three military-owned companies exclusive rights over logging operations throughout the country.

2.3. Illegal logging: Illegal logging is increasingly widespread in the country because of corrupt officials who collaborate with investors, officials and local people who are hired as loggers. Illegal logging is estimated at about 17% of the total wood volume that is felled legal (Anonymous, 2000).

2.4. Infrastructure development: In recent years, deforestation has been increasingly caused by infrastructure projects (hydroelectric or irrigation reservoirs, roads, electricity lines etc.) and conversion of forest lands for agriculture and rural development including resettlement programmes. Currently, almost 50% of the official log harvest comes from hydroelectric project areas.

3. General information about Lao PDR

Lao PDR is a landlocked country full of mountains and valleys, spread over an area of 236,800 km^2 located geographically between latitudes 13˚ 50' and 22˚ 30' N, and longitudes100˚ 10' to 107˚ 40' E. The country shares the borders with Myanmar to the northwest, the Peoples Republic of China to the north, Vietnam to the east, Cambodia to the south and Thailand to the west. It has a small population of 5.2 million with an annual growth rate of 2.4% (NSC, 2001). Forest occupies about 42% of the total land area mainly in two types: evergreen and deciduous. Evergreen forests are dry or semi evergreen and hill evergreen. The deciduous forests are mixed deciduous.

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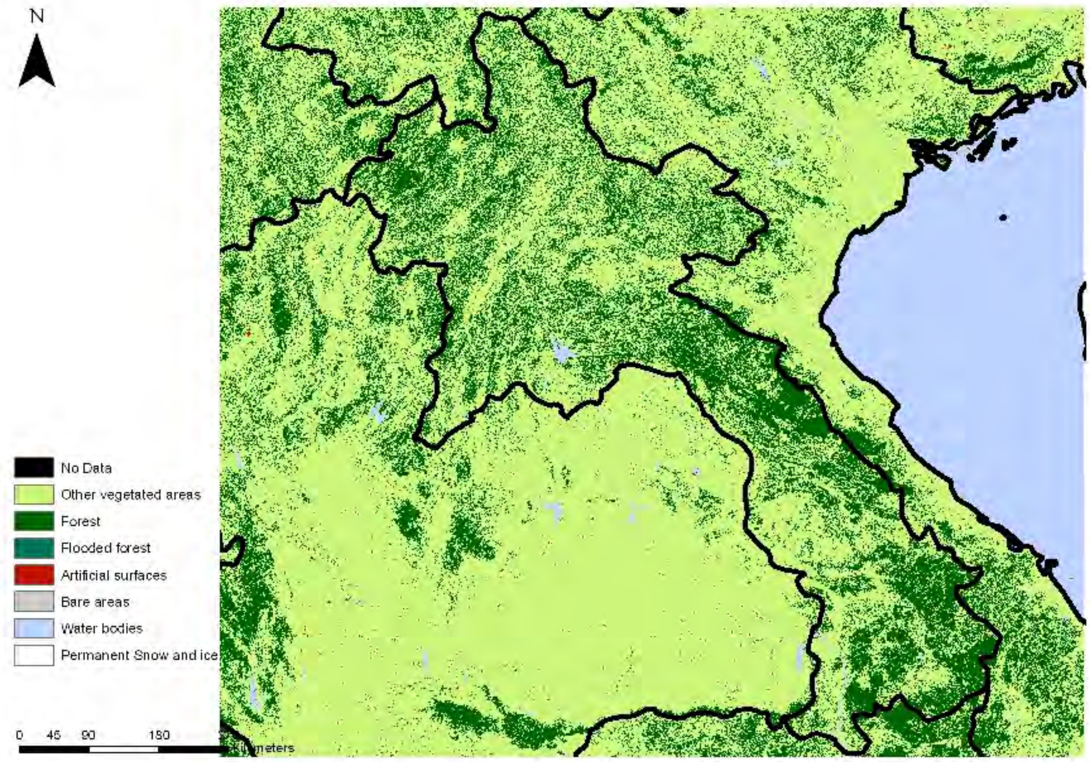
Figure 50: Map of Lao People's Democratic Republic showing main areas of forest cover



Malaysia

Size of country:	0.33m km^2
Forest cover before deforestation:	95% on peninsular Malaysia in mid-1850s (Brookfield, Potter and Byron 1995)
Present forest cover:	63.6% in 2005 (FAO 2005)
Forest lost to date:	31.4% (based on Brookfield, Potter and Byron 1995 and FAO 2005)
Current deforestation rate:	0.7% y^{-1}; 1,400 km^2 y^{-1} (FAO 2005)
Emissions from Land-Use Change & Forestry:	698.9 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Malaysia since large scale deforestation began

Time period	1900 – 1980	1990 – 2000	2001 – 2005
Approx deforestation rate in km^2 yr-1 **	N.A.	780	1,400
Proximate drivers	A,W	A,W	A,W
Underlying drivers	D,E,P	E,P	E,P
Notes	- Rapid expansion of rubber plantations at the beginning of 19th century - After independence (1957), land development programs and resettlement programs led to continued high rates of forest conversion - Oil palm emerges as a relevant tree-crop in the 1960s	- Rapid expansion of oil palm - since 1980s increased forest conversion also in Sabah and Sarawak - Despite commitments for sustainable forest management, selective logging may lead to severe forest degradation	- Continued rapid oil palm expansion - Despite commitments for sustainable forest management, selective logging may lead to severe forest degradation
References	Aiken 2006; Wertz-Kanounnikoff and Kongphan-Apirak 2008	FAO 1981; FAO 2005; Wertz-Kanounnikoff and Kongphan-Apirak 2008; Grieg-Gran et al. 2007	FAO 2005; Wertz-Kanounnikoff and Kongphan-Apirak 2008; Grieg-Gran et al. 2007

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

Although forest cover of Peninsular Malaysia was still approximately 95% until well into the 19^{th} century, forest areas were used by indigenous people for hunting, gathering of forest products, shifting cultivation and fruit tree planting. In some areas, forests were cleared for permanent paddy rice cultivation. With the arrival of the British at the end of the 18^{th} century, forest change began to accelerate, particularly in a number of settlements along the Mallacan Strait. Conversion of forests to rubber plantations increased rapidly at the beginning of the 19^{th} century (Abdullah and Hezri 2008). In 1941, 11% of the total land area of Peninsular Malaysia was under rubber (Aiken 2006). In 1958, one year after the Federation of Malaya became independent, about 74% of the land area in the region was still under forest (Wyatt-Smith 1958 cited in Aiken 2006).

The pace of deforestation has accelerated since then. The area under forest declined from 68% of the total land area in 1966 to about 44% in 1997 (Bernard and De Konick 1997, Tuck 1999, both cited in Aiken 2006). After the foundation in 1956 of FELDA (Federal Land Development Authority), government land development programs and resettlement schemes opened up further land for development, especially for rubber plantations (Aiken 2006). Since the 1970s, oil palm has become increasingly important, with rubber and other cash crop plantations (cacao, coffee) being increasingly converted into oil palm, due to its comparative advantage in terms of profit over rubber as rubber prices began to decline in the mid 1960s (Abdullah and Hezri 2008). An important driver of further land use change was the national development policy aimed at reducing poverty and unemployment in rural areas (NEP New Economic Policy in 1971). Between 1974 and 1985 rubber and oil palm expanded by 0.4 Mha or 30%, with a corresponding loss of 0.8 Mha of forested land between 1975 and 1980 (Abdullah and Hezri 2008). In 2000, approximately 15% of peninsular Malaysia was covered by oil palm (and an additional 9% in rubber), compared to only 4% in 1975. Urbanization has increasingly become a driver of land use change on Peninsular Malaysia, including deforestation, although it is small compared to logging and conversion to tree-crop (oil palm) agriculture (Abdullah and Hezri 2008).

At present, deforestation in Malaysia is largely happening in Sabah and Sarawak. It has been estimated that approximately the same area as is deforested is subject to forest degradation per annum (Grieg-Gran et al. 2007). Expansion of commercial cash crops (oil palm) is the main driver of deforestation, while forest degradation occurs as a consequence of selective logging practices (Richard 1999). The latest FAO statistics (FAO 2005) show a decrease in forest plantation area. This reflects the decrease in rubber plantations, which are counted as tree plantations by the FAO. Rubber plantations were mostly converted to oil palm. More than half of the new oil palm plantations in Malaysia and Indonesia established between 1990 and 2005 have replaced forest land (Koh and Wilcove 2008), partly due to the possibility of using returns from timber sales to finance plantation establishment (FWI/ GFW 2002).

Recent annual estimates of deforestation rates for Malaysia are: 1980-1990: 3,960km^2 (Grieg-Gran et al. 2007); 1990-2000: 2,380 km^2 (FAO 2001); 1995-2000: 780 km^2; 2000-2005: 1,400 km^2 (FAO 2005).

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Agricultural expansion (mainly oil palm): In the past 15-20 years, forest conversion for oil palm plantations has increased rapidly (Grieg-Gran et al. 2007; Jomo et al. 2004). Together with Indonesia, Malaysia is the largest producer of palm oil worldwide, with the two countries producing more than 80% of global palm oil (Ardiansyah 2007) . Oil palm contributes 5.6% to Malaysia's gross national income (Koh and Wolcove 2007). Establishment of oil palm plantation first began in Peninsular Malaysia and Sabah, although currently the greatest expansion is taking place in Sarawak. Some 2 Mha of oil palm plantations were established between 1990 and 2005 (Grieg-Gran et al. 2007). The increase in area under oil palm (1980-2004) was 125% for Sabah and 329% for Sarawak. The largest oil palm growing areas are now Sabah, Johor, Pahang and Sarawak accounting for 76% of total plantation area (Kessler et al. 2007). Between 1995 and 2005, oil palm plantations expanded at the cost of natural forest on 7,600 km^2, implying that oil palm expansion was the cause of 70% of the deforestation (11,000 km^2) between 1995-2005 (Grieg-Gran et al. 2007), confirming the assessment of Koh and Wilcove (2008) that more than half of new oil palm plantations between 1990 and 2005 in Malaysia and Indonesia were established on forestlands. Since the year 2000, conversion of forest to pulpwood production has been another driver of deforestation, although by 2003 only 2360 km^2 had been established (Grieg-Gran et al. 2007). Shifting cultivation is present in Sabah and Sarawak, but is of little relevance as a driver.

2.2. Logging: Legal logging in Malaysia is primarily a driver of forest degradation rather than deforestation. Grieg-Gran et al. (2007) report an increase of the area of secondary forests from 35% in 1995 to 45% in 2005. Logging takes place in Permanent Forest Reserves (PFRs). Woon and Norini (2003) report an area under PFRs of 141,000 km^2 of a total of 189,000 km^2 of natural forests (primary and secondary forests). A commitment to achieve sustainable forest management led to formulation of the Malaysian Criteria and Indicators (MC & I) and subsequent establishment of the Malaysian Timber Certification Council (MTCC). Malaysian National Policy on Biological

Diversity, established in 1998 means that all natural forests should be managed for their environmental services. The Forests in the PRFs are supposed to be managed to provide sustainable yields. However, logging damage can be as high as 60-80% of the forest area (Richard 1999). Malaysian media reported on widespread illegal logging in Sarawak. Malaysia is also suspected to have been a major importer of illegally felled timber from Indonesia, particularly between 1999 and 2003 (Grieg-Gran et al. 2007).

2.3. Infrastructure extension (settlements, urbanisation, industrial estates): Processes of expanded settlements and urban areas are mainly an issue in peninsular Malaysia and can be locally relevant there (Abdullah and Nakagoshi, 2007). Wertz-Kanounnikoff and Kongphan-Apirak (2008) list weak governance and international demand for palm oil and other cash crops as two underlying causes of deforestation in Malaysia:

3. General information about Malaysia

Malaysia is a federation that consists of thirteen states and three federal territories. Its territory is spread over three "regions" (see map below): at the southern part of the SE Asian peninsular (peninsular Malaysia), and on the island of Borneo (Sarawak and Sabah). The neighbouring countries are Thailand and Brunei in the north and Singapore and Indonesia in the south. In 2003, a total of 24.8 m people (World Bank 2005) lived on an area of 0.33 m km^2. About 95% of Peninsular Malaysia's forests are classified as dipterocarp forests, while Sabah ranges from coastal beach forests and mangroves, lowland dipterocarp, to montane forests. Sarawak contains hill mixed dipterocarp forest, peat swamp forest, mangrove forest, Kerangas forest, and montane forest (UNEP 1997). Total forest cover was 63.6% in 2005 (FAO 2005).

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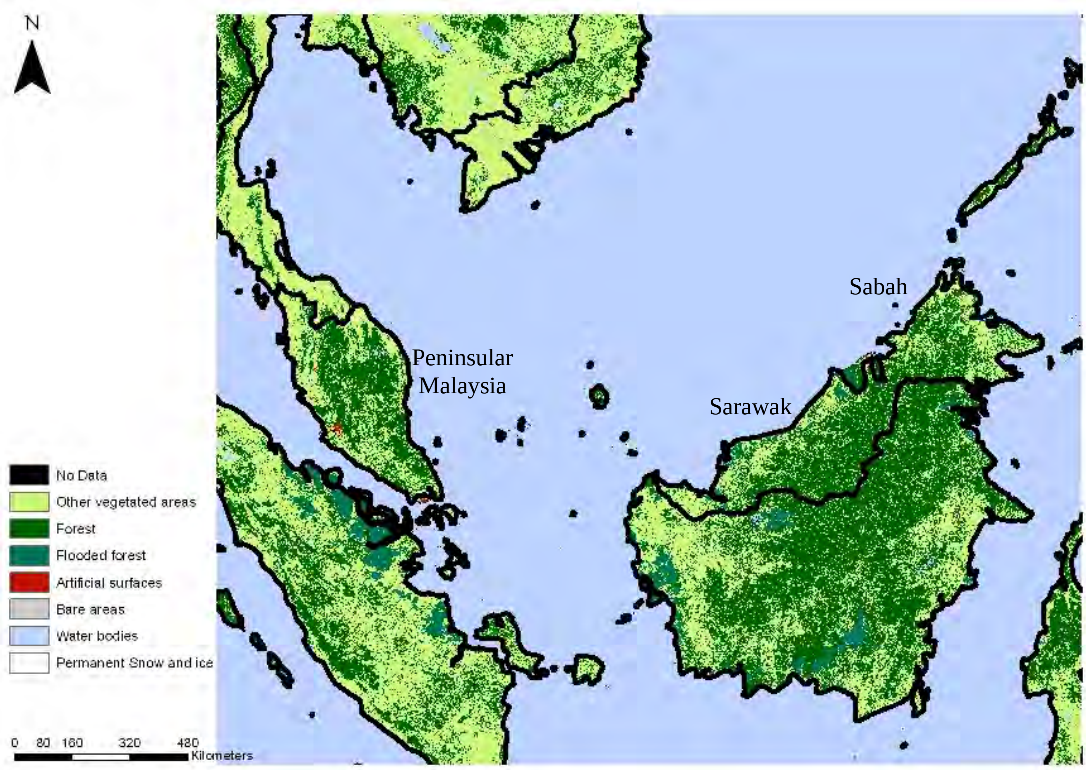
Figure 51: Map of Malaysia showing main areas of forest cover



Myanmar

Size of country: 0.677 million km^2
Forest cover before deforestation: 57% (in 1955)
Present forests cover: 49% (in 2005)
Forest lost to date: 14% (during 1955-2005)
Current deforestation rate: 4660 km^2 y^{-1}, 1.4% y^{-1} (during 2000-2005)
Emissions from Land-Use Change & Forestry: 425.4 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and the drivers of deforestation since 1955

Time period	1955-1975	1975-1989	1990 – 2005
Deforestation rate (km^2 y^{-1})	3121	2188	4665
Proximate drivers†	A,I,W	A, I, W	A, W
Underlying drivers	D.P	D,P	D,P
Activities	1. Shifting cultivation 2. Agricultural expansion 3. Logging	1. Shifting cultivation 2. Agricultural expansion 3. Urbanisation, building dams and roads. 4. Logging	1.Shifting cultivation 2. Agricultural expansion 3. Logging/Illegal Logging 4. Fuel wood demand
References	FD (2003) MOF (2005)	FD (2003); MOF (2005); Khai et al. (2003)	FAO (2006a); CIFOR (2008)

†Letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (2002) as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.

Drivers of deforestation through history (up to 1990)

Before the turn of the 20^{th} century, the lowlands of Central and Southern Myanmar were largely deforested as a result of agricultural expansion, firewood cutting, and charcoal production (WRI, 1998). Myanmar forests were rich in teak which was one of the major products of trade between the neighbouring countries since colonial times. After independence in 1948, Myanmar Timber Enterprise (MTE) was responsible for teak forest management and timber extraction. Following the military coup in 1962, the timber industry became nationalized and was taken over by the military, and logging became a major source of revenue for the regime. Increase in demand for wood from neighbouring countries also increased the rate of deforestation. As a result, forest cover decreased from about 0.39 million km^2 (57%) in 1955 to 0.32 million km^2 (48%) in1975 (MOF, 2005) with an average annual deforestation rate of 3121 km^2 yr^{-1} (Table 1). Forest area further declined to 43% in 1989. The major drivers of deforestation during these periods were population pressure, logging and conversion into other uses like agriculture, building dams and roads.

2. Recent drivers of deforestation (1990 – 2005)

2.1. Shifting cultivation: Shifting cultivation is a major driver of deforestation in the uplands of Myanmar, with about 1770 km^2 of forest area being annually lost (Forest Department, 1996) About 187,000 families, or about 30% of the total population in upland areas, practise shifting cultivation, often in steep, hilly areas which are unsuitable for permanent cultivation.

2.2. Agricultural expansion: Shrimp farming and oil palm plantations are the recent trends of agricultural expansion in Myanmar. Industrial shrimp farming has gained momentum since 1998 especially along the coastal zone. The mangrove forests are converted to fish and prawn farms and the produce is mainly exported. Currently, the deforestation rate of mangrove forests in Myanmar (1% yr^{-1}) is highest in Asia Giri et al.(2008). Expansion of commercial oil palm plantations in the lowland forests (Tanintharyi Division) is another driver of deforestation (Leimgruber et al., 2005).
2.3. Logging/illegal logging: Even though a ban on raw log exports has existed in Myanmar since 1993, logging and log export continues illegally in the border areas such as northern Kachin State. Chinese companies in Yunnan province, local people and government officials from Myanmar are involved in this trade. It has been estimated that about 95% of Burma's total timber exports to China in 2004 were illegal (Global Witness, 2005).
2.4. Fuel wood demand: More than 20% of the lowland mangrove forests in the southern Ayeyarwady Division have been deforested to satisfy the demands of the Yangon metropolitan area for fuel wood (FAO, 2001b).

3. General information about Myanmar

Myanmar, the largest South East Asian country stretches between a latitude of 09°32’N to 28°31’N and longitude of 92°10’E to 101°11’E with a total geographical area of 677,000 km^2 and population of 52.4 million (MOF, 2005). Three-fourths of the country lies within the tropics with a wide latitudinal range. The altitude ranges from sea level to peaks higher than 5000m. Myanmar has one of the highest proportions of forest cover in Asia and the Pacific (49%). Forests and are highly diversified due to the different climatic conditions within the country. The most common type of forest is mixed deciduous, but other types include tropical evergreen, dry, deciduous dipterocarpus, hill and temperate evergreen and tidal swamp forest.

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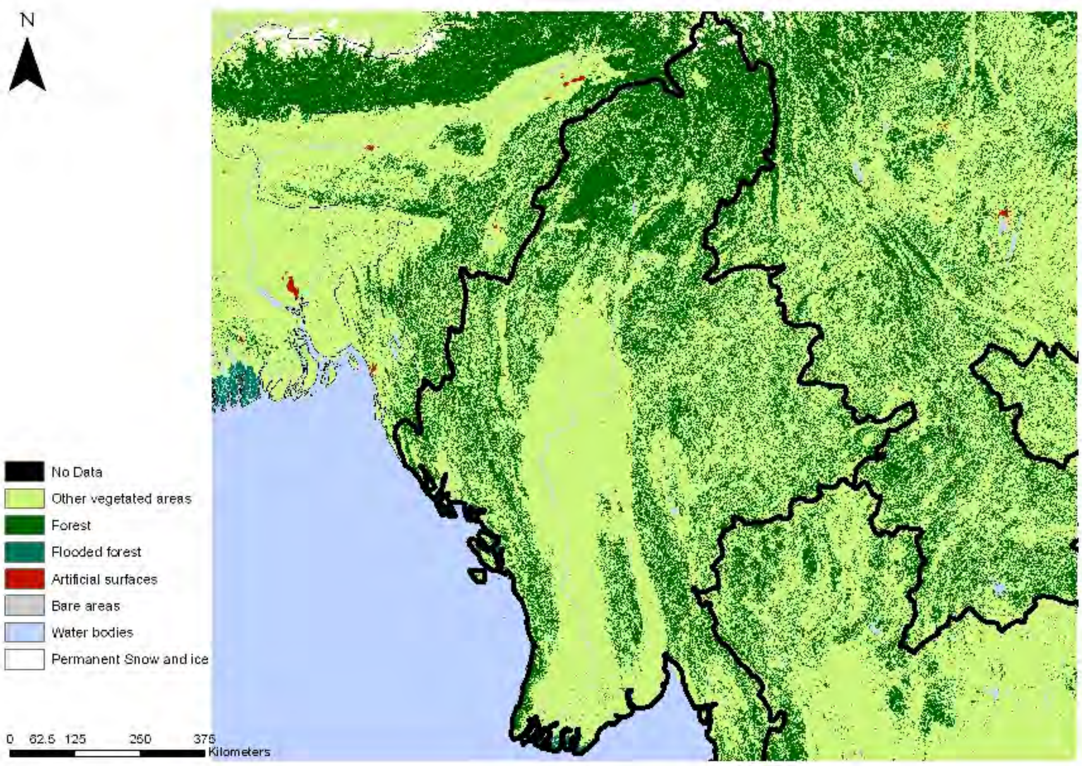
Figure 52: Map of Myanmar showing main areas of forest cover


N
No Data
Other vegetated areas
Forest
Flooded forest
Artificial surfaces
Bare areas
Water bodies
Permanent Snow and ice
0 62.5 125 250 375
Kilometers

Nepal

Size of country:	0.147 m km^2
Forest cover before deforestation:	-
Present forests cover:	24.7%; 37.6% including “other wooded land”5 (FAO 2005)
Forest lost to date:	-
Current deforestation rate:	1.4% yr^{-1}; 530 km^2 yr^{-1} (FAO, 2005)
Emissions from Land-Use Change & Forestry:	123.5 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Nepal since large scale deforestation began

Time period	Pre 1957	1957 – 1990	1990 – 2000	2001 - 2005
Approx deforestation rate in km^2 yr-1 **	N.A.	N.A. but significant increase	920	530
Proximate drivers	A,W	A,W	A,W	A,W
Underlying drivers	D,P,E	D,E,P,I,O	D,E,P,O	D,E,P,O(Tourism, forest fires)
Notes	From 1920, forest exploitation to increase agricultural production for growing population and increase tax revenue.	Eradication of malaria in the 1950s. Nationalisation of forests and trees on private land in 1957 is generally considered as main cause of rapid increase in deforestation. Re-settlement programs beginning in the 1950s increase pressure on land. Beginning of development of tourism industry. Other industries (mining, textiles) locally relevant.	More effective integration of local communities into forest management since 1989. Slowed rate of deforestation in middle hills but less so in Terai region	Political instability may have exacerbated deforestation. Some evidence of forest re-growth (Terai and middle hills).
References	Gautam et al. 2004	Shrestha 1999; Gautam et al. 2004	FAO 2005; Gautam et al. 2004	FAO 2005; Dhital 2009; Nagendra 2007

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.

Historic deforestation

Due to data limitations, it is very difficult to assess how forest cover in Nepal has changed over time. Early deforestation activities for central Nepal can be traced back several thousand years ago and deforestation intensity increased in the Solu area in the period from the late 10^{th} century to the first half of the 20^{th} century (Iwata et al. 1999). Until the 1950s, forest use for subsistence was barely regulated. Government policies actually promoted the conversion of forest land to increase agricultural production and improve the tax base. The forests of the Terai lowlands are reported to having been relatively undisturbed until the late 1920s, when government policies encouraged the expansion of agricultural land and the clearing of forests for timber to be exported to India (Gautam et al. 2004). According to Shrestha (1999), however, the extent of the problems caused by deforestation was comparatively modest before 1957.

Although it is difficult to quantify deforestation over time, there is a consensus that significant deforestation has occurred since then. A widely cited cause of rapid deforestation was the nationalisation of all forest land through the Private Forest Act in 1957 (Shrestha 1999, Gautam et

[5] Land not classified as forest, spanning more than 0.5 hectares; with trees higher than 5 m and a canopy cover of 5–10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use (FAO 2005).

al. 2004), supposedly initiated to prevent the ongoing destruction of the forest resource base (Regmi 1978 in Gautam et al. 2004). Forests became quasi open-access resources, and the traditional system of rights associated with access and utilisation of forests was destroyed (Gautam et al. 2004, Nagendra et al. 2005). (Illegal) clearing of forests to claim property rights to the land was a consequence of this policy, and of resettlement programs beginning in the 1950s (Wallace 1981; Wallace 1983). Environmental degradation and poverty in the hilly and mountainous regions on the one hand, and improved economic opportunities and the eradication of malaria on the other hand, contributed to increased and uncontrolled migration into the terai lowland region, leading to severe deforestation (Shrestha 1999, Gautam et al. 2004).

Initial efforts to increase the level of community participation in forest management were made in the late 1970s. People’s involvement, however, was limited, and the success of the cooperation of the Forest Department with local communities was limited (Nagendra et al. 2005). Beginning with the 25-year Master Plan for the Forestry Sector approved by the government in 1989, the transfer of access and management rights to local communities became a fundamental pillar of Nepalese forest policy. The success of community forestry programs in Nepal varies widely across regions. While such programs in the middle hills are often cited as ‘role models’ (see references in Gautam et al. 2004, 136), there was limited success in the Terai region. This has been attributed to, amongst other factors, fewer pre-existing traditional and indigenous institutions of forest management in this region (Nagendra et al. 2005). Therefore, deforestation rates are considered to be lower in the middle hills compared to the Terai region.

Because almost the entire rural population, particularly in the hilly and mountainous regions, depend on forests for the provision of fuel wood, timber for construction and fodder for livestock, these have been the main proximate causes of deforestation and degradation. Given the subsistence nature of large parts of the rural economy, clearing land for subsistence agriculture has been cited as a principal factor particularly in the hilly regions. Slash and burn agriculture contributed to deforestation in more remote hills. Underlying causes have been government forest policies, rapid population growth, infrastructure development, development of industries (traditional iron and copper mining using charcoal, carpet industry), and the growth in the tourism industry (Shrestha 1999, on tourism also see Stevens 2003, who portrays a less clear-cut picture of the links between tourism and forestry for the Mount Everest region).

Deforestation during the 1990s took place at a rate of 2.1% per year and decreased to an estimated rate of 1.4% per year in the period from 2000-2005. At the same time, the area covered in “other wooded land” increased from 1.2 Mha in 1990 to 3.6 Mha in 2005 (FAO, 2005).

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Agricultural expansion: (Illegal) logging for agricultural expansion is a continued proble,m particularly in the Terai lowland region.

2.2. Logging for fuel-wood and charcoal production: As large parts of the rural population rely on fuel-wood for energy provision, logging for fuel-wood may continue to be a major driver of deforestation, or at least forest degradation. Locally links to tourism industry can be of relevance.

2.3. Logging for construction timber: Locally, links to the tourism industry can be of relevance.

2.4. Forest use to generate fodder for livestock: This includes grazing of livestock on forested land and the collection of fodder for stall-fed animals. Livestock grazing also exaggerates or inhibits the natural regeneration in forests.

2.5. Other secondary or locally relevant proximate drivers: Forest fires and disturbances due to floods and landslides are reported in Dhital (2009). They do, however, not clarify the original source of these events. For the Terai region, Dhital (2009) also mentions illicit felling of timber for smuggling across the border to India.

3. General information about Nepal

Nepal covers an area of 140,718 km^2, and stretches 850 km from east to west and up to 180 km from south to north. It is surrounded by India except in the north, where it borders to China. Nepal's highly diverse physiography is shaped by huge altitudinal differences that range from 300 m in the Gangetic plain to Mount Everest in the Himalayas at 8,850 m. Nepal can be separated into three broad physiographic zones:

1. The Terai region in the south is a lowland tropical and sub-tropical belt of flat, alluvial land along the border to India in the Gangetic plain. Due to fertile land and (until the early 1990s) larger amounts of accessible and valuable timber resources, the Terai plains have become Nepal's richest economic region.
2. North of the Terai plains, the Hill region (middle hills) includes Kathmandu valley and ranges from 1,000 m to 4,000 m in altitude. The Siwalik hills and the Mahabharat range form the transition from the Terai to the Hill region. Despite its isolated geographical location and its limited economic potential, the Hill region has always been the centre of political and cultural influence in Nepal.
3. The Mountain region comprises the central part of the Himalayan range. Most of its land has an elevation of 4,000 m above sea level and above. Due to the harsh climatic and topographical conditions, its economic potential is severely limited. Mountaineering and tourism have become a significant contributor to the regional economy.

The latest FAO estimate of total forest cover is 24.7% (the largest part of it being semi-natural forest), or 37.6% if "other wooded land" is included (FAO, 2005). Because of the extreme topographical and climatic variation across the country, Nepal's natural vegetation ranges from tropical vegetation in the south to alpine vegetation in the north. In 2004, 85% of the 25.2 million Nepalese live in rural areas, and the population growth rate was 2.1% per annum (FAO, 2005).

The most important recent direct/proximate causes of deforestation are agricultural expansion, logging for fuel-wood and charcoal production, logging for construction timber and forest use to generate fodder for livestock. Deforestation is driven by population growth and related demographic and economic problems (poverty); political instability in the past decade; forest policy changes (e.g. recent (2001) changes in community forestry legislation) require forest user groups to share 40% of their income from forest products with national and local governmental institutions (Gautam et al. 2004)); and tourism.

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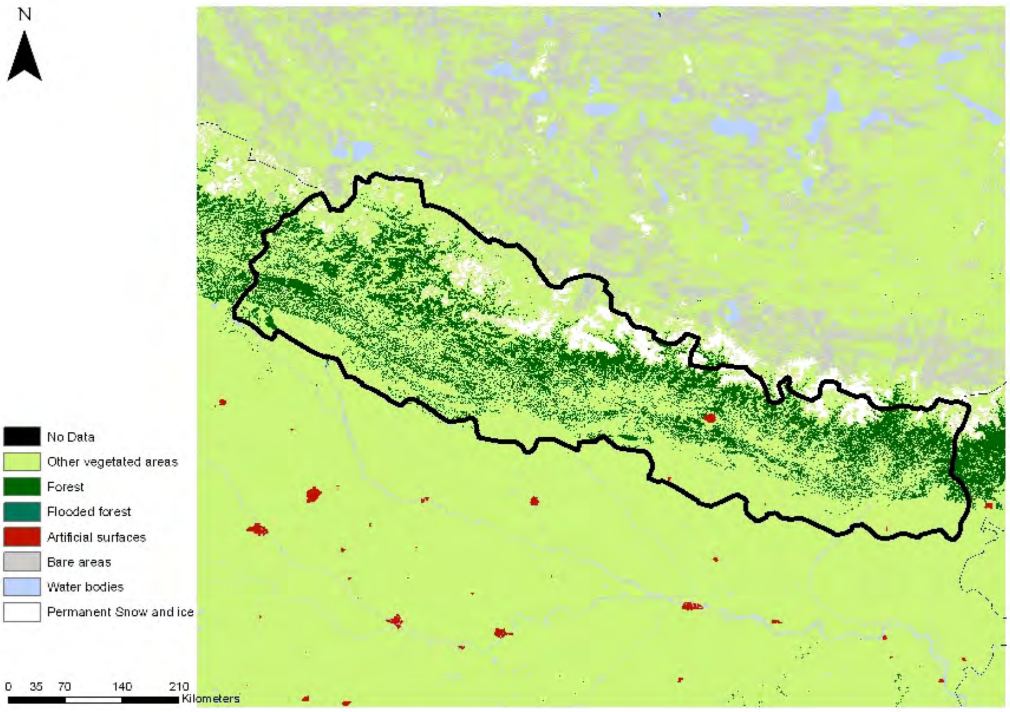
Figure 53: Map of Nepal showing main areas of forest cover



Papua New Guinea (PNG)

Size of country: 0.452 m km^2
Forest cover before deforestation: earliest reliable estimate 1972: 3.4% (Shearman et al. 2009)
Present forests cover: 65% (2005; FAO 2005)
Forest lost to date: -
Current deforestation rate: based on linear extrapolation from 1996: -0.5% yr-1; 1,390 km^2 yr^{-1} (FAO 2005)
Emissions from Land-Use Change & Forestry: 146 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Papua New Guinea since large scale deforestation began

Time period	1980 – 2000	1972 - 2002	1990 - 2000	2000 - 2005
Approx deforestation rate in km^2 yr-1 **	500 – 700	~1,600 1972-73 ~3,900 2001-02	1,390	1,390
Proximate drivers	A,W,O (mining),I	A,W,O (Fire, mining)	A,W,O(mining), I	A,W,O(mining) ,I
Underlying drivers	D,E	D,E,P	D,E,P	D,E,P
Notes	The three main proximate causes are: 1. Subsistence food production 2. Mining (off-site effects, 'dieback'!) 3. Commercial crops (locally relevant) Timber harvesting mainly causes degradation rather than deforestation – which is not factored in the estimates above. Selected main factors limiting past deforestation: 1. Reduced export-crop production competitiveness due to hard currency (kina) 2. Infrastructure (road) under-development 3. Customary land ownership 4. Physical barriers	Above estimates include degradation and correspond to an annual rate of change in total forest extent from -0.4% (72/73) to -1.4% (01/02), down from -1.8% in 1997/98. The main drivers of deforestation and degradation are: 1. Logging (regional differences due to accessibility, in drier areas logging may increase fire risk) 2. Subsistence agriculture (expansion at lower population densities, intensification at higher densities) 3. Forest fires (especially in combination with El Nino) 4. Commercial crops and plantations (fertile lowland areas) 5. Mining (locally, but potentially large offsite effects see Wunder 2003)	Deforestation rate estimates based on FAO statistics. Drivers and underlying causes taken from Wertz-Kanounikkoff and Kongphan-Apirak (2008) Corruption for obtaining logging concessions is mentioned as an underlying cause.	Deforestation rate estimates based on FAO statistics. Drivers and underlying causes taken from Wertz-Kanounikkoff and Kongphan-Apirak (2008) Corruption for obtaining logging concessions is mentioned as an underlying cause.
References	Wunder (2003)	Shearman et al. (2009)	FAO (2005)	FAO (2005)

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

PNG was settled by humans at least 40,000 yrs ago, and forest disturbances in pollen records are documented from about 5,000 years ago. The traditional agricultural system experienced a major change with the introduction of the sweet potato (*Ipomoea batatas*) that arrived from South America in PNG via the Philippines, which allowed settlement in high-altitude valleys and plateaux. In the lower parts of highlands extensive shifting cultivation was practised, involving the clearing of large areas of forest. Sweet potato is now the primary staple in PNG for 60% of the population. The more recent spread of other introduced crops such as cassava, African yam and potato has further increased per ha food production. Prior to contact with Europeans, most of the lowland forests were in use for shifting cultivation at different rates of recurrence. Permanent conversion to agriculture and grasslands could be found in places with relatively high population density and/or places with unfavourable environmental conditions for forest re-growth.

Contact with Europeans expanded from coastal areas into the highlands from 1930s on. At first, population growth was slowed down by the spread of new diseases, but after WWII, improved medical services removed this barrier to population growth. As a consequence of increasing populations, land use was intensified and the area of agricultural land expanded into the forest. Intensification in some areas resulted in shortened periods of fallow that exaggerated the re-establishment of forests.

The population size in 1900 was about 1 million, and increased to 4.7 million in 2000 and was estimated at 5.5 million in 2003 (World Bank 2005). The population has grown at a rate of 2.2% in the 1980s and 2.3% in the 1990s. 82% of the population lives in rural areas (World Bank 2005). The overall population density is still comparatively low at just over 10 people km^{-2}. However, there is a large variation in population density across regions that can be attributed to the nutritional value and agricultural production in different areas. In some highland areas, population densities exceed 100 persons km^{-2}. Lower altitude areas relying on yam and bananas have population densities of around 5 persons km^{-2}, while those areas where people rely on the extraction of the nutrient-poor sago palm tend to have less than 1 person km^{-2}. In addition, malaria in coastal areas limited population growth during the first decades following WWII. The growth of the rural population has not led to a proportional expansion of agricultural land into forest land (Wunder, 2003). Rather than moving along an expansion path agricultural land use in existing areas was intensified (McAlpine and Freyne 2001). Compared to other SE Asian countries such as Indonesia, deforestation rates over time have been low. Both physical (slopes/natural hazards) and social constraints limited the expansion of the agricultural area. Social and institutional obstacles also play an important role. Land tenure is characterised by so-called resource-owners controlling 99% of all forest land. The customary ownership makes it difficult for external and internal community developers to gain access to secure land rights and provides disincentives for establishing longer-term land uses, e.g. with perennial cash crops. An additional barrier to forest conversion is the system of intra-clan decision making. Clearing of forest land requires a collective decision, which may sometimes be difficult to obtain, so the path of least resistance often leads to intensification of existing agricultural land and adaptation of fertility-maintaining technologies. However, recent research by Shearman et al. (2009) questions whether the increase in PNG's population has been supported mainly by agricultural intensification rather than expansion into forest land. Their findings suggest that expansion takes place in areas with lower population density and that as population density increases, intensification increasingly prevails over expansion.

Timber production, especially logs for export, increased rapidly in the 1980s, supported by development policies (Saulei, 1997) and the depreciation of the currency (kina) (Wunder, 2003). It is unclear whether logging activities result in degradation of forests (Wunder, 2003), or if logging also significantly contributes to deforestation, as suggested by Shearman et al. (2009). According to the latter, 36% of accessible rain forests were deforested (14%) or degraded (22%) between 1972 and 2002.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Forest conversion for commercial and industrial timber production: Recent evidence suggests that logging has had a greater impact on forest change in the past decades than previously assumed. However, it is important to note that logging activities in PNG often result in degradation rather than deforestation. Approximately 33% of PNG's rain forests have been classified as accessible, and 49% of this area has already been allocated to the commercial logging industry. As the government has control over logging activities, in contrast to the expansion of (subsistence) agriculture, reducing logging impacts should be a priority target for any PNG REDD strategy. Logging roads can stimulate some deforestation, but according to Wunder (2003) the indirect effects of road development on deforestation are rather localised and logging roads are often not build to last.

2.2. Agricultural expansion for subsistence purposes: Assessing the amount of land that is permanently converted from forest to other land uses is complicated by the fact that shifting systems dominate agricultural food production, and that biophysical and social constraints may act as a further barrier for agricultural expansion at forest margins. However, Shearman et al. (2009) suggest that at a low regional population density, demand for food is met largely by expansion rather than intensification.

2.3. Mining: The direct effects of mining on deforestation are quite limited. However, severe off-site erosion of mining discharge can result in permanent or increasingly frequent flooding downstream, which can either lead to deforestation (waterlogged trees are dying) or forest degradation. This effect is called vegetation dieback and is expected in the Ok Tedi watershed alone to affect 2,569 km^2 in the long term (Wunder, 2003).

2.4. Forest fires: Large forest fires accounted for 4.4% of the total forest change between 1972 and 2002 (Shearman et al. 2009). Forest loss through burning was especially found to be an important driver at higher altitudes. Forest fires were particularly frequent during the last bigger El Nino event (1997-1998).

2.5. Clearing of forests for commercial crop plantations: The establishment of commercial crop plantations is an important but relatively localised cause of forest loss in some of the lowland areas of West New Britain and Milne Bay (Shearman et al. 2009). The severe loss in competitiveness of agricultural exports due to the mineral boom and the resulting highly appreciated kina, significantly contributed to the limited expansion of a plantation economy in the post-war decades (Wunder, 2003). This contrasts with other countries in SE Asia such as Indonesia and Malaysia.

3. General information about Papua New Guinea

Located in Oceania, PNG (officially the Independent State of Papua New Guinea) occupies the eastern half of the world's second biggest island plus 600 other islands and archipelagos. Its population of about 6 million is characterised by a huge cultural diversity and a low proportion of its citizens living in urban areas. About 75% of PNG is covered with forests, with moist forests being the natural vegetation type on most lands. Closed broadleaved forests dominate. There is a greater diversity of forests to be found in PNG that differs from the dominance of dipterocarp forests in much of the rest of SE Asia. The most important drivers of deforestation, which has recently been estimated to have been taken place at higher rates than official FAO statistics suggest (Shearman et al. 2009), are forest conversion for commercial and industrial timber production, agricultural expansion for subsistence purposes, mining, forest fires. In contrast to countries such as Indonesia and Malaysia, clearing of forests for commercial crop plantations is still of limited importance for overall forest cover change.

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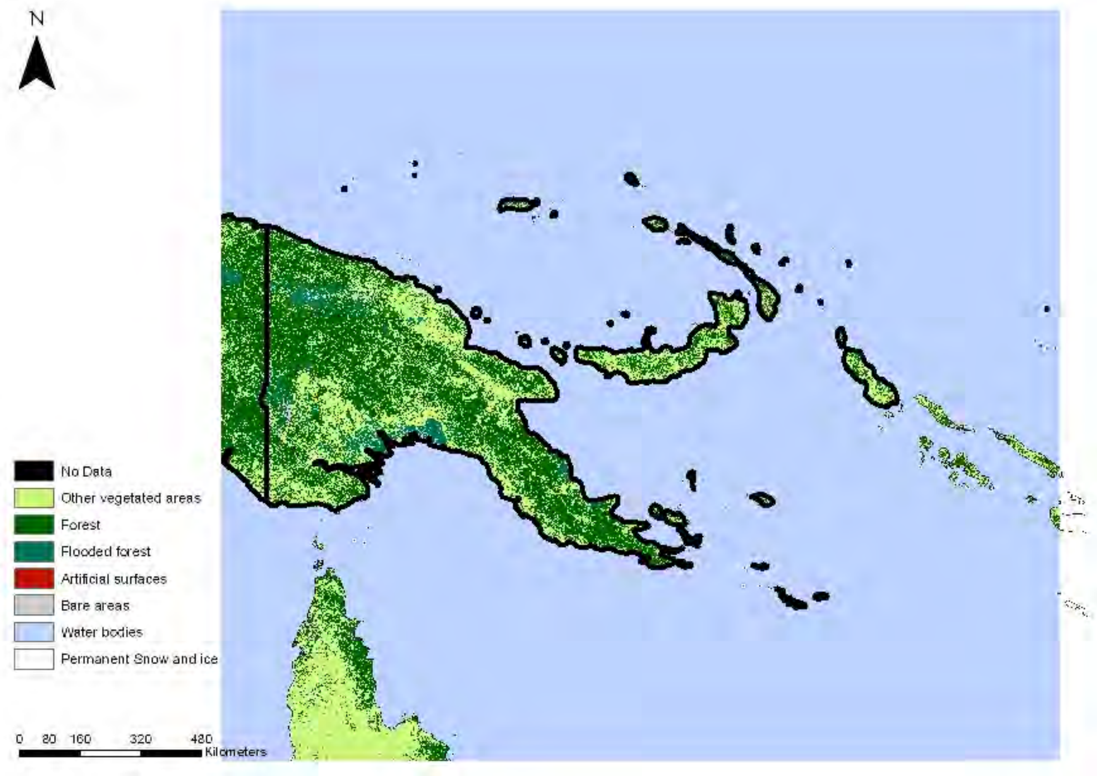
Figure 54: Map of Papua New Guinea showing main areas of forest cover



Philippines

Size of country:	0.299 million km^2
Forest cover before deforestation:	0.275 m km^2 (92%) in mid 16th century; 0.148 m km^2 (50%) in 1950 (Bankoff 2007)
Present forests cover:	24% in 2003 (FAO, 2005)
Forest lost to date:	74% (mid 16th century); 48% (1950)
Current deforestation rate:	2.1% yr^{-1}; 1,570 km^2 yr^{-1} (FAO 2005)
Emissions from Land-Use Change & Forestry:	94.9 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Philippines since large scale deforestation began

Time period	1565-1903	1903 – 1950	1950 – 1987	1990 – 2000	2001 – 2005
Approx deforestation rate in km^2 yr^{-1} **	216.8	1,261	2,109	2,620	1,570
Proximate drivers	A	A,I,W	A,W	A,W	A,W
Underlying drivers	D,P,E	D,E,T,P	D,P,O (corrupt)	D,E,P	D,E,P
Notes	Spanish colonial rule; population increase and spread of commercial agriculture; demand for construction timber (towns, ships)	American colonial rule; infrastructure development for industrial timber production led to rapid increase of commercial logging to cater increasing demand in USA and Asia (Japan); continued spread of commercial agriculture and population increase associated with spread of subsistence agriculture	Unregulated large scale commercial logging followed by some form of agriculture; End of Marcos era in 1986 marks significant change towards more sustainable forest policies	Loss of forest cover and degradation continues, and forest cover change is described more and more by the complex interaction of deforestation, forest degradation and reforestation that characterises the present	Main pattern: - Primary forests are declining (Mindanao, also Luzon and Samar), however little large scale commercial logging; - Frontier Agriculture in some areas, in others eases agricultural intensification in lowlands pressure on upland forest frontiers - Secondary forests with commercial value are logged - Poor-quality degraded secondary forests are on the rise - Plantation forests are increasing rapidly → Increase in total forest or wooded land cover expected, but quality and diversity of forests expected to diminish (Illegal) mining activities may underlie some deforestation
References	Bankoff (2007); Kummer (2006)	Bankoff (2007); Kummer (2006)	Based on estimates of national forest cover reported in Kummer (2006); Grainger and Malayang III (2006)	FAO 2005; Kummer 2006	FAO 2005; Kummer (2006); Wertz-Kanounnikoff and Kongphan-Apirak 2008

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.

Pre 1950-

From the early 16th century to the 19th century a considerable amount of deforestation took place that can be attributed to population increase, urbanisation and associated land use change, and the demand for timber by the Spanish colonial powers for the construction of towns, large buildings and ships. Forests were felled for the extension of agricultural land (with swidden agriculture (known as kaingin) increasingly being replaced by permanent fields and paddies) and settlements as the population grew from under 1 million in the mid 16th century to about 7 million in the late 19th century. Timber was needed as building material for towns and cities, which were frequently devastated by earthquakes and fires. In the 19th century, a first forest administration was set up by the Spaniards. Timber trade became more commercialised. The period of American colonial power (1899–1935) saw a steady rise in the amount of timber cut, especially in the aftermath of WW1, which follows an increasing demand for timber mainly in the USA, Japan, China and Europe. A major driver of forest exploitation during this period was the availability of technology (logging engines) and infrastructure (railways and sawmills) that allowed timber harvesting to take place at an industrial scale. Between 1901 and 1940, total annual production of lumber increased from 94,000 m^3 to 2,500,000 m^3. Rapid deforestation for timber production continued during the Commonwealth period of internal self rule (1935 – 1941) and was accompanied by a partially controlled extension of agricultural land into forest areas. Although commercialised logging slowed down under the rule of the Japanese (1941 – 1945), forest clearing for agricultural production exploded. Forest cover dropped by almost one half – from 275,000 km^2 in the mid 16th century to 148,000 km^2 in 1950. The same time saw a 25-fold population increase. Forest loss and degradation was worst on the island of Luzon. Forests on Mindanao, in contrast, remained largely unexplored. Rate of deforestation (Bankoff 2007): Spanish rule 0.15% per annum (310 years), American period: 0.71% per annum (47 years). Average total 0.16%. Colonial deforestation was much higher in the Philippines than in South East Asia in general, and the forest cover left much lower than anywhere else.

1950 - present

Kummer (2006) finds similar patterns for the period 1950-1987 to the situation found today in Indonesia. The main proximate drivers of deforestation were unregulated large scale commercial logging, mainly for timber exports, followed or accompanied by some form of agriculture (subsistence, commercial mainly for domestic markets). From 1950 to 1975, exploitation was emphasised in actual and stated policies, and deforestation continued at very high rates (the state claimed ownership of all forest land, allowing it to issue licenses for logging). The Philippines became the world’s leading tropical hardwood producer and exporter in the early 1960’s, and production peaked in 1970 (Grainer and Malayang III 2006). In the late 1970s to early 1980s, the deforestation rate in the Philippines was among the highest in the world (Tumaneng-Diete et al. 2005). Between 1975 and 1986, the main direction of forest policy remained exploitative, although from 1974 onwards, partial logging bans were introduced in some regions. However, these forest policies were largely driven by the interests of powerful and privileged elites. After the Marcos era came to an end in 1986, more effective policies on sustainable management of forests (e.g. banning log exports, imposing logging moratoria in some provinces, reducing the number of Timber License Agreements) were implemented under Marcos’ successor, Corazon Aquino. Grainger and Malayang III (2006) denote the period from 1986 – present as a “Sustainable Management Phase”. These efforts could not prevent the Phillippines from becoming a net importer of forest products in 1990. It is difficult to quantify the effect of policy initiatives post 1987. Deforestation rates do not seem to have slowed down in the 1990s. The pattern of forest cover moved towards the complex mix of deforestation, forest degradation and reforestation that characterises present times (Kummer, 2006). Rapid population growth and consequently increasing demand for subsistence agriculture is found over the whole period. Especially in upland areas, increases in agricultural production led to expansion of the cultivated margin into forest areas. The upland population more than doubled in the period between 1960 and 1987, contributing to the rapid decline of forest area during that period. Kummer (1992), argues that, as the state had control of the nation’s forest and logging activities, the exploitation of the forest resources for the interest of politically powerful elites was the primary cause of deforestation, at least until 1986.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Forest conversion for commercial and industrial timber production: Due to the fact that primary forests are declining (Mindanao, also Luzon and Samar) and old-growth forests have almost vanished (Laurence, 2007), commercial logging (both legal and illegal) mainly takes place in secondary forests with commercial value. Kummer (2006) notes that the area of plantation forests has increased rapidly. This, however, is at odds with the estimates for plantation forests given by the FAO (2005), who estimate that plantation forests have decreased by about two-thirds between 1990 and 2005.

2.2. Agricultural expansion: Agricultural expansion into forest land (mainly into degraded, secondary or residual forest areas (Coxhead and Jayasurya 2002)) may continue in some areas. Forest conversion for expansion of the cultivated margin differs from Indonesia and Malaysia by the fact that agricultural production is mainly driven by subsistence needs and for domestic markets rather than exports. Furthermore, there is no clear pattern of agricultural expansion across the whole of the Philippines: in some areas agricultural intensification in lowlands has been found to ease pressure on upland forest frontiers (Shiveley and Pagiola 2004). Furthermore, abandonment of farms increases the area of poor-quality degraded secondary forests (Kummer 2006).

2.3. Illegal mining: According to Wertz-Kanounnikoff and Kongphan-Apirak (2008) illegal mining is considered as a key driver of deforestation in the Philippines. We lack information, however, that would support this claim or describe it in greater detail.

3. General information about the Philippines

The Philippines consist of a group of 7,101 island that stretch approximately 1,850 km and 1,000 km from north to south and from east to the west, respectively. The major islands are Luzon with the capital Manila in the North, the Visayan islands in the centre and Mindanao in the South. Luzon and Mindanao make up more than 2/3 of the total land mass. Population growth has been rapid. In 1960, 27.1 million people lived in the Philippines. In 2000, a total of approximately 76.5m people live on an area of 299,400 km^2. Forest land in 2003 accounted for 71,620 km^2 or 24% of the total land mass (FAO 2005). Of the total forest area, 80% is secondary forest, 12% old-growth forests (mainly dipterocarp forests) and 8% are plantation forests (FAO 2005). The importance of forestry in the Philippine economy has declined markedly as a result rapid deforestation since the 1960s. Having been the leading exporter of tropical hardwoods in the 1970s, the Philippines have become a net importer of forest products by the 1990s. Since the end of the Marcos era in 1986, the Philippines have moved towards more sustainable forest policies. The main drivers of deforestation are legal and illegal commercial logging, agricultural expansion and potentially illegal mining activities. However, the Philippines may have hit the bottom of the forest transition curve, as deforestation goes along with a complex pattern of reforestation and a rapid increase in plantation forestry. An increase in total forest or wooded land cover may be expected in the future, but the quality and diversity of forests is expected to further diminish. According to Laurence (2008), primary forests have almost vanished.

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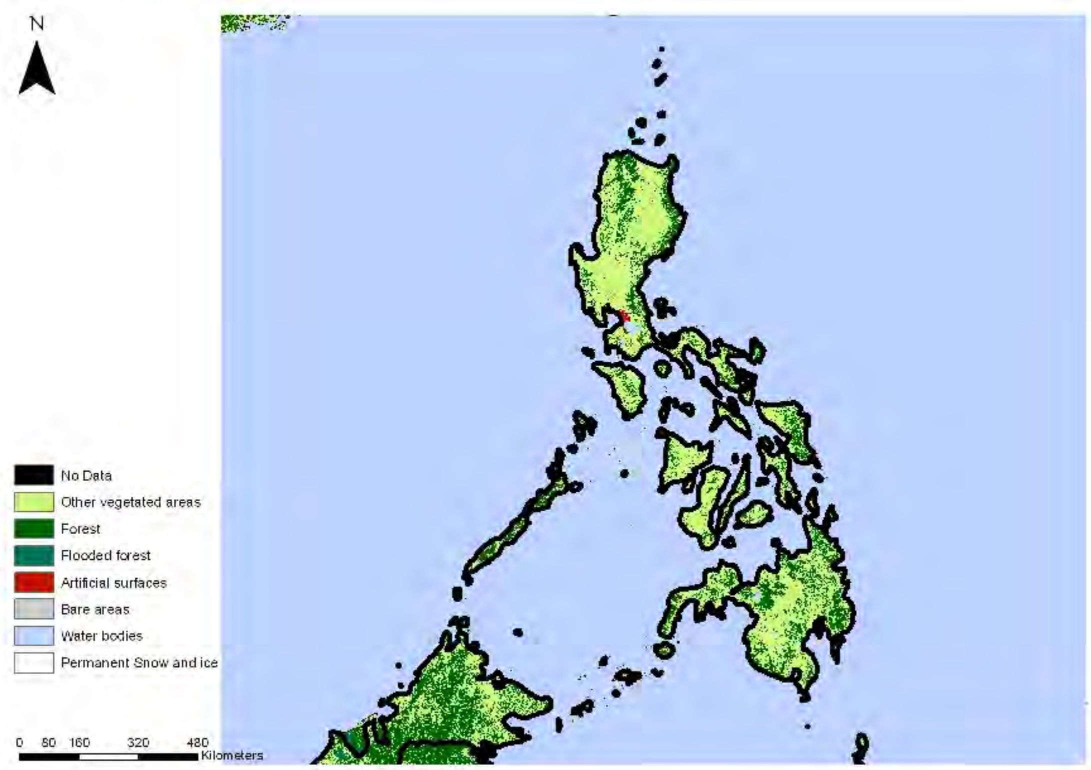
Figure 55: Map of the Philippines showing main areas of forest cover



Thailand

Size of country: 0.51 million km^2
Forest cover before deforestation: 58 % (in 1957)
Present forests cover: 29% (in 2005)
Forest lost to date: 50% (during 1957-2005)
Current deforestation rate: 590 km^2 y^{-1}, 0.4 % (during 2000-2005)
Emissions from Land-Use Change & Forestry: 47.6 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and the drivers of deforestation since large scale deforestation began in 1957

Time period	1957 - 1967	1967-1977	1977-1987	1990 - 2005
Deforestation rate (sq. km y^{-1})	6882	10000	6237	963
Proximate drivers†	A,I,W	A,I,W	A,I,W	W, I
Underlying drivers	E,D	E, D, P	E,D	E, D
Activities	1.Paddy rice cultivation 2. Shifting cultivation 3. Infrastructure development 4.Logging	1.Paddy rice cultivation 2. Shifting cultivation 3. Infrastructure development 4. Logging concessions 5. Cultivation of Cash crops 6.Political insurgency	1.Paddy rice cultivation 2. Shifting cultivation 3. Infrastructure development 4. Logging concessions 5. Cultivation of cash crops	1. Shifting cultivation 2. Cash crops 3. Illegal logging
References	Hirsch (1987); Delang (2002)	Hirsch (1987); Delang (2002)	Hirsch (1987); Delang (2002)	FAO (2006a); Delang (2002); CIFOR (2008)

†Letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (2002) as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.

Drivers of deforestation through history (up to 1990)

In 1900, the Government promoted the settlements in the peripheral regions of the country to handle the threat of colonial powers of Britain and France, who were established in SE Asia. The colonisation of the periphery and establishment of rail networks to connect different parts of the country resulted in deforestation of large areas until 1950s. The increase in demand for Thai rice and paddy rice cultivation for export was one of the major drivers of deforestation during this period. As a result, rice area increased from 9,600 km^2 in 1850 to 56,000 km^2 in 1950 by bringing more forest area under rice cultivation (Delang, 2005). Increase in population and the scarcity of suitable lowland areas for cultivation, forced the landless farmers to highlands practicing shifting cultivation, which alone accounted for 5000 km^2 of deforestation annually (Feeny, 1988).

From 1950, the demand for wood increased in the domestic and international market. During 1957-1967, annually 6882 km^2 area is deforested (Table1). Realising this demand, in 1968, the government issued logging concessions to few private companies. The forest areas allotted to these logging companies were later transformed to timber plantations, agriculture and bare lands. In 1970s, highlands of Northern Thailand became a refuge for Communist Party of Thailand, who opposed the military regime in power. Large areas of forests in Northern Thailand were removed during this peak insurgency (1973-1978) (Phongpaichit & Baker, 2002). The growth of agribusiness since 1970s switching from traditional rice cultivation to cash crops also contributed to deforestation in the highlands. The large scale deforestation continued till 1989 when the government ordered a ban on deforestation and cancelled all the existing logging concessions.

2. Recent drivers of deforestation (1990–2005)

2.1. Shifting cultivation: More than 3% of forest land is under shifting cultivation in Thailand (Rerkasem, 2001). Shifting cultivation mainly in the high lands is practised not only by the upland minorities, but also lowland people moving into these highlands. Increasing population of ethnic minorities (0.2 million in 1987 to 0.79 million in 1996; Delang, 2005) also put pressure on forests in the highlands.

2.2. Cash crops: Many parts of the uplands are agronomically suitable for diverse crops including high-value commercial crops. These include temperate vegetables, cut flowers, and subtropical fruits. Agribusiness companies often enter into contracts with upland farmers. These intensive farming systems are linked to increased destruction of natural forests in the uplands (Rerkasem, 2003).

2.3. Illegal logging: The government has banned forest concessions since January 1989 after realising its environmental implications. However, the wood consumption constantly increased and much of which is met through wood import from neighbouring countries. A part of this wood demand is also met through illegal logging (about 5000-25000 m^3 y^{-1}; Nalampoon (2003)).

3. General information about Thailand

Thailand is located in Indochina between 5° to 21° N latitude and 97° to 106° E longitude, and is bordered by Cambodia and Laos on the east, Laos and Myanmar on the north, Myanmar on the west and Malaysia, and the Gulf of Thailand in the south. Thailand has a total geographical area of 513,115 km^2 with a population of about 62 million (Nalampoon, 2003). Thailand has mainly two types of forests: evergreen and deciduous covering 29% of the total land area (FAO, 2006a). Evergreen forests are sub-divided into tropical evergreen forests, tropical rain forests, dry evergreen forests, hill evergreen forests, coniferous forests and swamp forest. Both freshwater and mangrove swamp forests can be found. Deciduous forests are sub-divided into mixed deciduous, dry deciduous, and savannah forests. One of the major drivers of deforestation in the country is shifting cultivation and agricultural expansion.

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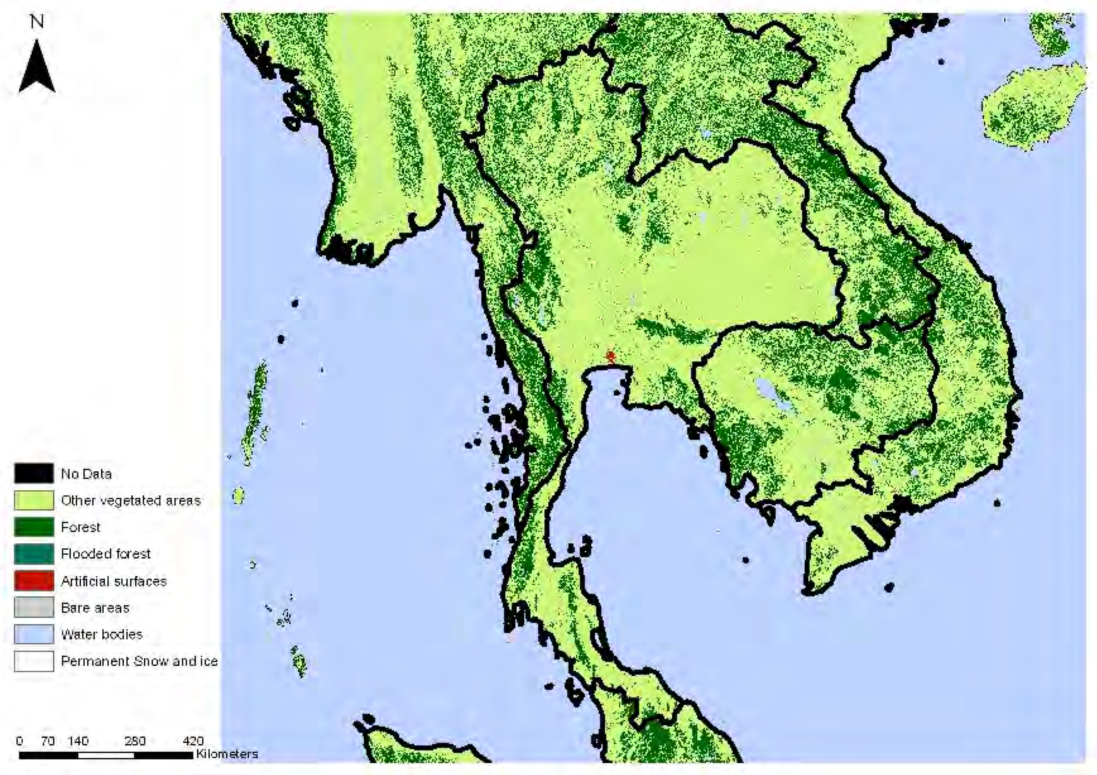
Figure 56: Map of Thailand showing main areas of forest cover



Vietnam

Size of country: 0.33 million km^2
Forest cover before deforestation: 43% (in 1935)
Present forests cover: 39% (in 2005)
Forest lost to date: 9.4% (during 1935-2005) - (93% of original forest loss)
Current reforestation rate: 2,410 km^2 y^{-1}, 2% y^{-1} (during 2000-2005)
Emissions from Land-Use Change & Forestry: -48.7 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and the drivers of deforestation/reforestation since large scale deforestation began in 1930s

Time period	1935-1958	1958-75	1975-1980	1980-1990	1990 – 2005
Forest cover change (km^2 y^{-1})	204‡	–1971	–1725	–1017	2379‡
Proximate drivers†	A, I,	W, A, I,O	W,A, I	W,A,I	W, A, I,O
Underlying drivers	D	D, P	D, P, E	D, P, E	D, E, P
Events	1. Agricultural expansion 2..Shifting cultivation	1. War 2. Logging 3. Agricultural expansion 4..Shifting cultivation 5.Resettlement 6. Infrastructure development	1. Logging 2. Agricultural expansion 3..Shifting cultivation 4.Resettlement 5. Infrastructure development	1. Logging 2. Agricultural expansion 3..Shifting cultivation 4.Resettlement 5. Infrastructure development	Deforestation 1. Agricultural expansion and plantations 2..Shifting cultivation 3. Infrastructure development 4. Illegal logging Reforestation 1.Land allocation program 2. Intensification of agriculture
References	Maurand (1943); Meyfroidt and Lambin (2008b)	FAO (1960); Meyfroidt and Lambin (2008b)	FAO (1981); Meyfroidt and Lambin (2008b)	FAO (1981); Meyfroidt and Lambin (2008b)	FAO (2005c); CIFOR (2008); Meyfroidt and Lambin (2008b)

†Letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (2002) as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.

‡ shows a net increase in the rate of forest cover

Drivers of deforestation through history (up to 1990)

Mountainous regions of Vietnam were extensively covered by forests until the mid-twentieth century (Poffenberger & Nguyen, 1998). In 1930s, natural forest cover was 143,000 km^2 (about 43%) (Maurand, 1943 ; Meyfroidt & Lambin, 2008b). During the colonial period, most of the upland regions of Vietnam were sparsely inhabited by ethnic minority groups practising traditional systems of land use. After independence in 1954, forests were nationalized (in North Vietnam) and handed over to State Forest Enterprises (SFE) for logging. The war during 1959-75 led to the devastation of large areas of forests due to bombing by US and logging by the communist insurgents. With an annual deforestation rate of about 1,971 km^2 (Table 1) the estimated total forest loss is 33,507 km^2. Out of this, about 22,000 km^2 of forest was estimated to be destroyed by the direct effect of bombing (Collins, 1990). Government policies to encourage resettlement in the uplands led to land clearing as millions of lowlanders moved to uplands and new roads were built from the coast to facilitate movement of people and goods.

During 1976-1990, about 980 km^2 has been contracted for logging annually and the forest area was reduced to 120,000 km^2 in 1980 and 93,537 km^2 in 1990. Slash-and-burn cultivation by ethnic minorities was responsible for as much as 25% of the estimated 2,000 km^2 of annual deforestation in Viet Nam (Nguyen, 1995) and the remaining due to agricultural expansion. Increase in population especially in the uplands due to both natural growth and migration (De Koninck, 1999; Lundberg, 2004) was the underlying cause of deforestation. Wood exploitation for local and urban needs also contributed to forest clearing (McElwee, 2004).

2. Recent drivers of deforestation and reforestation (1990 – 2005)

Since the mid-1990s, forest cover increased remarkably through natural regeneration and tree plantations. In 1995 forest cover increased to 28% as a result of forest protection and rehabilitation programs. However, the original forests continued to decline. Between 1990 and 2005, Viet Nam gained a forest cover of about 35,700 km^2 and lost 3,000 km^2 of its primary forests even though deforestation rate of primary forests have largely decreased since 1990s.

<u>2a. Drivers of deforestation</u>:

2a.1. Agricultural expansion and /plantations: In the 1990s, the government encouraged migration to highlands (Dac Lac province) to plant coffee. By 1995 coffee was Vietnam's second highest export earner and in 1999 Vietnam became the world's third-largest coffee exporter. According to the Vietnam Coffee Association, more than 5,000 km^2 are now under coffee cultivation, with more than 740 km^2 of forest having been cleared in Dac Lac province alone to make way for coffee growing.

2a.2. Shifting cultivation: Shifting cultivation is practised in many areas of the country despite its prohibition. About 2.9 million people from 400,000 ethnic minority families in 34 mountainous provinces are involved in shifting cultivation (Sargent, 1991). These ethnic minorities were responsible for as much as 25% of the estimated 2000 km^2 of annual deforestation occurring in Viet Nam (Nguyen, 1995).

2a.3. Infrastructure development: About 3,000 km^2 of forest land is estimated to be lost annually by infrastructure development such as roads, dams for electricity and irrigation etc. (World Bank, 1995).

2a.4. Illegal logging: The ban on legal logging since 1990 and a total ban on timber export in 1997 made illegal logging more widespread. In some cases, the logging was carried out with the support of corrupt government officials.

<u>2b. Drivers of reforestation</u>:

2b.1. Land allocation program: The Land Law in 1993 allocated lands to households, local communities, private companies, and state enterprises. By this law Government restricted slash-and burn-agriculture and provided incentives to manage the allocated land on condition that farmers are not allowed to change the land use. For example, land classified as forest land should not be used for agriculture. This policy had a positive impact on natural forest regeneration (Meyfroidt & Lambin, 2008a).

2b.2. Intensification of agriculture: With increase in population and land scarcity farmers chose to concentrate on the most suitable plots on the marginal lands and abandon the least suitable plots for reforestation. Increase in cropping intensity in terms of increase in cropping frequency was one of the main factors contributing to natural forest regeneration and to the growth of tree plantations. Multi-cropping allowed many households to become food self-sufficient without having to rely on upland rice cultivation anymore (Castella & Erout, 2002)

3. General information about Vietnam

Vietnam is located between a latitude of 8˚ 02' to 23˚ 23' N and a longitude of 102˚ 10' to 109˚ 30' E and borders with China to the North, Laos, Cambodia to the West and the East Sea to the East and Pacific to the South. Vietnam has a total land area of 0.33 million km^2 with a population of 81 million (CIFOR, 2006). Three fourths of the country consists of high mountains with a complex topography and steep slopes. Vietnam's complicated topography and climate explains its diversity including mangrove forests, muddy forests, muddy forests, monsoon forests, and evergreen deciduous forests on high and low mountains. Forest cover of the country is 39% in 2005. Most important driver of deforestation is agricultural expansion mainly due to increase in population.

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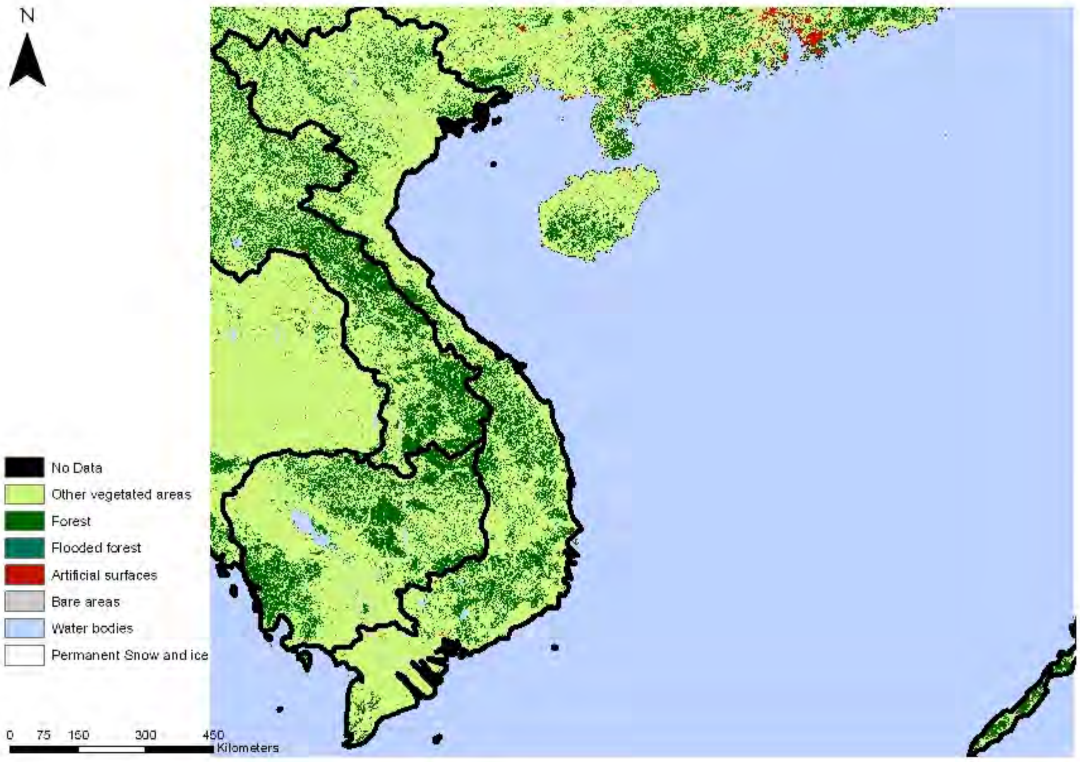
Figure 57: Map of Vietnam showing main areas of forest cover


N
No Data
Other vegetated areas
Forest
Flooded forest
Artificial surfaces
Bare areas
Water bodies
Permanent Snow and ice
0 75 150 300 450
Kilometers

<u>**South and Central America**</u>

Argentina

Size of country:	2.7 million km^2
Forest cover before deforestation:	-
Present forests cover:	11% (0.3 million km^2 natural forest and 9,260 km^2 of plantation forest)
Forest lost to date:	~ 95% of native tropical forests
Current deforestation rate:	1500 km^2 yr^{-1}, 0.4 % yr^{-1} (FRA, 2005)
Emissions from Land-Use Change & Forestry:	55.1 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

This section gives a short overview of deforestation rates and drivers from the time deforestation began in Argentina as a whole to the present day. More information is available in the literature for the Chaco forests than other types of forest in the country, which is not surprising given the large area that the Chaco covers.

Table 1. Deforestation rates and drivers for Argentina since large scale deforestation began

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 2000
Approx deforestation rate in km^2 yr^{-1} **				
Proximate drivers	A, W*	A, W*	A, W*	A
Underlying drivers	D	E,O (climate)	E,O (climate), T	T, E
Notes	A for pasture and dominant regional crops (sugar cane in Yungas and cotton in Chaco) Forest recovery takes place. Wood extraction in the Atlantic Forest	A for pasture and annual crops (black bean and local soybean) Rainfall increase also factor for ag. expansion Some forest recovery takes place Wood extraction in the Atlantic forest	Ag expansion as in 1971-1980 plus new types of soy introduced Atlantic forest threatened by plantation forests	Use of bulldozers for deforestation becomes widespread in Chaco. Dramatic spread of soybean plantations to supply Asian market Ag far more mechanised
References	Gasparri et al. 2008 Zak et al. 2008	Gasparri et al. 2008 Zak et al. 2008 Izquierdo & Grau, 2009 Bonino 2006	Gasparri et al. 2008 Zak et al. 2008 Izquierdo & Grau, 2009	Boletta et al. 2006 Zak et al. 2008 Grau et al. 2008

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Recent drivers of deforestation (2001 – present)

Argentina is ranked by FAO among the countries with the largest losses of forest cover during the 1990 – 2000 period. Most of this deforestation is in the Chaco seasonally dry forest, however the smaller areas of Yungas and Atlantic forests are still experiencing deforestation. Argentina is the only 'non-tropical' country in the FAO's list of the top 20 deforesting countries (FRA 2005). Deforestation in Argentina is estimated to be the largest source of C ermissions from the land in the extra-tropical southern hemisphere. Argentinean Chaco is undergoing rapid deforestation with deforestation rates being several times higher than the world average. The lower elevations of the

Yungas have experienced deforestation again mainly for agriculture although this is largely confined to the lowlands with forests on the montane areas of the Yungas remaining in tact. Atlantic forests are particularly threatened by forest plantations.

Table 2. Drivers of deforestation 2001-present and associated activities

Activities in forest areas related to deforestation	**Areas within Argentina affected (in general)**	**Proximate drivers**		**Underlying drivers**		**Notes**	**Studies/references**
Selective logging	Chaco in some areas		W				Zak et al 2008
Wood extraction	Atlantic forest	Threatened by plantation forests	W		E		Gasparri et al. 2008
Expansion of grazing lands	Chaco		A	(promoted by government subsidies and colonisation programmes in some provinces)	P D		Grau et al. 2008
Cropland expansion for mechanised agriculture	Chaco and Yungas in lowland areas	Rainfall has been increasing in some areas since the 1940s allowing different crops to grow	A O	International demand for soybean is growing New Soy varieties available Bulldozers used to clear land	E T	Agricultural areas especially for soybean are rapidly expanding in the Chacos and are a major threat	Zak et al. 2004 Zak et al. 2008 Grau et al. 2008 Gasparri et al. 2008 Bolletta et al 2008
*Decreasing deforestation	A few marginal areas of the Chacos are being depopulated and forest is recovering			Traditional rural population moving to the cities	D		Isquierdo and Grau 2009

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (see section X)

3. General information about Argentina

Size of country: 2.7 million km^2 and is the second largest country in South America.

Lat and long plus geographic position: 34 00 S, 64 00 W (Bordered by Paraquay and Brazil in the north east, Uruguay in the east, Bolivia in the north west and Chile in the west).

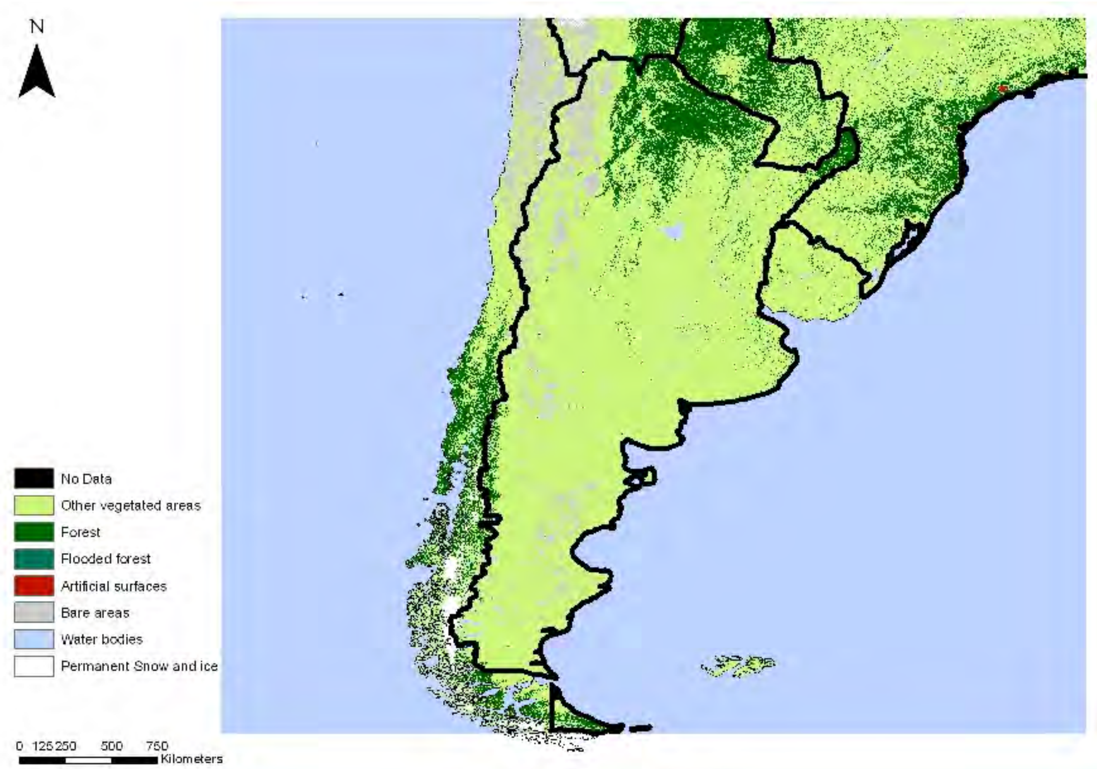
Population: 40,913,584 (CIA, 2009).

Area of the country under forest: Approximately 11 % (0.3 million km^2 natural forest and 9,260 km^2 of plantation forest).

Forest types in the country: Eighty three percent of Argentina's forests are temperate or boreal and the remaining 17% tropical. Argentina is home to 61% of the **Chaco forest**, a seasonally dry forest with a summer rainy season which consists of areas of dense tree cover and savannah. This is located mainly in the north of the country. The Chaco is humid in the east, becoming drier and more heat tolerant in the west. In the mountainous areas that neighbour the Chaco on its eastern side is the **Yungas** which covers seventy thousand km^2 of Argentinean territory. The Yungas is an evergreen and semi-evergreen forest in the foothills and eastern slopes of the Argentinean Andes. In addition, in the north east corner of Argentina there is a section of **Atlantic forest**, covering ~ 1.2 million ha. Atlantic forest is evergreen and humid.

Most important drivers of deforestation: Cattle ranching, soy production

Figure 58: Map of Argentina showing main areas of forest cover



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Bolivia

Size of country: 1,098,581 km^2
Forest cover before deforestation: -
Present forests cover: 54.2 % (FRA, 2005)
Forest lost to date: -
Current deforestation rate: 2700 sq km yr^{-1} 0.5 % yr^{-1} (FRA,2005)
Emissions from Land-Use Change & Forestry: 83.8 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Bolivia since large scale deforestation began

Time period	1950-1970	1971 – 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **					
Proximate drivers	I, A	I, A	I, A, W	I, A, W	A
Underlying drivers	D, P	D, P	P, T, E	E, P, T	E, T
Notes	After the 1952 revolution and its agrarian reform the state retained land property right. From the 1950s to the late 1970s Bolivia pursued aggressive colonization policies. This colonization did not produce explosive deforestation or outmigration like the one experienced in Rondonia (Brazil). After an initial phase of infrastructure development in the 1960s the government encouraged sugar and rice cultivation.	From the 1950s to the late 1970s Bolivia pursued aggressive colonization policies. This colonization did not produce explosive deforestation or outmigration like the one experienced in Rondonia (Brazil). State owned land did not allowed for it to be used as vehicle or various kinds of institutional rents.. However government provided subsidized agricultural credit.	After 1985 structural adjustment, establishment of the Expansion Zone, changes in agrarian legislation, and technical change in agriculture produced an exponential deforestation pattern. In this period deforestation by small farmers increased in a linear way. More fertile areas were preferred in the period before 1989. Infrastructure, vicinity to city and soil and climate have are less important in the period 1989-1994. Forest degradation by timber extraction was a factor, even if not as important as soybean production, which followed Bolivia's structural adjustments after 1985.	In a study in the Department of Santa Cruz it was found that total and permitted deforestation is explained by past deforestation level and density of road, while institutional performance had an important impact in controlling unauthorised deforestation. Deforestation in the area was primarily due to industrial soybean plantations. Cleared land increase land value. Mechanised agriculture (soy, rice, maize, wheat, sunflower) Before 1996 the State retained land property rights, this might have function as a break for some forms of deforestation. The new Agrarian reform started mechanisms that promoted deforestation. In certain areas where timber was not valuable land privatisation resulted in expansion of cattle ranching.	Mechanised and high technological agriculture.
References	Hecht 2005, Mertens et al. 2004, Benoit et al. 2004	Hecht 2005, Mertens et al. 2004, Benoit et al. 2004	Hecht 2005, Mertens et al. 2004, Benoit et al. 2004, Kaimowitz et al. 1999.	Andersson and Gibson 2006, Hecht 2005, Mertens et al. 2004, Benoit et al. 2004, Kaimowitz et al. 1999.	Hecht 2005

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

The rate of deforestation in the Bolivian Amazon during the 1990s was among the most intense in the region. This spike in deforestation rate was characterised by elements different from those that affected deforestation during the previous two decades. Accelerated clearing in the 1990s was affected by the new context of globalization, structural adjustment, regional integration, and rapid technological changes (Hecht 2005, Mertens et al. 2004).

A recent study by Hecht (2005) states that Bolivian's lowland frontiers differ from most of the other Amazon development front. This because it is characterised by a "powerful modernizing elite based in the city of Santa Cruz who developed the most economically dynamic agricultural sectors in Bolivia's national economy (Hecht 2005: 376). The department of Santa Cruz accounted in 2000 for two-thirds of the land cover allocated to rice, maize, wheat, sunflower and soy, and in this area production is mechanized and with modern inputs. The soil quality allows for double cropping, but years of intensive cultivation is already affecting areas that have been under heavy soybean production since the mid-1980s. These areas have been converted into pastures for cattle production.

There are authors (cited in Hecht 2005) that suggest in Bolivia clandestine economies of narcotics, gold and timber generated large revenues that were then recycled and used for soybean expansion. For example in the region of Chapare small farm production of coca and food crops is the source of most deforestation. However, coca production is very labour intensive so that each household, without hired labour cannot cultivate more than one hectare of coca plus some food crops (Kaimowitz et al. 1999). Agricultural expansion in Bolivia also attracted international investments from other Latin American countries and Asia, as well as international colonization projects such as those of the Japanese and Mennonites that provided both capital and labour for mechanized soybean production.

2. Detail on recent drivers of deforestation (2001 – present)

Table 2. Drivers of deforestation 2001-present and associated activities

Activities in forest areas related to deforestation	**Areas within Bolivia affected (in general)**	**Proximate drivers**		**Underlying drivers**		**Notes**	**Studies/ references**
Mechanized agriculture	Santa Cruz		A		E	Since late 1990s the dynamic of deforestation in the region is not driven by demographics and peasant agriculture. Instead, it is linked to industrial production of soybean, wheat, sorghum and sunflower.	Hecht 2005

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (see section X)

Studies of deforestation in Bolivia published after 2001 discuss deforestation up to that year. However, it seems to be likely that the trends towards a high input, high technological agriculture that started in the late 1990s has continued in the early years of the current century.

3. General information about Bolivia

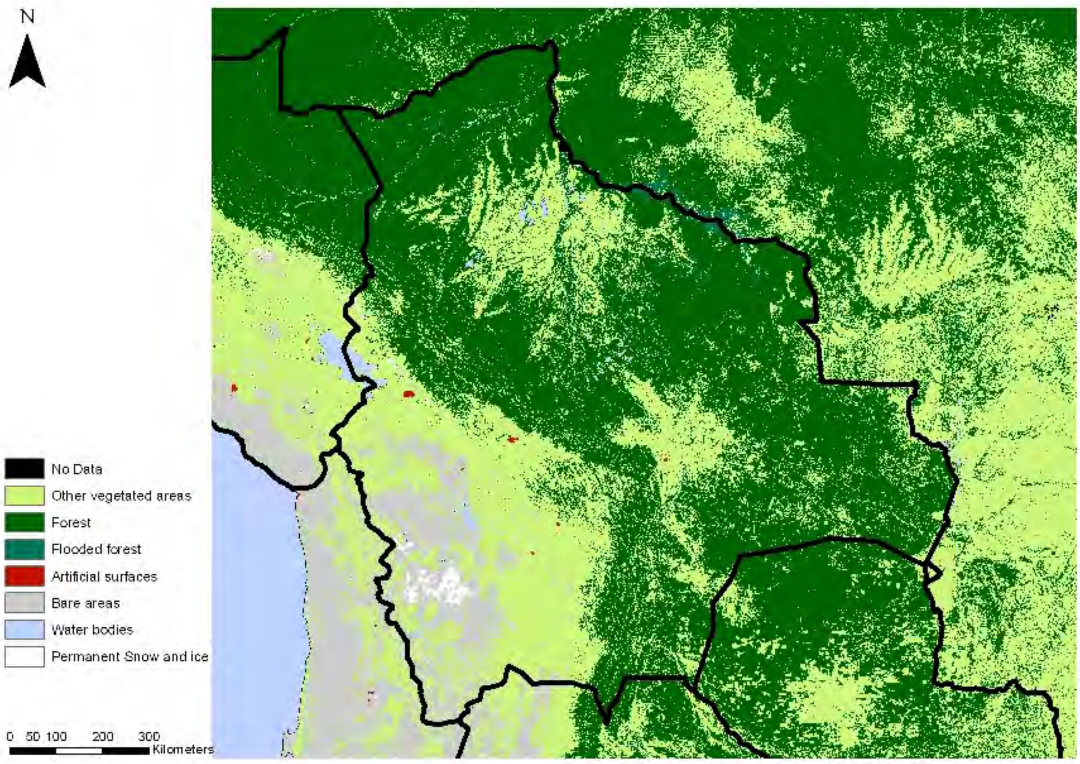
Size of country:	1,098,581 km^2
Lat and long plus geographic position:	9^0 38' and 22^0 53'S and longitude 57^0 25' and 69^0 38' W. Borders with Brazil to the north and east, Peru and Chile to the west, Argentina and Paraguay to the south
Population:	9,353,846 (mid-2006)
Area of the country under forest:	587 400 km^2
Forest types in the country:	Amazon rainforest

Most important drivers of deforestation: Agriculture

The Republic of Bolivia has a total land area of 1,098,581 sq km located between the latitude of 9^0 38’ and 22^0 53’S and longitude 57^0 25’ and 69^0 38’ W. It borders with Brazil to the north and east, Peru and Chile to the west, Argentina and Paraguay to the south. The country has a population of about 9,353,846 (mid-2006). Bolivia is landlocked and has to the centre-west the high Andes, and to the west reach down into the Amazon Basin. The plateau in the high Andes, which account for about 1/3 of the territory, is know as the *altiplano*; the lower eastern slopes and valleys of the Cordillera Oriental are called the Yungas, finally the Amazonian-Chaco lowlands fo the south-east are called Llanos. Forest is concentrated in the Yungas, which tends to be steep with a subtropical climate, and in the Amazon plains (Europa World Online 2009).

Bolivia’s economy greatly relies on exports of hydrocarbons and minerals. However, agriculture accounted in 2007 for 10% of the country’s GDP and it is an important source of employment. Since the 1980s soyabean has represented the most dynamic sector. Timber and Brazil nuts are other forms of export agriculture from the lowlands. Coca production, despite programs eradication is a crop of economic importance. It is estimated that in 2006 27,500 ha were under coca cultivation (Crabtree 2009).

Figure 59: Map of Bolivia showing main areas of forest cover



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Brazil

Size of country:	8.46 million km^2
Forest cover before deforestation:	-
Present forests cover:	56.5 % (FRA, 2005)
Forest lost to date:	~570,000 km^2 of the Brazilian Amazon have been lost since large scale deforestation started in the 1970s (WRI, 2008)
Current deforestation rate:	11,968 sq km yr^{-1} in 2008 (source: http://www.obt.inpe.br/prodes/index.html)
Emissions from Land-Use Change & Forestry:	1,372.10 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for the Brazilian Amazon since large scale deforestation began

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 1995	1996 – 2000	2001-2005
Approx deforestation rate in km^2 yr^{-1} **			17,500 (3 yr average 1988-1990)	16,733 (1995 peak rate of 29,059)	16,851	22,215
Proximate drivers	I	I, A,W	A,W	A, W	A, W	A, W
Underlying drivers	D	P, D, E	E,T,P	E,T,P	E,T,P	E,T,P,O
Notes	Small amount of deforestation for timber and small agriculture	Large scale infrastructure development and migration and fuelled by economic incentives, for cattle ranching are part of a federal government policy for regional economic integration. Also timber extraction, hydroelectric projects and mining	Economic incentives phased out, small farms consolidated into large cattle ranches. However the economic context still favour land speculation and deforestation in the “frontier”.	Mechanized agriculture becomes more prevalent, deforestation for cattle ranching continues.	Mechanized agriculture begins to deforest directly, deforestation for cattle ranching continues. Cattle industry modernizes opening new market opportunities	Amount of deforestation directly for mechanised agriculture continues. Logging and farming activities that increase forest fragmentation and degradation also increase susceptibility to climate change and wild fires.
References	-Kirby et al 2006; -Moran, 1993(53)	-Kirby et al 2006 -Carvalho et al. 2002 -Nepstad et al. 2006 -Martens et al. 2002	-Fearnside 1990, 2008 -Kirby et al 2006	-Cardille and Foley 2003 -Kirby et al 2006 -Morton et al 2006	-Kirby et al 2006 -Morton et al 2006 -Nepstad 2006	-Morton et al, 2006 -Nepstad 2008, 2006 -Fearnside 2008 -Tollefson 2008 -Wertz-Kanounnikoff et. Al 2008 -Boyd 2008

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (see section X). The most prominent are in bold.
** Data source: http://www.obt.inpe.br/prodes/index.html

Sixty percent of the Amazon Rainforest is situated in the north of Brazil, covering an area of approximately 5 million km^2. Brazil also has smaller areas of forest along the eastern coast known as the Atlantic forest. This review is confined to the Brazilian Amazon. Before the 1960’s deforestation in the Amazon was limited as access was restricted. In the 1970s construction of two federal highways (Belém-Braziliá and Cuiaba- Porto Velho) and other smaller roads, increased access and deforestation began to happen on a large scale (Kirby et al. 2006). Throughout the 1970s and early 1980s settlement in the Brazilian Amazon was encouraged by tax incentives and government subsidies (Fearnside, 2005). Land was cleared for small scale agriculture or timber extraction before being consolidated into larger areas, mainly used for cattle ranching (Morton et al., 2006). Subsidies were officially discontinued in 1991, but migration continued, as cattle production and timber extraction remained economically profitable. During the 1990s deforestation was exacerbated by the recovery of the Brazilian Real following its devaluation. Cattle ranching continued to be the main land use on deforested areas in the 1990s, however from the late 90s to the present day expansion of commercial crop production has become an increasingly important driver. Since the year 2000, the area under large scale mechanised agriculture has increased dramatically pushing commercial agriculture further north into the Amazon (D'Avila 2003; Sato 2003).

2. Recent drivers of deforestation (1990 – 2009)

Deforestation rates for 2006, 2007 and 2008 were 14109, 11532 and 11968 sq km yr^{-1}. (Data source: http://www.obt.inpe.br/prodes/index.html)

Table 2. Drivers of deforestation 1990-present and associated activities

Activities in forest areas related to deforestation	Areas within Brazil affected (in general)	Proximate drivers		Underlying drivers		Notes	Studies/references
Cattle Ranching	Rondonia and Mato Grosso	Large and medium-sized ranches account for about 70% of clearing activity	A	Price of Beef, domestic and later international market. Economic incentives. Land tenure policy	E, P, D, T	Cattle ranching is the major land use after deforestation, Cattle industry has modernized opening international market opportunities.	-Catteneo, 2002 -Fearnside, 2005 -Fearnside, 2008 -Nepstad et al. 2006, 2008, -Tollefson 2008,
Small scale agriculture	Areas along the major roads. Rondonia	Settlements along Transamazon Highway, Rondonia	A, I		D	Colonists and settlers, 'sem terras'(organised landless migrants)	-Fearnside, 2008
Large scale mechanised agriculture for export market	Mainly the state of Mato Grosso also Rondonia. Soy farmers also moving into Santarém	Permanent cultivation for commercial soybean production	A	Price of soybean, demand from Europe and Asia	E, T, P, D,	Deforestation for cropland accounts for about 17% of large scale forest clearing Soy expansion displaces cattle ranching priming the move of operation to the north. Infrastructure improvements linked to this industry attract further deforestation.	-Morton et al 2006 -Nepstad 2006, -Fearnside 2008, -Wertz-Kanounnikoff et al. 2008
Selective logging	Acre, Mato Grosso, Pará and Rondonia	Wood extraction	W			Major cause of forest DEGRADATION	-Broadbent et al 2008 -Gerwing 2002
Large scale deforestation for timber extraction	All along the arc of deforestation. Started in N. Mato Grosso then moved to Rondonia, now areas along the BR163 and along the east of the Amazon river. Espirito Santo, Paraná Timber also often sold by ranchers when clearing land	Commercial wood extraction. Timber sales when land cleared for agriculture	W, I	Price of timber, access to road or river	E, T	Authorised logging operations are mapped by IBAMA, unauthorised are unknown	-Asner et al 2006 -Fearnside 2008 -WRI, 2008
Road building	Along BR163 and other minor roads	S	I		P	Both paved and unpaved roads are key drivers of the deforestation process	-Kirby et al 2006 -Boyd 2008, -Fearnside 2008. -Wertz-Kanounnikoff et al. 2008
Mining	Often distant areas away from the frontier, does not result in large areas of deforestation	Goldmining	O	International price of gold Migration by speculators	E, D	Cause of forest DEGRADATION	-Catteneo 2002, -Kirby et al 2006 -Fearnside 2008

Activities in forest areas related to deforestation	Areas within Brazil affected (in general)	Proximate drivers		Underlying drivers		Notes	Studies/references
	Rondonia, Para						
Hydroelectric	Potentially Santo Antônio and Jirau rapids on the Madeira River in Rondonia	Public service (electricity supply)	I				-Switkes 2007 -Catteneo 2002 -Kirby et al 2006 -Fearnside 2008
Forest fragmentation and degradation		Linked to selective logging, agriculture, climate change and extreme climate events (i.e. ENSO)			O		-Nepstad et al. 2008, 2006, -Boyd 2008, -Wertz-Kanounnikoff et al. 2008

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (see section X)

3. General information about Brazil

Size of country:	8.46 million km^2. It is the largest country in South America.
Lat and long plus geographic position:	10 00 S, 55 00 W. Borders Columbia, Peru, Bolivia, Paraguay and Uruguay in the west, Venezuela, Guyana, Suriname and French Guiana in the north
Population:	198,739,269 (CIA, 2009)
Area of the country under forest:	4 776 980 km 2 (56.5 % of the country)
Forest types in the country:	Amazon rain forest in the north of Brazil. Atlantic forest on the eastern coast
Most important drivers of deforestation:	Cattle ranching, soy bean production

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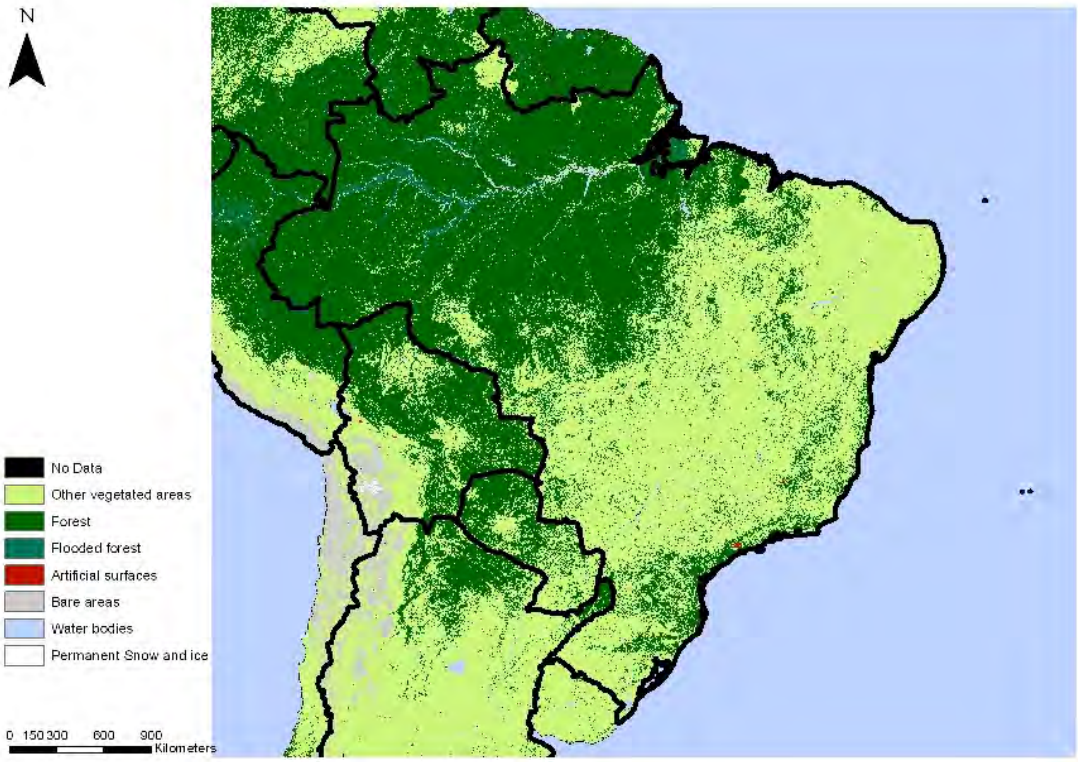
WRI (World Resources Institute) 2008. [online] URL: http://www.globalforestwatch.org/english/interactive.maps/Brazil_Datasets.htm#VegetaionAndDeforestation. (Accessed 21/01/09)

Figure 60: Map of Brazil showing main areas of forest cover



Ecuador

Size of country:	276,840 km^2
Forest cover before deforestation:	-
Present forests cover:	39.2% (FRA 2005)
Forest lost to date:	-
Current deforestation rate:	1,980 sq km yr^{-1} , 1.7 % yr^{-1} (FRA, 2005)
Emissions from Land-Use Change & Forestry:	58.9 $MtCO_2eq$ in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Ecuador since large scale deforestation began

Time period	1960-1970	1971 – 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **				1,980 km^2 yr^{-1}	1,980 km^2 yr^{-1}
Proximate drivers	I	I	I, W	I, A	A, W, I
Underlying drivers	D, E, P	D, P, E	D	D, E	D
Notes	Oil exploitation at the end of the 1960s attracted settlers in the Northern Ecuadorian Amazon. In the previous decade deforestation was linked to the introduction of large palm oil plantations.	Oil exploitation at the end of the 1960s attracted settlers in the Northern Ecuadorian Amazon.	In the Northern Ecuadorian Amazon demographic factors such as population density and accessibility factors are important to explain deforestation at the parish level. At the household level important socio-economic factors were household size. In Northwest Ecuador deforestation was closely linked to commercial logging mainly for internal market.	In the Northern Ecuadorian Amazon demographic factors such as population density and accessibility factors are important to explain deforestation at the parish level. At the household level important socio-economic factors were household size, distance by road to main cities, education and hired labour. In this period researchers observe an increase in production of cash crops.	
References	Mena et al. 2006 Vina et al. 2004	Mena et al. 2006, Vina et al. 2004	Mena et al. 2006, Vina et al 2004, Rudel et al. 2002, Sierra 2001.	Mena et al. 2006, Vina et al 2004, Rudel et al. 2002	Mena et al. 2006, Vina et al 2004

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

In the Latin American context, Ecuador has experienced the highest rate of deforestation between 1990 and 2000 with an average of 1.2% yr^{-1} (on average 1,370 km^2 yr^{-1}). In the previous decade the deforestation level in Ecuador was even higher with 2380 km^2 yr^{-1} on average (Mena et al. 2006). In the Northern Ecuadorian Amazon population growth was an important driver of deforestation up to the early 2000s. The movement of people in the area followed the development of infrastructure for petroleum exploitation which began in 1967 with the first drill by Texaco (Mena et al. 2006; Vina et al. 2004).

Ecuador is not a coca producing country. A study looking at the Ecuador region bordering with Colombia (Vina et al. 2004) report that at that time 60% of the economically active population of the region worked in agriculture and cattle-raising.

In Western Ecuador deforestation of tropical forest started more than a century ago. It accelerated during the second half of the last century. By 1996 an estimated 75% of lowland and foothill forest in the area had been cleared (Sierra, 2001).

2. Detail on recent drivers of deforestation (2001 – present)

Table 2. Drivers of deforestation 2001-present and associated activities

Activities in forest areas related to deforestation	**Areas within Ecuador affected (in general)**	**Proximate drivers**		**Underlying drivers**		**Notes**	**Studies/references**
Agriculture	Northern Ecuadorian Amazon (NEA)	Road network facilitate spontaneous colonization and uncontrolled development in the form of unplanned urbanization. This period (despite low prices of cash crops and cattle) is more market oriented.	A I	Both at the parish and farm level population pressure and road networks emerge as the most important drivers of deforestation.	D	At the household level population pressure is a driver because it forces farm subdivision. Improved accessibility and education seem to drive deforestation for market oriented productions.	Mena et al. 2006, Vina et al. 2004
Timber extraction	NEA	Spontaneous colonization is also associated with illegal timber extraction	W I		D		Mena et al. 2006
Cattle ranching	NEA		A		I	Improved accessibility and education seem to drive deforestation for market oriented production.	Mena et al. 2006, Vina et al. 2004

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (see section X)

Only a couple of studies look at deforestation in the current period. What emerges is the importance of the legacy of policy and infrastructure development for the exploitation of petroleum in the Amazon region. This opened the way to immigration and consequent land clearing. Despite the decrease in agricultural credit and subsidy programs in the 1990s, deforestation for agriculture and cattle production continued as a consequence of the growth household size.

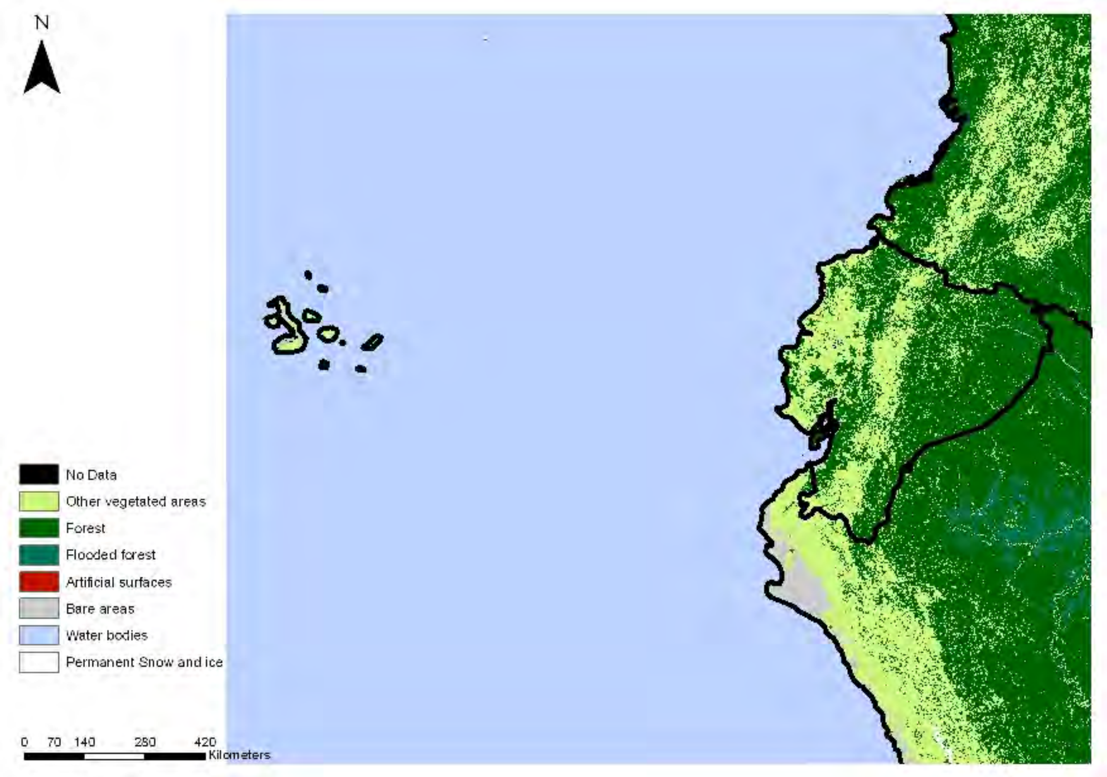
3. General information about Ecuador

Size of country:	276,840 km^2
Lat and long plus geographic position:	2^0 00’ S and longitude 77^0 30’ W. Borders Colombia on the north, Peru on the east and south, and the Pacific Ocean on the west
Population:	19,201,995 (mid-2006)
Area of the country under forest:	39.2 %
Forest types in the country:	Tropical rain forest, deciduous forest, mountain forest
Most important drivers of deforestation:	Policy and infrastructure development for the exploitation of petroleum in the Amazon region

The Republic of Ecuador has a total land area of 272,045 sq km located at latitude of 2^0 00’ S and longitude 77^0 30’ W. It borders with Colombia to the north, Peru to the east and south. The country has a population of about 19,201,995 (mid-2006). The Costa, about ¼ of the country to the west is a rich agricultural region with forested hills to the north. The Sierra or central highlands descend eastwards with forested slopes to end in alluvial plains. To the east of the cordilleras Oriental are the eastern jungles, these consist of the forested slopes of the Andes and the plains covered with tropical rainforest. Half of Ecuador is covered by trees (Europa World Online 2009).

Poor infrastructures, lack of mechanization, the effect of ENSo and financing difficulties affect negatively the agricultural sector in Ecuador (Markwick 2009). Agricultural productions for exports are mainly concentrated in the coastal region where a modern agro-industry is present. Ecuador is major exporter of Bananas in the world. Cocoa used to be the main export until bananas took over in the 1940s, coffee is also produced for the foreign market. Staple crops like rice, potatoes, maize, soybeans, wheat, etc. are produced for domestic consumption (Markwick 2009).

Figure 61: Map of Ecuador showing main areas of forest cover



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Mexico

Size of country: 1.95 million km^2

Forest cover before deforestation: Approximately 66% before the Spanish conquest in 1519

Present forests cover: ~ 33 % (FRA, 2005) half of which is primary forest

Forest lost to date: ~ 90 % of original forest lost to date (FRA, 2005)

Current deforestation rate: 0.4 % yr^{-1} (FRA, 2005)

Emissions from Land-Use Change & Forestry: 96.8 $MtCO_2eq$ in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Mexico since large scale deforestation began

Time period	1894 - 1940	1940 - 1960	1960-1985	1985 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **				1990-2000 0.5% yr^{-1} (FAO)	2000 – 2005 0.4% yr^{-1} (FAO)
Proximate drivers	O	W,I	A, I,	A	A
Underlying drivers	D, P	P	P, D	P	P
Notes	In Mexican revolution (1910-17) Maya Indians given some land back Agrarian reform, ejidos set up for chicle extraction Forest concessions granted In Lacandón US companies commercial logging	Boom in selective logging for Mahogony and Cedar Chicle extraction declines after 1945 In S. Yucatan infrastructure dev Nationwide gov distributed nearly 4.5 million ha of federal lands	Large scale gov. directed colonisation in S. Yucatan for pasture 1967 part of Lacandón forest made national territory - failed to stop deforestation 1972 highway 186 completed and migrants came 1982 national debt crisis slowed deforestation	Rise in mechanised ag and intensification, but also secondary forest growth. Gov establish some permanent forest areas State policy in Chiapas inadvertently favours logging 1988 ban on logging by gov.	Agricultural expansion for pasture and cash crops such as chile 80% of Mexico's forests communally held Some secondary forest establishment Infrastructure improvements in southern Yucatan for tourism, meant to curb deforestation
References	Bray & Klepeis 2005, Geoghegan et al. 2004	Bray & Klepeis 2005, Chowdhury 2007, Durand and Lazos 2004	Bray & Klepeis 2005, Klepeis and Vance 2003,	Bray & Klepeis 2005,	Klepeis and Vance 2003, Geoghegan et al. 2004,

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

In Mexico the drivers of deforestation have varied greatly over time and with region. In the first half of the 20th century deforestation was limited with selective logging and chicle production (resin used in chewing gum) being the main drivers. In the 1940s and 50s the country underwent a logging boom in the Yucatan, with selective extraction of mahogony and cedar being very important. In the 1960s and 70s colonisation of forest areas by both spontaneous groups and government organised groups drove further deforestation. The government declared much of the forest land in the country as *ejido* land (communally owned land) (Durand and Lazos, 2004). These *ejidos* practiced slash and burn subsistence agriculture or cash cropping depending on the region. In the early 1980s the Mexican debt crisis reduced government investment in colonisation programs and deforestation slowed. Today Mexico has lost more than 95% of its original rainforest cover and has one of the fastest deforestation rates in the world (Perez-Verdin, 2009). Much of this is attributed to agricultural expansion for pasture and cash crops (Bray et al. 2004).

2. Detail on recent drivers of deforestation (2001 – present)

Table 2. Drivers of deforestation 2001-present and associated activities

Activities in forest areas related to deforestation	Areas within Mexico affected (in general)	Proximate drivers		Underlying drivers		Notes	Studies/references
Selective logging for mahogany	Quintana Roo		W			Some secondary forest recovery in the area. Logging supposed to be under gov regulated plans.	Bray & Klepeis 2005
Logging	Lacandon		W				Bray & Klepeis 2005
Slash and burn agriculture small scale	Quintana Roo S. Yucatan		A		E	Chili is a popular cash crop and relies on shifting ag.	Bray & Klepeis 2005
Large scale mechanised agriculture	S. Yucatan peninsular Campeche and Quintana Roo		A		E	Disked plots becoming more popular for chili Mechanised maize production biggest crop	Bray & Klepeis 2005 Klepeis & Vance, 2003 Geoghegan et al. 2004
Colonisation and population growth	Lacandon				D, P	Colonisation declined in 1990s put growth in established settlements continues to put pressure on forest	Bray & Klepeis 2005
Pasture for cattle ranching	Lacandon		A		P	Major cause of deforestation in Lacandon, 90% of this forest area is now pasture.	Bray & Klepeis 2005, Bray et al. 2004
Fire	Areas with ejidos especially northern Mexico		O		D, C	Fires are used to clear land for ag. and often get out of control clearing larger areas	Perez-Verdin et al., 2009 Rodriguez-Trejo and Fulé, 2009

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (see section X)

3. General information about Mexico

Size of country: 1 958 200 km^2 (FAO, 2005)

Lat and long plus geographic position: 23° N and 102° W. Located in the southern part of North America, is bordered by the United States on the north, the Pacific Ocean on the west, the Gulf of Mexico and the Caribbean Sea on the east, and Guatemala and Belize on the south.

Population: 111,211,789 (CIA, 2009)

Area of the country under forest: 642,380 km^2 of which 328,500 are primary forest (FRA, 2005)

Forest types in the country: Mexico's has rainforests in the southeastern area of the country along the Gulf of Mexico and in the state of Chiapas. Rainforest once formed a continuous band across the states of the Yucatán Peninsula, Chiapas, Tabasco, Oaxaca, Veracruz and Puebla, as well as occurring in Hidalgo and San Luis Potosí. There are now 6 islands of rainforest left in this area the largest of which is in Chiapas.

Most important drivers of deforestation: Subsistence activities—fuelwood collection and land clearing for agriculture, using fire.

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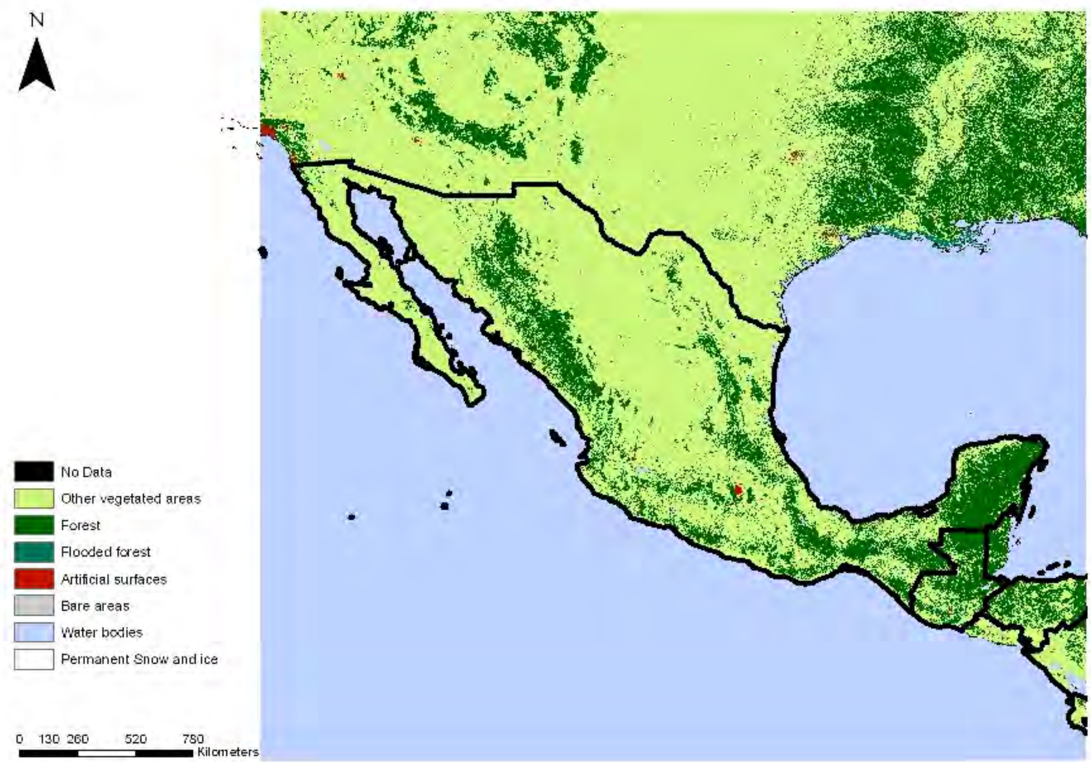
Figure 62: Map of Mexico showing main areas of forest cover



Peru

Size of country: 1.28 million km^2
Forest cover before deforestation: -
Present forests cover: 53.7 % (FRA, 2005)
Forest lost to date: -
Current deforestation rate: 940 km^2 yr^{-1} , 0.1 % yr^{-1} (2000-2005)
Emissions from Land-Use Change & Forestry: 187.2 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Peru since large scale deforestation began

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **				940	940
Proximate drivers	I, A*	I, A*	A	A	A, W
Underlying drivers	P, D, E	P, D	E, P	E, P	D, E
Notes	Political drive to occupy the Amazon territory is realized with the development of roads connecting Lima-Pucallpa. This process, similar to the one in Brazil, across the border is followed by development of agriculture and livestock production. Agricultural credit programs supported the production of commercial crops in certain areas (highlands and coastal area).	Political drive to occupy the Amazon territory is realized with the development of roads connecting Lima-Pucallpa. This process, similar to the one in Brazil, across the border is followed by development of agriculture and livestock production. Focus of the Rural Devt Bank on expansion of agricultural lands particularly in the Amazon.	Agricultural produce like Guarana' and Heart of Palm have no developed international market and are produced for local and national markets. Coca production instead is entirely driven by international markets. National economic and agrarian policies are important drivers of deforestation (e.g. credit and land title). Violence in some areas resulted in migration to cities and regeneration, and other areas increased due to illegal drugs. RDB ceased in 1992.	Agricultural produce like Guarana' and Heart of Palm have no developed international market and are produced for local and national market. Coca production instead is entirely driven by international markets. National economic and agrarian policies are important drivers of deforestation, e.g. austerity in this period moved farming along rivers where soils were better suited for agriculture. Investment in infrastructure following period of political violence.	Expansion of gold mining activities in south – completely destroying the forest. Pollution from mercury – killing fish. In the north, illegal crops are expanding again due to increase in price. Pressure is on Columbia so more drug production occurring in Peru. Poppy increasing in upper basins. Roads in north and south to Brazil have been improved resulting in more deforestation. (Inter-Ocean Highway) Also investment in infrastructure to (roads, clinics, schools) replace illegal crops with legal crop, but still deforestation occurring. Extreme poverty decreased.
References	Imbernon 1999, Arce-Nazario 2007	Imbernon 1999	Imbernon 1999, Alvarez and Naughton-Treves 2003, Phillips et al. 2006, Arce-Nazario 2007	Imbernon 1999, Alvarez and Naughton-Treves 2003, Arce-Nazario 2007	Escobal and Aldana 2003, Phillips et al. 2006, Zwane 2007 Ugarte-Guerra, L. 2009. Migracion carreteras y la dinamica de deforestacion en Ucayali. In: alternativa agroforestal en la amazonia en ntransformacion EMBRAPA brasili,(ed. Roberto Porro).

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

Development of roads into the forest and connecting rivers to urban markets was followed by migration of peasants into the Amazon, mainly from Andean highlands because of impoverishment and demand for coca. At first migrants practice slash and burn agriculture with very low capital investments. This stage is followed by a shift to commodity production and finally production of cash crops and livestock for national markets. Since the 1980s land, capital and labour have been concentrated on coca production due to its high profitability (Imbernon, 1999).

2. Detail on recent drivers of deforestation (2001 – present)

Table 2. Drivers of deforestation 2001-present and associated activities

Activities in forest areas related to deforestation	Areas within Peru affected (in general)	Proximate drivers		Underlying drivers		Notes	Studies/ references
Slash and burn agriculture for subsistence first and market after settlement	Department of Madre de Dios Peruvian Selva	Slash and burn agriculture is responsible for 80% of deforestation in this area.	A	A study by Zwane 2007 has found that income is positively correlated with deforestation but at a decreasing rate, significant is the positive correlation between clearing and labor availability in households.	D E	Immigration from the Peruvian Andes is a cause of deforestation especially along the highway. The poor exert more pressure on the rainforest as farmers than as lumberjacks. However, wealthier households use forest resources more intensively.	Escobal and Aldana 2003, Phillips et al. 2006, Zwane 2007
Timber extraction	Department of Madre de Dios	Timber extraction cause less deforestation because done selectively but results in near extinction of certain species.	W		E		Escobal and Aldana 2003
Cattle ranching	Madre de Dios		A		E		Phillips et al. 2006
Commercial fruit plantations	Madre de Dios		A		E		Phillips et al. 2006
Other forest products	Case study comprising upland and floodplain in an area 20Km south of Iquitos	Charcoal production	W		E	Reaction to the decreasing credit availability for agriculture has induced small farmers to cultivate only for household consumption and concentrate on charcoal production for the increasing nearby urban centers	Arce-Nazario 2007
*Decreasing deforestation				Rural population moving to the cities. Guarantee tenure security.	D P	Increase urbanization, e.g. development of Puerto Maldonado, is associated with job opportunities in the service sector and increase secondary education, both associated with less deforestation. Tenure security is a critical determinant of reforestation for Brazil nuts gatherers. Comparison of 2001 deforestation with previous period shows decrease in deforestation of mature forest.	Escobal and Aldana 2003, Phillips et al. 2006

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin (see section X)

Deforestation in the Peruvian Amazon has been studied mainly in the Department of Madre De Dios. These studies have showed that in this areas deforestation is linked to accessibility of the forest, hence it concentrates along roads and rivers. Production is mainly for local and national markets.

3. General information about Peru

The Republic of Peru has a total land area of 1.28 million km^2 located between the latitude of 10^0 00’ S and longitude 76^0 00’ W. It borders with Ecuador and Colombia to the north, Brazil to the west and Bolivia to the south. The country has a population of about 27.4 million. It is the third largest country in South America. To the west the country is characterised by the Pacific coastal plains (10% of the country) and the foothills of the Andes. To the east the high Andes and the north-eastern Selvas descend in wooded lower slopes and the rainforests plains of the Amazon basin, both covering about 60% of the country. Woodlands cover nearly half of the country (Europa World Online 2009). Peru has 1.3 million ha under cultivation. These are concentrated in the Andean Sierra (53%) and in the coastal region (30%). Only 17% of the rainforest is under cultivation, its potential being untapped due to lack of infrastructure (Markwick S. 2009).

Where infrastructures were developed in the rainforest they supported internal migration. Crops produced in the area were mainly for the domestic market, e.g. cassava, rice, bananas, oranges, tea, cacao (cocoa plant), beef, rubber and oil palm. In this region coffee is produced for export, the most valuable legal agricultural export. Area devoted to coffee production went from 76,000 ha in 1960 to 230,000 in 2004. Where the Sierra meets the rainforest coca for the production of cocaine is grown. Peru used to be the second producer of coca after Ecuador; production is estimated to be still high despite ongoing Government's eradication campaigns (Markwick, 2009).

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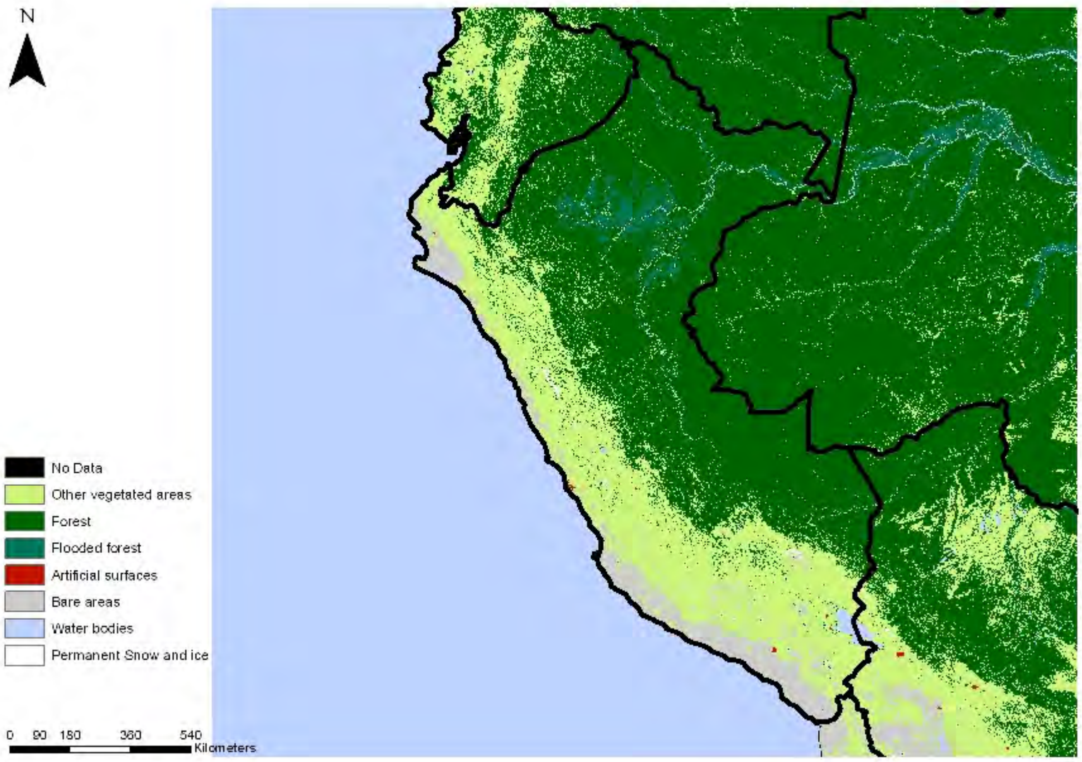
Figure 63: Map of Peru showing main areas of forest cover



Africa

Angola

Size of country:	1 246 700 km^2
Forest cover before deforestation:	-
Present forests cover:	47.4% in 2005
Forest lost to date:	-
Current deforestation rate:	1,250 km^2 yr^{-1} (0.2% yr-1 in 2005)
Emissions from Land-Use Change & Forestry:	17.8 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Angola since large scale deforestation began

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **				1,250 (0.2%)	1,250 (0.2%)
Proximate drivers	A: agriculture	W: firewood, logging A: agriculture	W: firewood, logging A: agriculture	W: firewood, illegal logging A: agriculture	W: firewood, industrial logging, illegal logging A: agriculture, overgrazing
Underlying drivers	D	D	D	O: war D: migration	D: Population distribution P: mismanagement
Notes				Logging to finance war, Displaced populations depending on natural resources	
References	Bernhard Brink and Douglas Eva, 2008	FAO, 1981 Bernhard Brink and Douglas Eva, 2008	FAO, 1981 Bernhard Brink and Douglas Eva, 2008	WRM, 1999 CBFP, 2006	Mongabay, 2006

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. War: Angola has been under civil war for several decades. About one and a half million people were displaced due to war between 1992 and 1994. Their forced nomadic state and lack of any means of survival or income has caused an accelerated rate of forest damage (cutting down extensive areas of forests and tree plantations) (WRM, 1999).

2.2. Wood extraction: The Angolan conflict has been financed to a large degree by logging (CBFP, 2006). To meet the costs incurred by the war, the government has sold a number of timber concessions to foreign timber companies (Mongabay, 2006).

2.3. Subsistence agriculture: Angola's rainforests (located in the north of the country) are threatened by subsistence agriculture which provides food for almost 90 percent of the population. Overgrazing is also a significant cause of forest clearing and degradation (Mongabay, 2006).

3. General information about Angola

Angola (12 30 S, 18 30 E) is the second oil producer in Sub-Saharan Africa after Nigeria, covering a total area of 1,246,700 km^2, almost half (47.4%) of which is forest. Its population is around 13 millions (CIA estimate) in 2009. The country started rebuilding in 2002, after the end of a 27-year civil war. War is believed to have destroyed forests in Angola, causing migrations and both legal and illegal logging. The rich exclave of Cabinda is separated from the rest of the country by the Democratic Republic of the Congo and has been the object of a separatist war.

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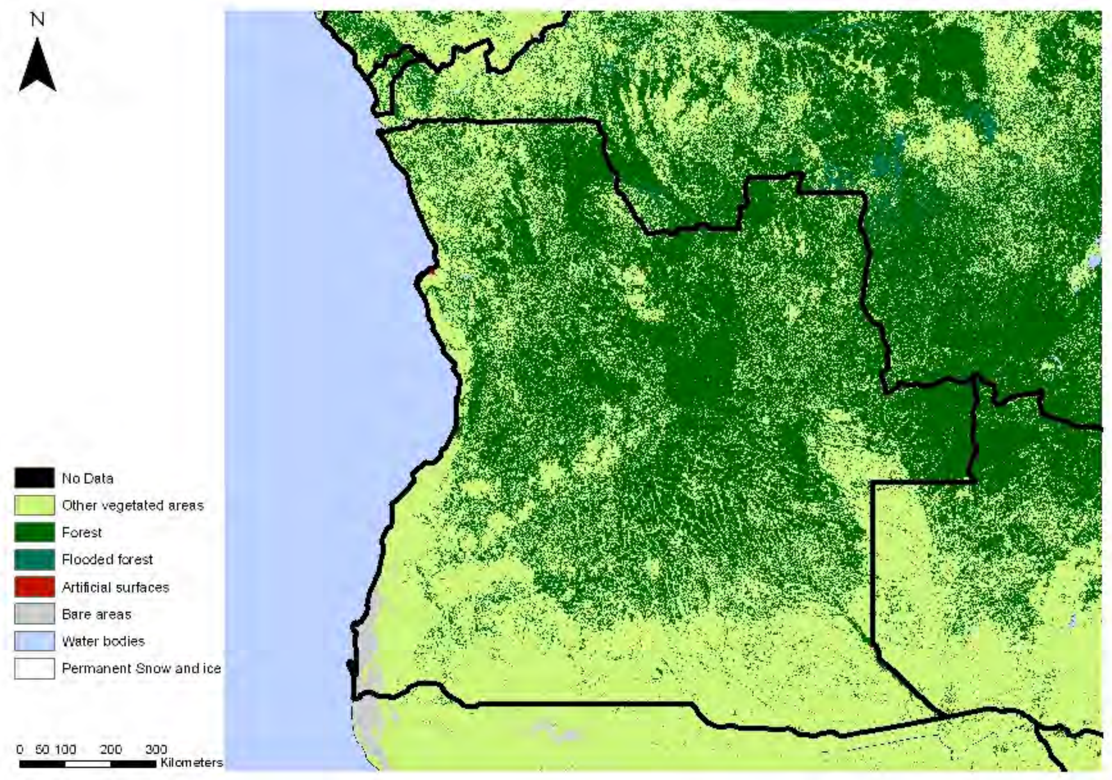
Figure 64: Map of Angola showing main areas of forest cover



Cameroon

Size of country: $475,000 km^2$
Forest cover before deforestation: -
Present forests cover: 45.6% in 2005
Forest lost to date: -
Current deforestation rate: $2,200 km^2 yr^{-1}$ (1.0%) in 2005
Emissions from Land-Use Change & Forestry: 77.1 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Cameroon since large scale deforestation began

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in $km^2 yr^{-1}$ **			1,220	2,200 (0.9%)	2,200 (1%)
Proximate drivers	A	A	A, W	A, W	A, W
Underlying drivers	D	D, E	D,P	D, P, E	D, P, E
Notes	• rural fertility rates	• Oil boom • High international coffee and cocoa prices • government's use of oil revenues to expand parastatal oil palm and rubber plantations • Rapid urban population and income growth made attractive for rural households to cultivate food for urban consumers	• End of the 1980s: declining real cocoa and coffee prices and reduced government services and subsidies • variance in remaining forest cover explained by variance in rural population density and by the variance in the share of land under temporary tenure rights	• Devaluation of currency CFA by 50% in 1994 • Structural Adjustment Policy with IMF	
References	(Ndoye and Kaimowitz, 2000)	(Ndoye and Kaimowitz, 2000)	(Ndoye and Kaimowi, 2000), (Daan van Soest, 1998)	Kaimowitz et al (1998) (Ndoye and Kaimowitz, 2000) (Nkamleu *et al.*, 2002)	

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Wood extraction and agriculture: Agricultural practices are the main direct cause of deforestation in Cameroon. However, as reported by Daan van Soest (1998), 98% of primary forests that are degraded into secondary forests, have first been exploited by the forestry sector even though it is only responsible of 10% of the annual loss of biomass. Up to the 1970s, the level of forest clearing for food crop production was largely determined by rural fertility rates, a situation that changed during the oil boom years (1977-1985) when high international coffee and cocoa prices and lower implicit taxation encouraged moderately higher levels of forest clearing for coffee and cocoa production. During the same period, oil revenues were also used by the government to expand oil palm and rubber plantations, which led to additional deforestation (Ndoye and Kaimowi, 2000).

2.2. Structural Adjustment Policies (SAP): The recent history of Cameroon's deforestation is marked by a few key events: the economic crisis in the late 1980s followed by structural adjustment plans negotiated with the IMF and the 50% currency devaluation in 1994. These events explain the schedule chosen by Ndoye and Kaimowitz (2000) to analyse how deforestation drivers have changed in the past decades. Policy changes were implemented by the Breton Woods institutions in the early 1990s in an attempt to address the crisis. Kaimowitz et al. (1998) studied the impact of SAP on forests, showing that the policy led to an increase of forest clearing for food crops. A negative correlation between income levels and fuelwood consumption has been established by Nkamleu *et al.* (2002).
2.3. Property rights: Kazianga and Masters (2006) show that increasing farmers' land tenure security raises their consumption and welfare by supporting higher investment rates which take the form of a relatively high rate of deforestation.

3. General information about Cameroon

Size of country:	475,000 km^2
Lat and long plus geographic position:	6 00 N, 12 00 E. Bordered by Central African Republic, Chad, Republic of the Congo, Equatorial Guinea, Gabon and Nigeria
Population:	18,879,301 (CIA, 2009)
Area of the country under forest:	212,450 km^2 in 2005 (FAO).
Forest types in the country:	Mostly lowland rainforest. Roughly 1% of forest cover is montane forest located around Mount Cameroon and the south western part of the country. Mangroves make up less than 1% of forest cover, primarily around the Rio del Ray and Cross River estuaries.
Most important drivers of deforestation:	Shifting cultivation

Cameroon has the second highest annual deforestation rate in the Congo Basin, after the Democratic Republic of Congo (GFW report 2000). Data on actual deforestation rates vary amongst sources. Gbetnkom (2005) reports that in 1965 forest covered an area of 280,250 km^2 of a total surface area of 475,000 km^2, representing almost 58% of the country. This forest area dropped to 233,000 km^2 in 1980, and in 1995 the extent of Cameroon forestland came down to 195,980 km^2 (Gbetnkom, 2005).

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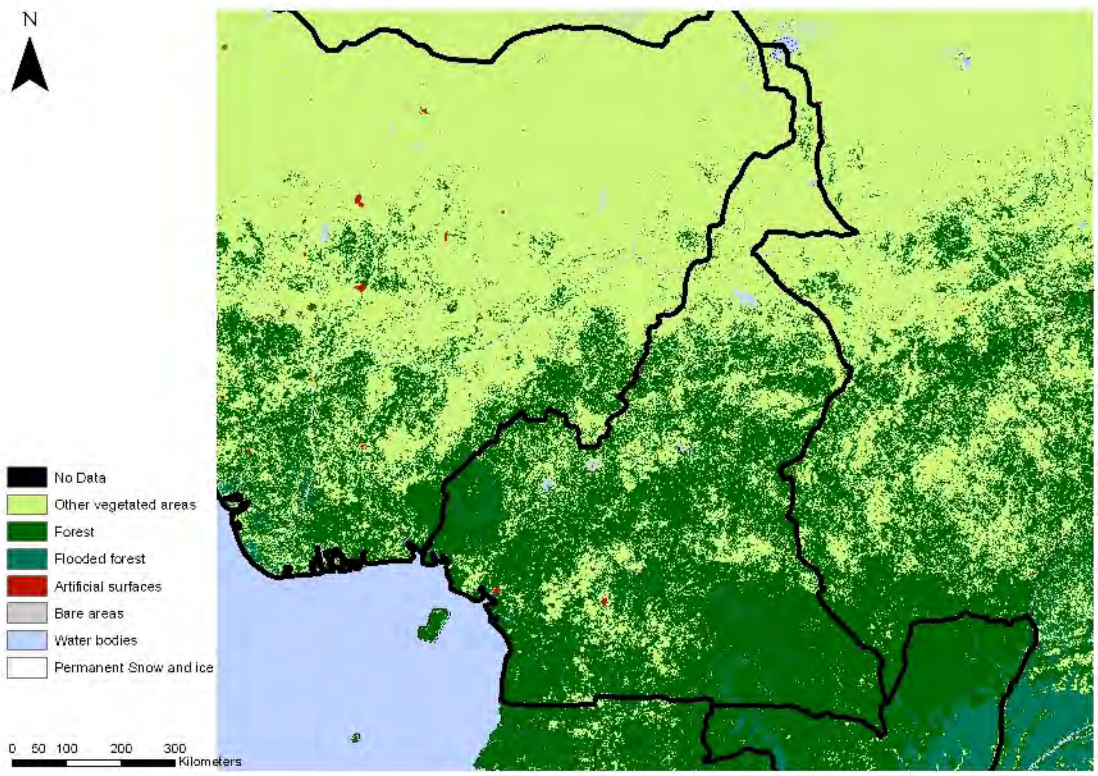
Figure 65: Map of Cameroon showing main areas of forest cover



Democratic Republic of Congo (DRC)

Size of country:	2,344,858 km^2
Forest cover before deforestation:	-
Present forests cover:	1,336,100 km^2 in 2005 (FAO, 2009)
Forest lost to date:	-
Current deforestation rate:	0.2% in 2005
Emissions from Land-Use Change & Forestry:	220 Mt CO_2e per year in 1990-2000 (Laporte, 2007)

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for DRC since large scale deforestation began

Time period	1960-1970	1971 – 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **				5,320 (0.4%)	3,190 (0.2% in 2000 – 2005)
Proximate drivers				A, W	A, W
Underlying drivers				D, O	D, P, O
Notes	•	•	•	Small-scale slash and burn agriculture. War (illegal and legal logging)	Small-scale slash and burn agriculture. War (Logging contracts to fund war)
References				Mongabay, 2006; FAO, 2009	Laurance, 2001; Brahic, 2007; FAO, 2009

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Agriculture: Deforestation in DRC is manly driven by small-scale slash and burn agriculture. Analyzing potential drivers of land cover change in the DRC, Laporte et al. (2007) showed that deforestation was correlated to population density, the degree of fragmentation in the landscape, and the spatial distribution of forest biomass. They noticed that deforestation is concentrated mainly where anthropogenic activities such as agriculture and mining are more intense. Current patterns of shifting agriculture in the DRC are not well known. It is estimated that only about 4–6 per cent of the land in the country's rainforest areas is devoted to agriculture. Most households grow less than one hectare annually, and farmers would often rather clear secondary forest than primary forest as most of them lack funds, labour and incentives to develop vast plantations (Debroux et al., 2007)

2.2.Logging: Extractive industries such as mining and commercial logging are also significant drivers of deforestation in DRC. The Second Congo war (1998 – 2003) is considered the deadliest conflict since World War II and has been sustained by both legal and illegal logging. For instance, the Virunga National Park suffered extensive damage by armed bands of soldiers and refugees from neighbouring camps, who harvested some 36 million trees from the park and hunted gorillas and other animals (Mongabay, 2006). A deal was struck between the Democratic Republic of Congo (DRC) and a logging corporation that is controlled by the Zimbabwean Army and Forestry Commission, in exchange for Zimbabwean President Robert Mugabe's pledge to help the DRC defeat rebels in the eastern part of the country (Laurance, 2001). Although the World Bank agreed in 2002 to provide $90 million of development aid to DRC with the proviso that the government did not issue any new concessions granting logging companies rights to exploit the forest, it is estimated that concessions amounting to 15 million hectares were granted between May 2002 and October 2005 (Brahic, 2007). Industrial logging operations are expanding in the region and oil palm is expected to increase rapidly following recent (October 2007) Chinese investment of $1 billion (Laporte et al. 2007).

3. General information about DRC

Size of country:	2,344,858 km^2
Lat and long plus geographic position:	0 00 N, 25 00 E (Central Africa, northeast of Angola)
Population:	70,916,439 (July 2010 est., CIA factsheets)
Area of the country under forest:	1,336,100 km^2 in 2005 (FAO, 2009)
Forest types in the country:	Lowland rainforests (860,000 km^2), dry forests and savannah woodland mosaic
Most important drivers of deforestation:	Agriculture, legal and illegal logging

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Ethiopia

Size of country: 1,104,300 km^2
Forest cover before deforestation: 40% in 1900
Present forests cover: 13.0% in 2005
Forest lost to date: -
Current deforestation rate: 1.1% in 2005
Emissions from Land-Use Change & Forestry: 8.4 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Ethiopia since large scale deforestation began

Time period	**1960-1970**	**1971 - 1980**	**1981 - 1990**	**1991 – 2000**	**2001 - present**
Approx deforestation rate in km^2 yr^{-1} **			1,630	1,410 (1.0%)	1,410 (1.1%)
Proximate drivers	A	A,W	A,W	A,W	A, W
Underlying drivers	D: migration P: land tenure	P	D	D,P	D, E
Notes	• Establishment of commercial farms (coffee and cereal crops)	• Change in land tenure following the revolution in 1974 by a military junta • Mechanized farming	• continuation of past trends	• Population growth • government's land-reform and re-settlement programs • Political transition in 1991: unplanned forest clearance may be attributed to significant social disruption	• Cash crop expansion
References	Dessie and Christiansson, 2008	Cheng et al., 1998	Reusing, 1998 (Dessie and Kleman, 2007)	Cheng et al., 1998 (Dessie and Christiansson, 2008)	(Dessie and Christiansson, 2008) (Feyisa and Aune, 2003:)

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Demography: Cheng et al. (1998) identified population pressure, lack of awareness, and weak management as the major causes for deforestation and the degradation of natural resources in the Belete-Gera area of the country. The natural forest is utilized by local residents for firewood, livestock grazing, bark, medicinal herbs, and coffee production.

2.2. Poverty: Based on a case study from the Dendi District in Ethiopia, Mamo et al., (2007) found that forest income contributed 39% to the average household income, roughly equal to agriculture, which contributed 40%. They estimated that forest income was more important than all other income sources combined for the poorest 40% of households and contributed more to household income than agriculture for 65% of households. While forest income represents 59% of the total household income for the poorest quintile, the contribution drops to 34% for the wealthiest quintile.

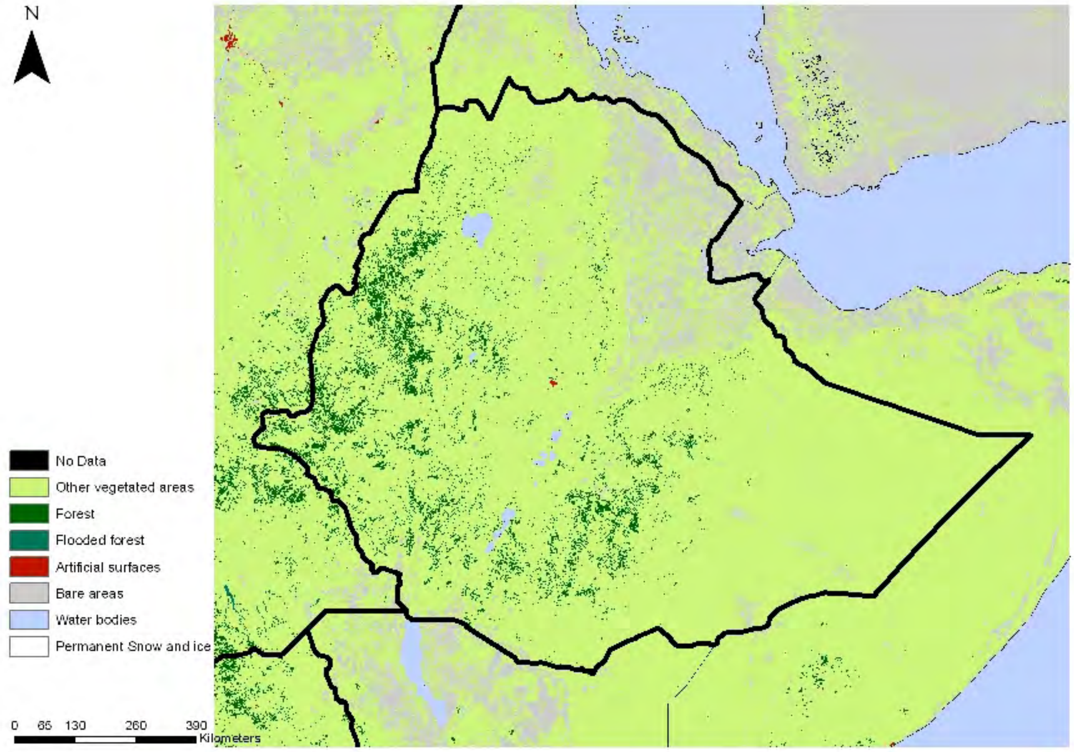
2.3. Agriculture: A study conducted by (Feyisa and Aune, 2003:) in the Ethiopian Highlands showed that approximately 70% of farmers' income in the study area is obtained from *khat*, a rapidly expanding perennial crop which is Ethiopia's second largest export item. The expansion is assumed to influence forest decline directly by conversion and indirectly through increased human activity in proximity to forests.

3. General information about Ethiopia

Size of country: 1,104,300 km^2

Lat and long plus geographic position:	8 00 N, 38 00 E (Bordered by Djibouti, Eritrea, Kenya, Somalia and Sudan)
Population:	85,237,338 (CIA, 2009)
Area of the country under forest:	130,000 km^2 in 2005 (FAO).

Figure 66: Map of Ethiopia main areas of forest cover



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Gabon

Size of country:	267,667 km^2
Forest cover before deforestation:	-
Present forests cover:	217,750 km^2 in 2005 (FAO, 2009)
Forest lost to date:	In 1995 and depending on sources, Gabon lost between 20 and 31 percent of its original forest cover (GFW, 2000)
Current deforestation rate:	100 km^2 yr^{-1} (0.05%) in 2005 (FAO, 2009)
Emissions from Land-Use Change & Forestry:	-

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Gabon since large scale deforestation began

Time period	**-1970**	**1971 - 1990**	**1991 – 2000**	**2001 - present**
Approx deforestation rate in km^2 yr^{-1} **	n/a	83.33 (0.04% in 1974 – 1992)	100 (0.0%)	100 (0.0% in 2000 – 2005)
Proximate drivers	**W**	**W**, A	**W,** A	**W**
Underlying drivers	E	E, D	E, D	E
Notes	The forest sector constituted the country's economic mainstay until the oil boom of the 1970s.	During the same period, agricultural land increased only by 0.01% per year		It is expected that declining oil revenues and migration will increase pressure on forest lands
References	GFW, 2000	Solon et al., 2000	Duveiller et al., 2008	FAO, 2009; GFW, 2000

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Logging: Gabon is not experiencing a high rate of deforestation. The main cause of forest biodiversity loss is likely to be logging (both through direct and indirect effects), as agriculture development is very limited (Nasi, 2001) and the population is highly urbanized (80%, according to CBFP (2006)). Until now, Gabon's small population, combined with high revenues from oil production and high operating costs, has sheltered its forest resources from demographic, agricultural, and industrial pressures. With declining oil revenues, however, increased demands have been placed upon forest resources (GFW, 2000).

3. General information about Gabon

Size of country:	267,667 km^2
Lat and long plus geographic position:	1 00 S, 11 45 E (Western Africa, bordering the Atlantic Ocean at the Equator, between Republic of the Congo and Equatorial Guinea)
Population:	1,545,255 (July 2010 est., CIA factsheets)
Forest types in the country:	Three categories: the broad group of coastal basin forests (evergreen high-forest with clear undergrowth), the more homogeneous forests of Central Gabon, and the north-eastern forests that share characteristics with semi-deciduous forests.
Area of the country under forest:	217,750 km^2 in 2005 (FAO, 2009)
Most important drivers of deforestation:	Logging

References

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Madagascar

Size of country: 587,040 km^2
Forest cover before deforestation: -
Present forests cover: 22.4 % in 2005
Forest lost to date: -
Current deforestation rate: 0.3 % in 2005
Emissions from Land-Use Change & Forestry: 60.2 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Madagascar since large scale deforestation began.

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **	1,110 (1.5%)	1,110 (1.5%)	1,110 (1.5%)	670 (0.5%)	370 (0.3%)
Proximate drivers	A,W		O	A,W (fuelwood collection, timber exploitation, cropland expansion, expansion of grazing land (pasture))	A,W
Underlying drivers	D		O: other factors	D,E (maize prices, transportation costs, migration and property rights)	D,E
Notes	• extensive nature of traditional slash-and-burn upland rice culture • forest concessions encouraged by the French with associated destructive logging practices, and the advocacy of selective forest • conversion to plantation and cash crops		• Deteriorating climatic changes (drought)	• Maize price increased from 1985 to 1998 by 460%, though this is less than the inflation of 620%.	
References	Green and Sussman, 1990 Sussman et al., 1996 Cassea et al., 2004	Green and Sussman, 1990	Green and Sussman, 1990 Sussman et al., 1996 Cassea et al., 2004	Cassea et al., 2004	Cassea et al., 2004

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

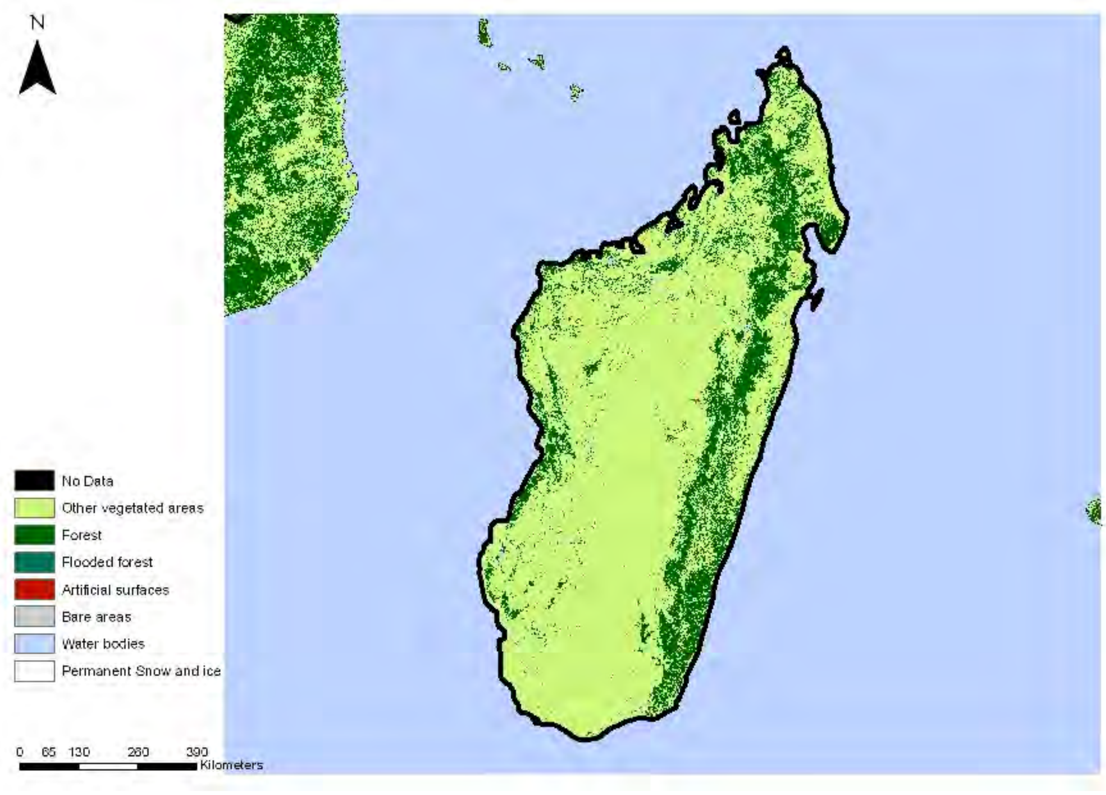
2.1. Agriculture: Agricultural expansion due to population pressure is considered the principal cause of deforestation in Madagascar. Cassea et al. (2004) have concluded from an analysis of deforestation drivers in southern Madagascar that maize is the single most important crop leading to the expansion of agricultural area. Another case study establishing the link between population and deforestation is presented by Agarwal et al. (2005). Adopting a spatially explicit perspective, they show that levels of deforestation are negatively associated with elevation, and forested landscape are positively associated with elevation in both the North and the South of the wet tropical forest biome within the Toamasina (or the Tamatave) Province of Madagascar.

2.2. Wood extraction: Fuel wood collection and legal and illegal logging are often cited as threats to forests in Madagascar. Brand and Pfund (1998) estimated the average fuel wood needs per household to be approximately 15 kg of biomass per day. Fuel wood marketing for urban consumption is also a supplementary activity for small farmers (Bertrand, n.d.). Logging is seen as potentially affecting forest structure and diversity. Ganzhorn (1990) noticed that the most profound ecological effect of logging is a reduction in the number of woody species in the regenerating cohort of trees.

3. General information about Madagascar

Size of country:	587,040 km^2
Lat and long plus geographic position:	20 00 S, 47 00 E (Southern Africa, island in the Indian Ocean, east of Mozambique)
Population:	20,653,556 (CIA, 2009)
Area of the country under forest:	130,230 km^2 in 2005 (FAO)
Forest types in the country:	Lowland forests along the eastern edge
Most important drivers of deforestation:	Agriculture

Figure 67: Map of Madagascar showing main areas of forest cover



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Sudan

Size of country: 2,505,813 km^2
Forest cover before deforestation: between 36% and 43% in 1950s
Present forests cover: 28.4% in 2005
Forest lost to date: -
Current deforestation rate: 0.8% in 2005
Emissions from Land-Use Change & Forestry: 30.5 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Sudan since large scale deforestation began

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **				5,890 (0.8%)	5,890 (0.8%)
Proximate drivers		A	I,A,W	A	I,A,W
Underlying drivers		P	D	D, P, T	D
Notes		• domestic policies under colonial and independent governments in Sudan contributed to *Acacia senegal* deforestation	• Wood extraction for domestic energy • Fuelwood consumption of the brick making industry	• high economic returns from crop (mainly sorghum) production was an important factor encouraging extensification of rainfed mechanized farming • policies in the energy sector can indirectly influence acreage expansion in the agricultural sector	• expansion of rainfed mechanized farming
References		Larson and Bromley, 1991	Alama and Starrb, 2009	Elnagheeb and Bromley, 1992 Elnagheeb and Bromley, 1994 Alama and Starrb, 2009	Elnagheeb and Bromley, 1992 Elnagheeb and Bromley, 1994 Alama and Starrb, 2009

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Fuel-wood: In the Sudan approximately 79% of the country's energy needs are met by burning biomass; mainly wood and charcoal, and 98% of the felled wood is used as fuel for domestic purposes (de Jang-Boom, 1990). The problem of heavy dependence on biomass as a source of energy is aggravated by the low efficiency with which it is utilized. This low efficiency is considered to be one of the important factors that have led to a high demand for firewood and charcoal (Agyei, 1998).

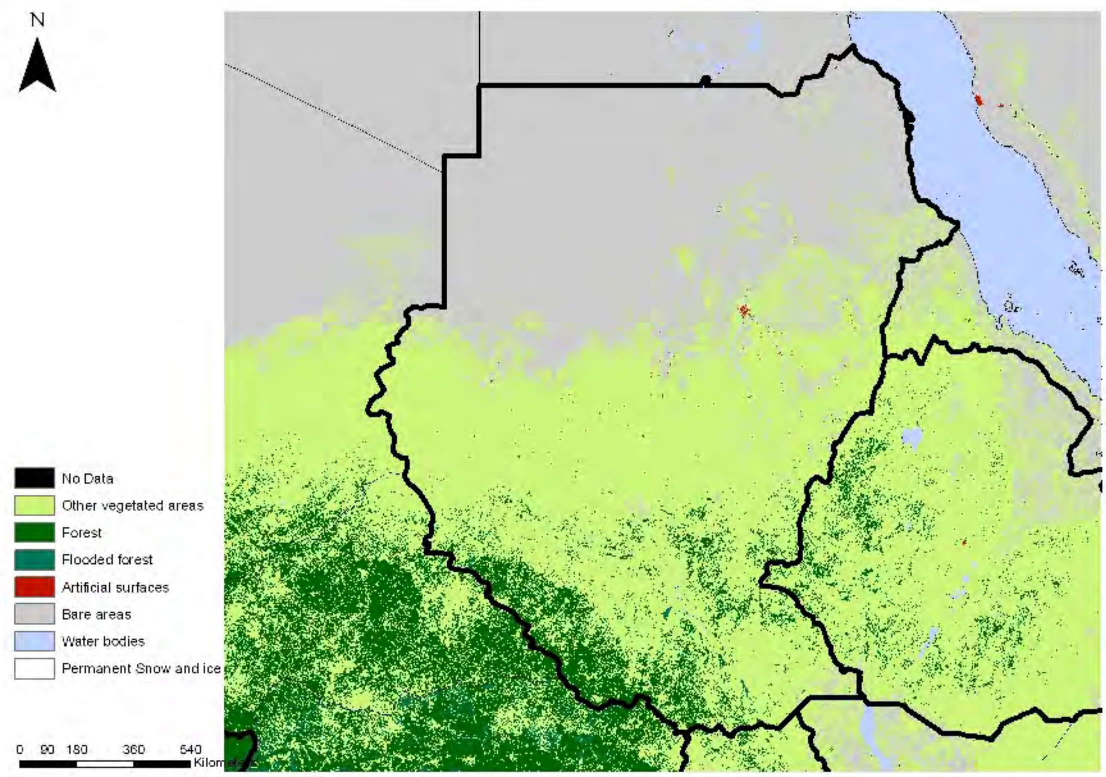
2.2. Infrastructure extension: The Brick Making Industry (BMI) in Sudan is both a significant cause of deforestation and source of GHG emissions. Alama and Starrb (2009) estimate that annual deforestation associated with the BMI for the whole of Sudan is 508,400 m^3 of wood biomass, including 267,600 m^3 round wood and 240,800 m^3 branches and small trees.

3. General information about Sudan

Sudan is situated in northern Africa (15 00 N, 30 00 E), bordering the Red Sea, between Egypt and Eritrea. It is the largest country in Africa, with an area of approximately 2.5 million km^2. It accounts for 60% of the forest reduction in northern Africa, with a loss of almost 12% of its forest area from

1990 to 2005. However, it remains the most forested country in the region (FAO, 2007). The population of Sudan is estimated at 41,087,825 in 2009 (CIA, 2009). In the 1950s, forest area in the Sudan was estimated to be between 36% and 43% of the total country area. The forest cover had shrunk to 19% of the total country area by 1990. This was mainly attributed to expansion of agriculture, building, fuel-wood production and grazing. The most recent forest inventory (1995/1996) conducted for northern Sudan (between latitudes 10º and 16ºN by the Forest National Corporation (FNC), in cooperation with the FAO), estimated forest area at 12% in this part of the country.

Figure 68: Map of Sudan showing main areas of forest cover



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Tanzania

Size of country:	945,090 km^2
Forest cover before deforestation:	-
Present forests cover:	39.9% in 2005
Forest lost to date:	-
Current deforestation rate:	4,120 km^2 yr^{-1} (1.1%) in 2005
Emissions from Land-Use Change & Forestry:	14.5 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for **Tanzania** since large scale deforestation began

Time period	1960-1970	1971-1980	1981-1990	1991-2000	2001- present
Approx deforestation rate in km^2 yr^{-1} **				412 000 ha/yr (1.0%)	412 000 ha/yr (1.1%)
Proximate drivers				A, W	A,W
Underlying drivers				E: prices D	D
Notes		•	•	•	•
References				Angelsen et al., 1999 Hofstad, 1997	Mitinje et al., 2007

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

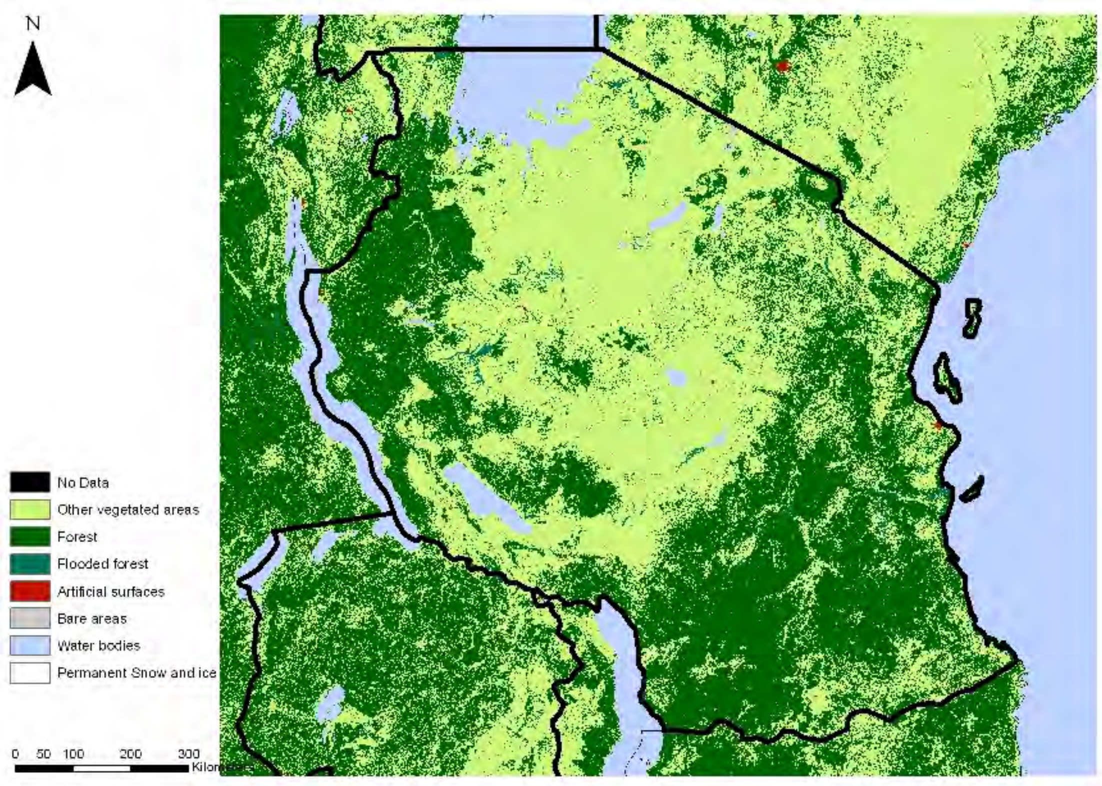
2.1. Demography: Mitinje et al. (2007) concluded that the causes of deforestation in the area are dependent on the daily needs of communities to cater for a growing human population and have little to do with an awareness of deforestation and its negative implications. Fallow periods are shortened when population growth is high, leading to decreased yields. The clearing of more virgin forest land can be more economical than continuing the fallow/cultivation cycle on the same site. Permanent agriculture is also often expanded due to the need for increased food production. Most household energy consumed in urban areas comes from wood fuel (Hofstad, 1997). Kaoneka and Solberg (1997) also estimate that population growth will cause deforestation over time due to the expansion of farmlands for food and future production.

2.2. Economic factors: Angelsen et al. (1999) show that increased agricultural output prices, in particular for annual crops, is a major factor behind agricultural expansion. A 1% increase in output prices leads to an approximate 1% increase in agricultural area. Other factors such as input prices, technology and economic growth are tested and discussed by the authors but the conclusions are less robust. The controversial role of population growth in explaining deforestation is addressed. Generally the results lend support to the market rather than the subsistence approach. Household consumption of charcoal may cause between 20 and 84% of total forest loss in a given year. While the upper limit is quite unlikely (charcoal production is not the only source of forest loss), a value within a tighter range of 30–60% is plausible (Mwampamba, 2007)

3. General information about Tanzania

Size of country:	945,090 km^2
Lat and long plus geographic position:	6 00 S, 35 00 E (Bordered by Burundi, Democratic Republic of the Congo, Kenya, Malawi, Mozambique, Rwanda, Uganda and Zambia)
Population:	41,048,532 (CIA, 2009)
Area of the country under forest:	352,570 km^2 in 2005.
Forest types in the country:	mostly savanna woodland and montane forest
Most important drivers of deforestation:	The forests of Tanzania are increasingly threatened by fuel wood collection by the rapidly expanding population, as well as by commercial felling of timber and expanding agriculture, which makes up 58% of the GNP.

Figure 69: Map of Tanzania showing main areas of forest cover



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Uganda

Size of country:	241,040 km^2
Forest cover before deforestation:	35% (108,000 km^2 in 1890, FAO)
Present forests cover:	18.4% in 2005
Forest lost to date:	-
Current deforestation rate:	860 km^2 yr^{-1} (2.2%) in 2005
Emissions from Land-Use Change & Forestry:	39.3 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Uganda since large scale deforestation began

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in km^2 yr^{-1} **				860	860
Proximate drivers		A,W	A: agricultural expansion	A: agricultural expansion	A: agricultural expansion W: fuel wood, charcoal production
Underlying drivers		P	D	D	O: climatic change D: Immigration for the tea industry
Notes		During Idi Amin's reign (1971-1979), the forests suffered from civil and political strife.			Weakened hydropower generation leading people to turn to fuel wood as energy source. Tea industry indirectly creates pressure on forests by hiring immigrants who subsequently settle in and clear forest remnants
References		Mongabay, 2006	Mwavu and Witkowski, 2008	Mwavu and Witkowski, 2008	Mwavu and Witkowski, 2008 Kafeero, F, 2007 Naughton-Treves et al., 2007 Kayanja and Byarugaba, 2001

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Wood extraction: Naughton-Treves et al. (2007) reported that charcoal production and the tea industry are causes of deforestation in western Uganda. Charcoal producers prefer old-growth hardwood species and are responsible for the greatest loss of natural forests. They access forests by finding landholders who, either willingly or through coercion, allow trees on their lands to be cleared. The impact of charcoal production is exacerbated by a license system that undervalues natural forests and rewards rapid harvests across large areas. The tea industry consumes mainly eucalyptus wood (*Eucalyptus spp*.) from corporate plantations, however they indirectly put pressure on natural forests by hiring immigrants who subsequently settle in and clear forest remnants. Over 90% of the national energy demands of Uganda are met from wood fuel. Approximately 18 million tonnes of firewood and nearly 500,000 tonnes of charcoal are consumed annually. Large volumes of timber are used for construction, furniture making and other manufacturing processes (800,000 m^3 per year). A further 875,000 m^3 of poles are produced each year. The value of non-timber products derived from forests such as medicines; craft materials and food are also known to be significant (Kayanja and Byarugaba, 2001).

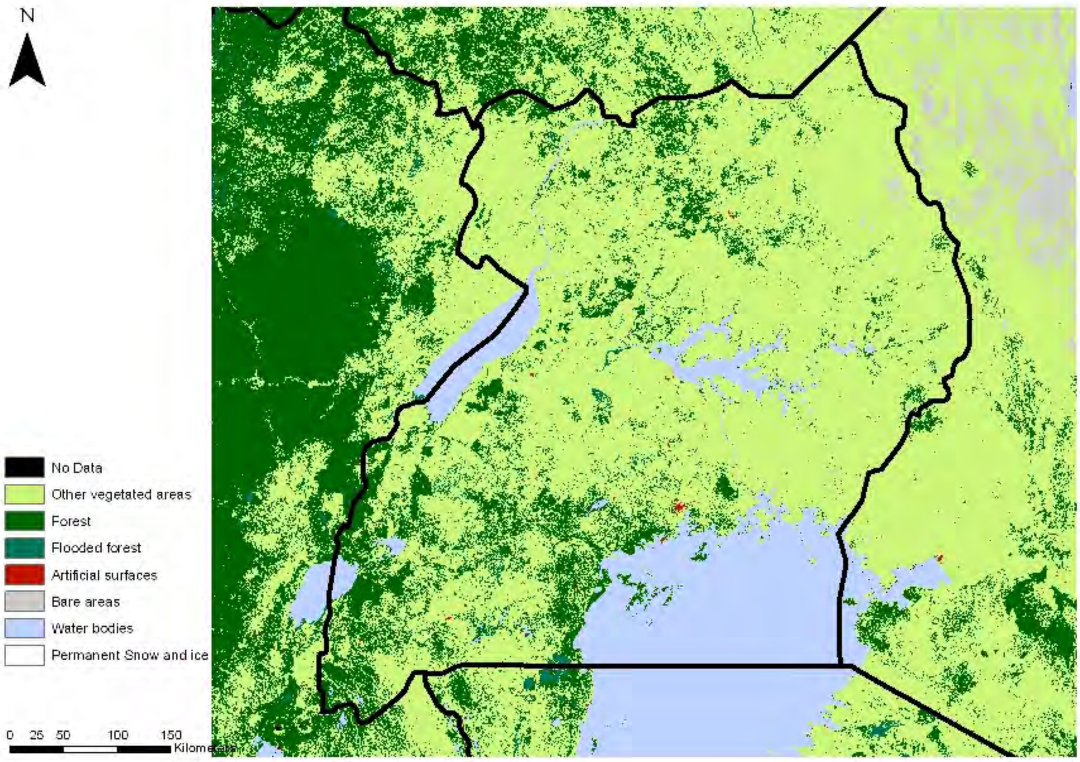
2.2. Climate change: Kafeero (2007) discusses the impact of reducing water resources in Lake Victoria (Uganda) due to climatic change. This impact has weakened hydropower generation, leading people to turn to fuel wood as an energy source, which then exacerbates deforestation.

2.3. Agricultural expansion: According to Mwavu and Witkowski (2008), the area under sugarcane cultivation in Uganda increased over 17-fold from 6.9 km^2 in 1988 to 127.29 km^2 in 2002, with a concomitant loss of about 46.8 km^2 (8.2%) of forest/woodland, mainly on the southern boundary of the Budongo Forest Reserve, (BFR, North West Uganda). There is an ever-increasing need for more land for agricultural expansion, resulting in continued loss of forest/woodland on private/communal lands and encroachment into the BFR.

3. General information about Uganda

Uganda is situated in East Africa. It shares borders with Kenya, Sudan, the Democratic Republic of the Congo, Rwanda, and Tanzania. The southern part of the country includes a substantial portion of Lake Victoria. The country covers 241,040 km^2, with a population estimated at 32,369,558 in 2009 (CIA, 2009). Drastic changes in the forest cover have taken place in Uganda during the past century. The FAO estimated the forest cover to have been as much as 108,000 km^2 in 1890 (35% of Uganda's land area). According to the National Biomass survey (data collected between 1989 and 1995), this has now shrunk to less than 50,000 km^2, or 16% of the land area (Kayanja and Byarugaba, 2001).

Figure 70: Map of Uganda showing main areas of forest cover



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Zambia

Size of country:	752,612 km^2
Forest cover before deforestation:	-
Present forests cover:	57.1% in 2005
Forest lost to date:	-
Current deforestation rate:	4,450 $km^2\ yr^{-1}$ (1%) in 2005
Emissions from Land-Use Change & Forestry:	235.5 Mt CO_2 eq in 2000

1. Drivers of deforestation through history

Table 1. Deforestation rates and drivers for Zambia since large scale deforestation began

Time period	1960-1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - present
Approx deforestation rate in $km^2\ yr^{-1}$ **				4,450 (0.9%)	4,450 (1%)
Proximate drivers	A, W	A, W	A, W	A, W	A, W
Underlying drivers	P	D, P	P, D	D	D, P
Notes	• wood fuel collection (for firewood and charcoal) • cultivation • replacement of natural woodland with forest plantations	• Rapid urbanization. • Dependence by the urban population on fuel wood is causing severe deforestation	• effect of SAP (Structural Adjustment Policies): o removal of (subsidized) credit through government channels, o removal of fertilizer subsidies • growing rural population in the shifting cultivation region of northern Zambia resulted in the reduction of the length of the fallow period from 25 years to 12 years	•	• D (Migration), P (Property rights) • A (Permanent Cultivation)
References	Chidumayo, 1989	Chidumayo, 1989 Chidumayo, 1984	Culas, 2004 Chidumayo, 1987	Unruh et al. 2005	Unruh et al. 2005

NB letters shown alongside the proximate and underlying drivers relate to categories given in Geist and Lambin as follows: A: Agricultural expansion; I: Infrastructure extension; Wood extraction; D: Demographic; E: Economic; T: Technological; P: Policy and Institutional; Cultural; O: Other factors.
The most prominent are in bold.

2. Detail on recent drivers of deforestation (2001 – present)

2.1. Structural Adjustment Policies (SAP): SAP was introduced in Zambia in 1989. According to Culas (2004), an increased use of credit may result in intensification of land use and therefore reduce pressure on forest resources based on the logic of the subsistence approach. However, they noted that since cash poor small-holders are not likely to have access to formal credit markets, the main effect of SAP will be removal of (subsidized) credit through government channels. The result could be expansion on marginal lands and more forest clearing. This effect has been present in Northern Zambia, where traditional shifting cultivation expanded. SAP also led to the removal of fertilizer subsidies, (including the removal of transport subsidies which reduce the transaction costs associated with the purchasing of the fertilizers) which resulted in an expansion of the traditional shifting cultivation system and deforestation.

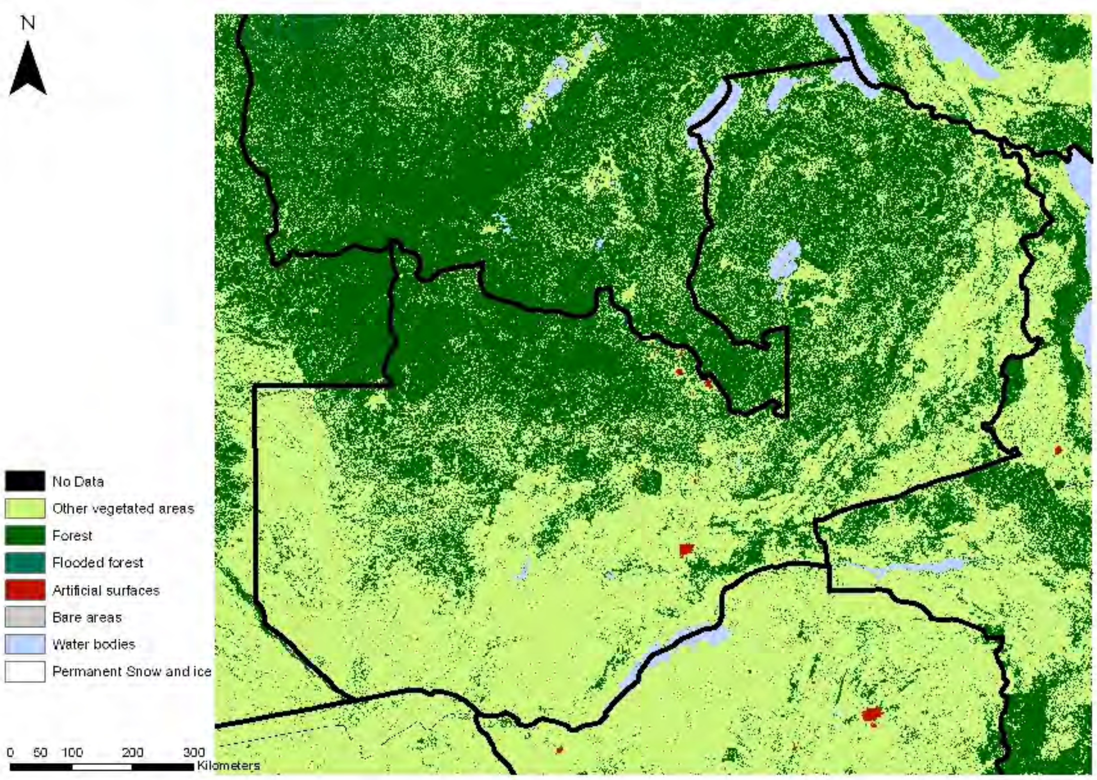
2.2. Property rights: Analyzing land rights reception (as opposed to provision) by migrant populations in southern Zambia, Unruh et al. (2005) show that their perception of these rights leads to the continued clearing of areas much larger than needed for cultivation, even when the arrangement appears counter-productive in terms of land rights provision and labour allocation.

2.3. Wood extraction and agriculture: Chidumayo (1989) showed that between 1937 and 1984 loss of natural woodlands in the Copperbelt area of Zambia amounted to 41% of the woodland area (8,419 km). The major causes of this deforestation are wood fuel collection (for firewood and charcoal), cultivation and replacement of natural woodland with forest plantations.

3. General information about Zambia

Size of country:	752,612 km^2
Geography:	15 00 S, 30 00 E (Bordered by Angola, Democratic Republic of the Congo, Malawi, Mozambique, Namibia, Tanzania and Zimbabwe)
Population:	11,862,740 (CIA, 2009)
Area of the country under forest:	424,520 km^2 in 2005 (FAO).
Most important drivers of deforestation:	mostly due to widespread slash-and-burn agriculture

Figure 71: Map of Zambia main areas of forest cover



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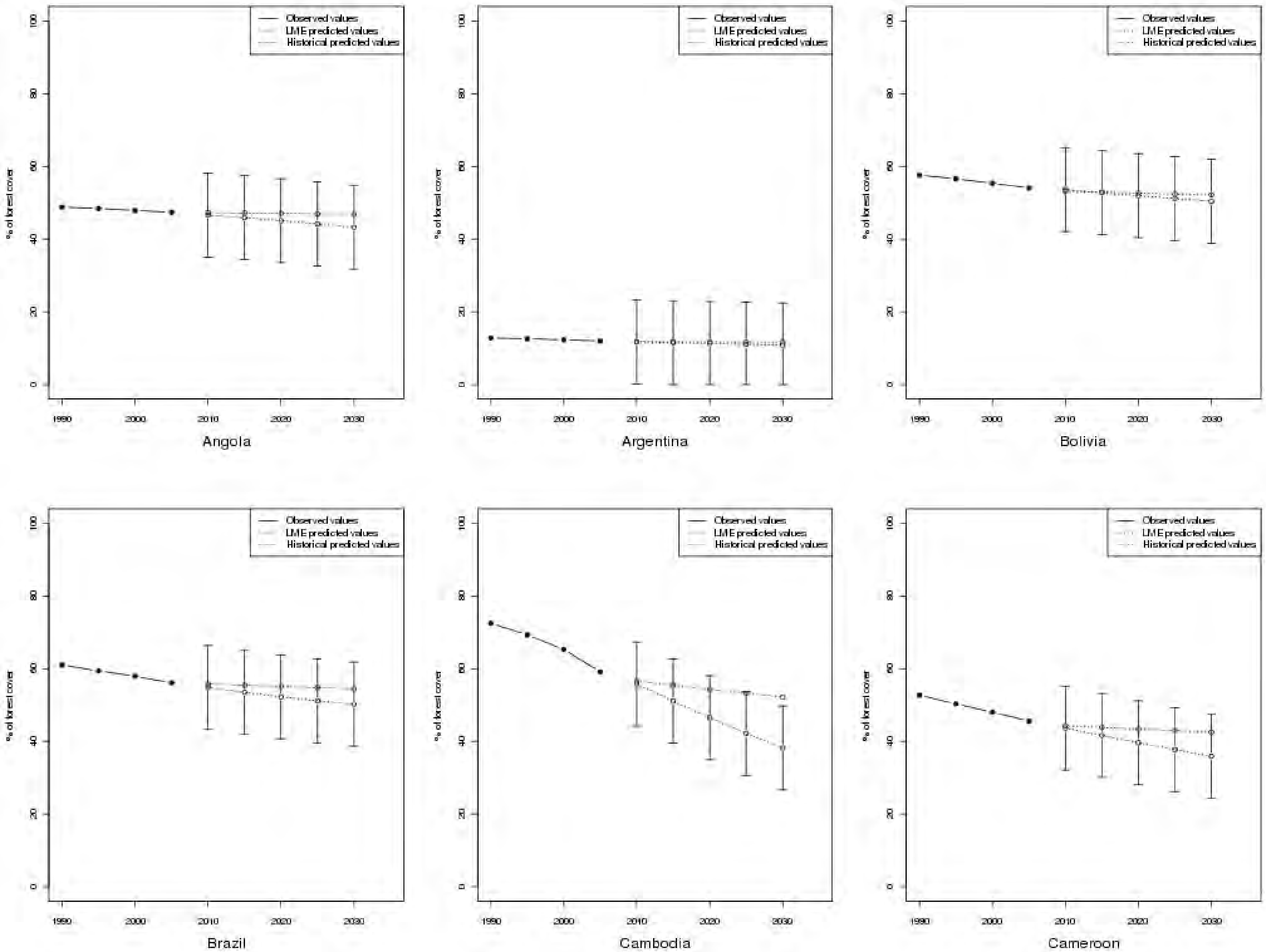
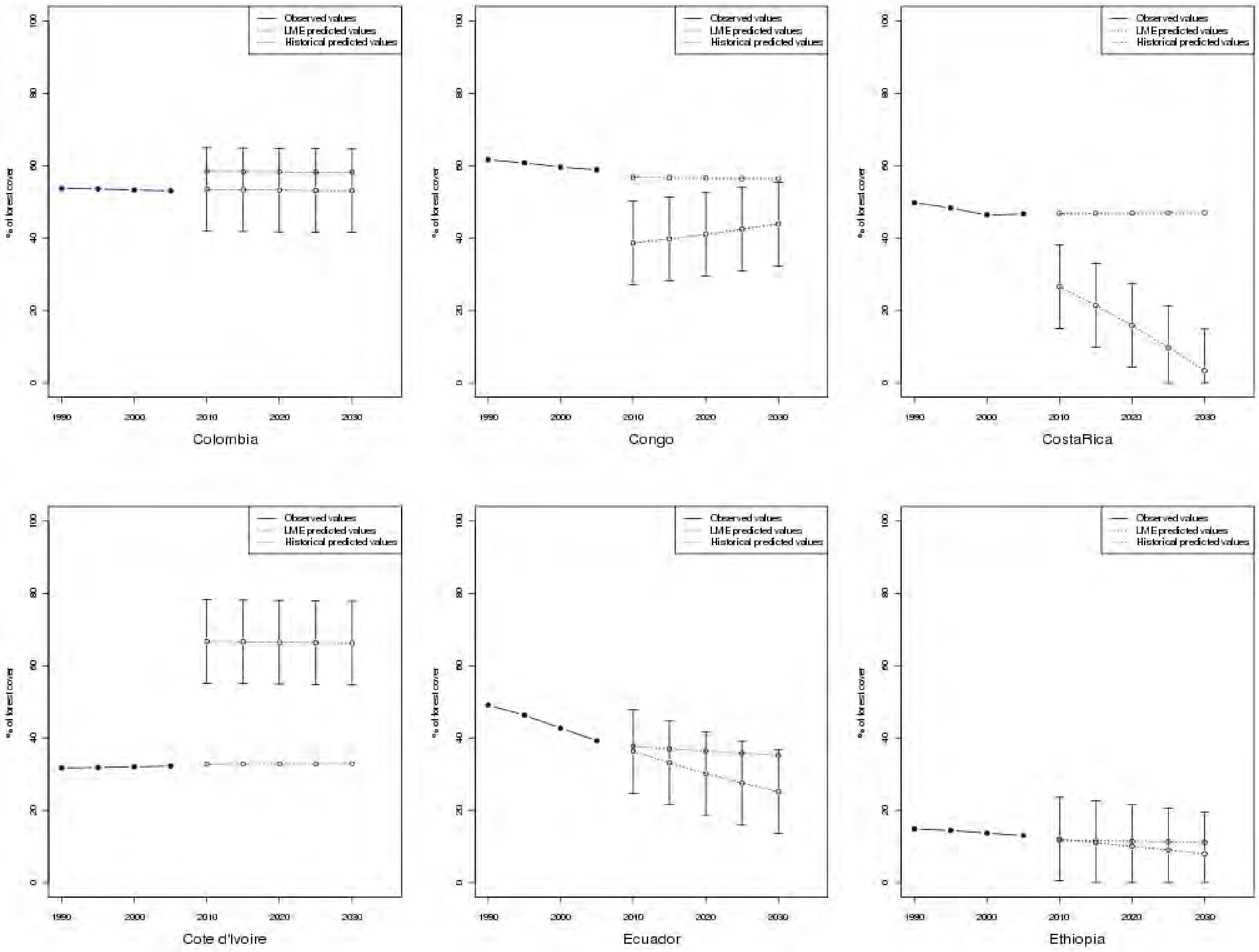
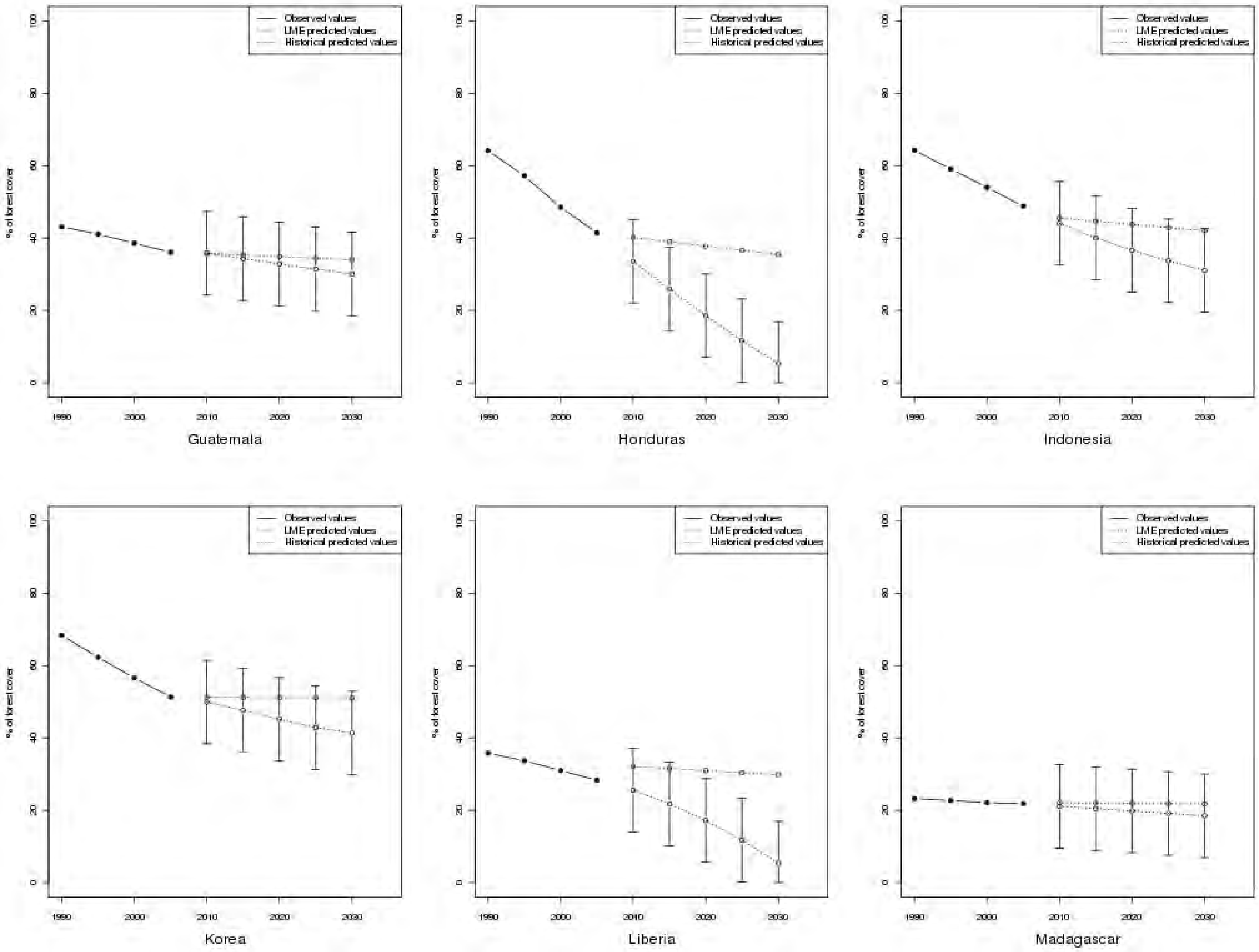
Annex 2: Predicted baselines and estimated uncertainties using a mixed-model approach

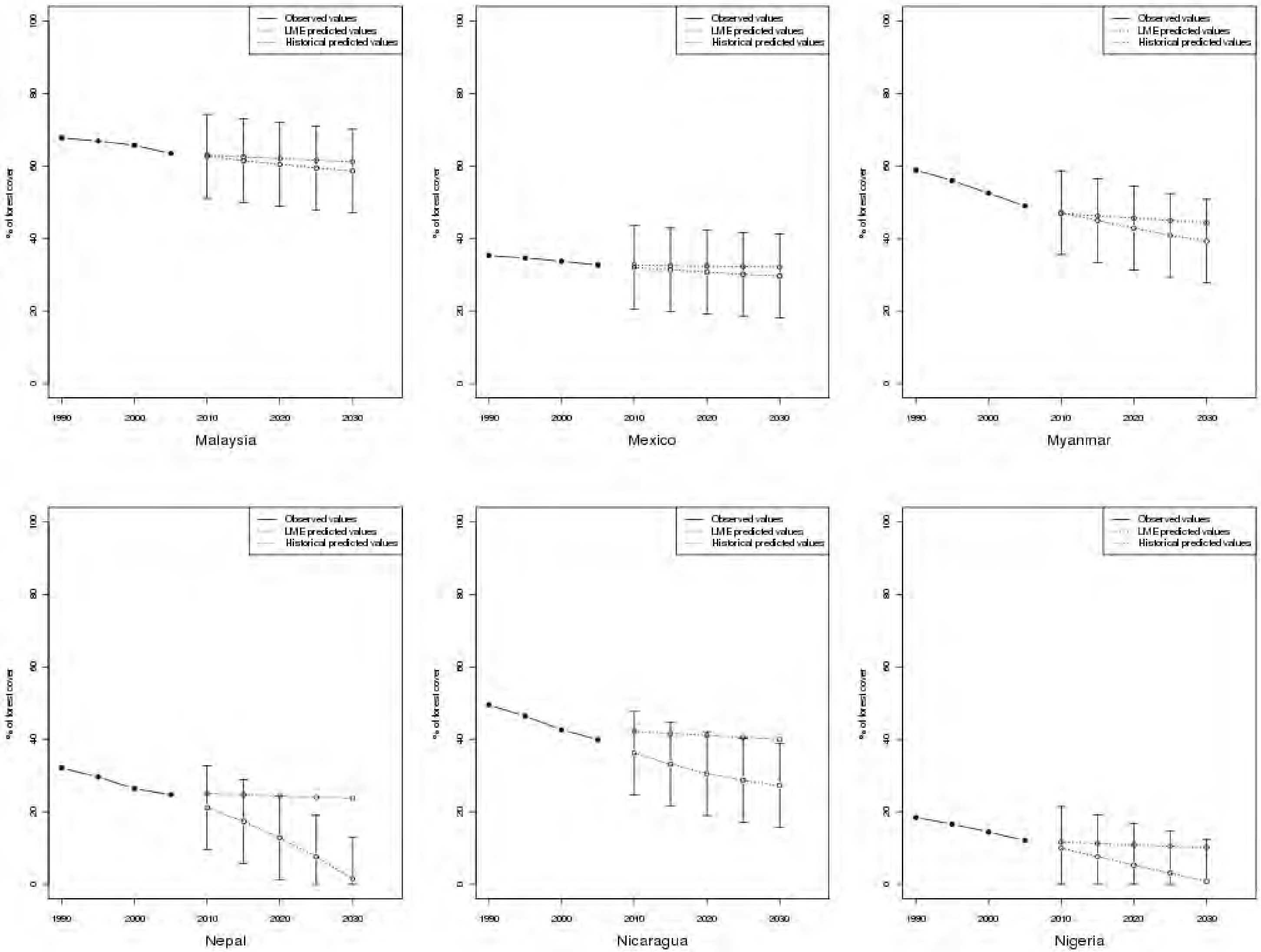
The following are graphs and tables of the predicted baselines for each country and the associated uncertainties of these predictions. See main report for details.

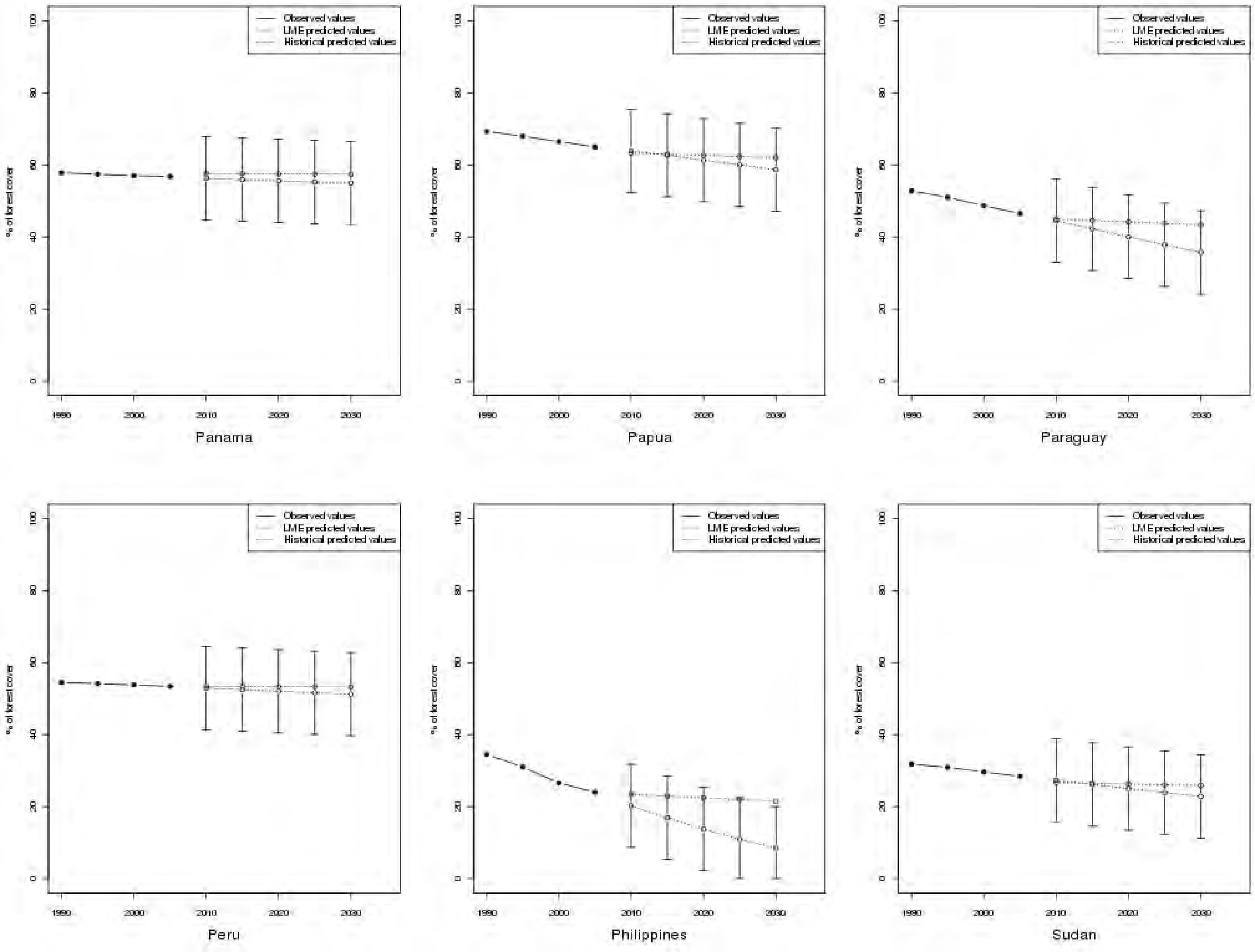

Observed values
LME predicted values
Historical predicted values
% of forest cover
Angola
Argentina
Bolivia
Brazil
Cambodia
Cameroon

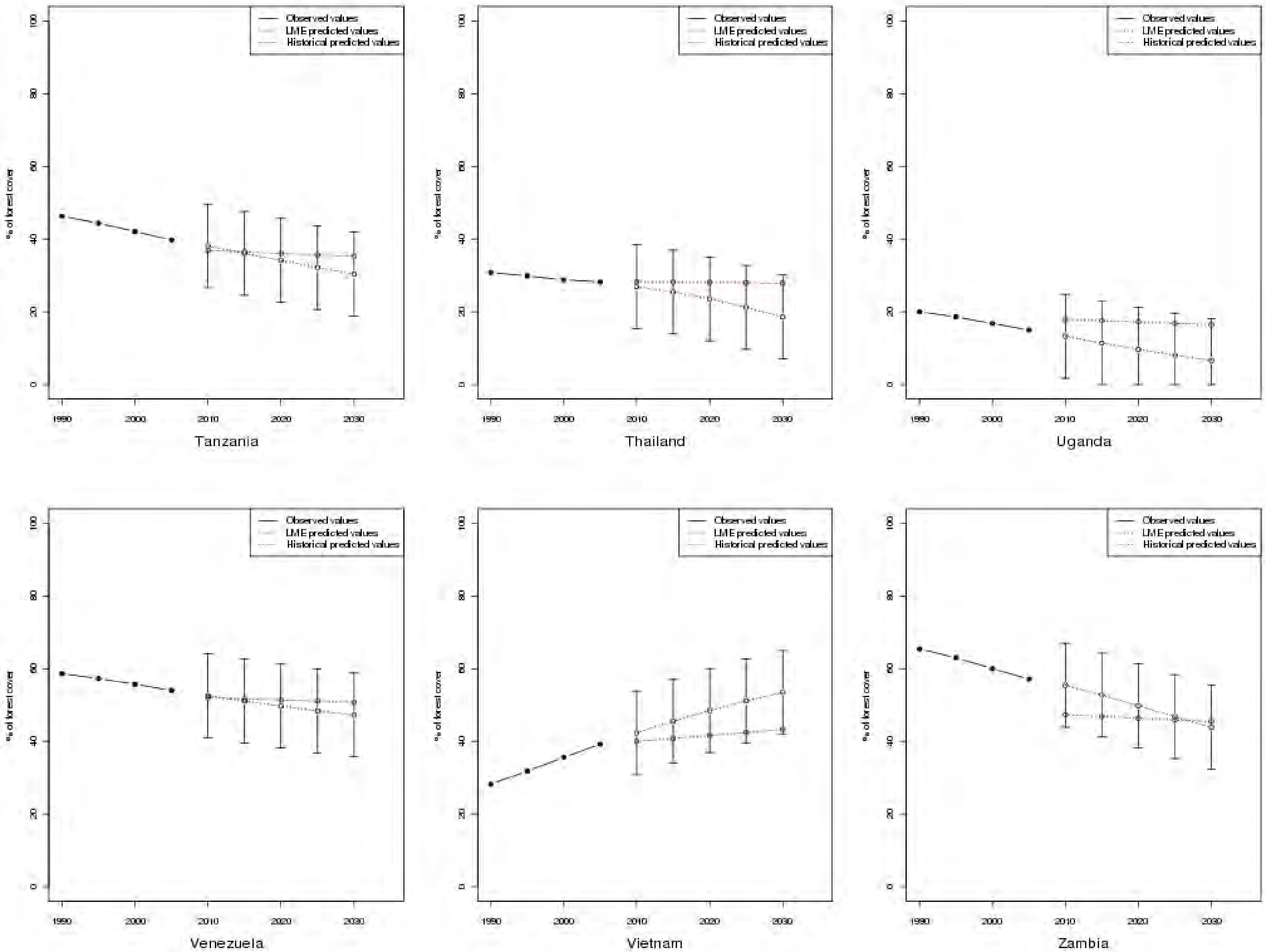


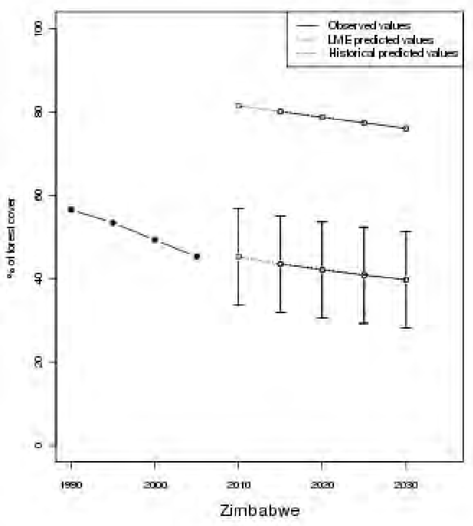
Observed values
LME predicted values
Historical predicted values
% of forest cover
Colombia
Congo
CostaRica
Cote d'Ivoire
Ecuador
Ethiopia


Observed values
LME predicted values
Historical predicted values
% of forest cover
Guatemala
Honduras
Indonesia
Korea
Liberia
Madagascar


Observed values
LME predicted values
Historical predicted values
% of forest cover
Malaysia
Mexico
Myanmar
Nepal
Nicaragua
Nigeria


Observed values
LME predicted values
Historical predicted values
% of forest cover
Panama
Papua
Paraguay
Peru
Philippines
Sudan


Observed values
LME predicted values
Historical predicted values
% of forest cover
Tanzania
Thailand
Uganda
Venezuela
Vietnam
Zambia



Observed values
LME predicted values
Historical predicted values
% of forest cover
0
20
40
60
80
100
1990
2000
2010
2020
2030
Zimbabwe

Country	Year	Historical	Mixed models: Lower 95% confidence limit	Mixed models: Predictions	Mixed models: Upper 95% confidence limit
Angola	2010	47.31	35.09	46.64	58.19
	2015	47.21	34.34	45.89	57.44
	2020	47.12	33.52	45.08	56.63
	2025	47.02	32.65	44.2	55.75
	2030	46.93	31.73	43.28	54.83
Argentina	2010	11.85	0.21	11.76	23.31
	2015	11.8	0	11.5	23.05
	2020	11.76	0	11.25	22.8
	2025	11.71	0	11.03	22.58
	2030	11.66	0	10.84	22.39
Bolivia	2010	53.23	42.11	53.66	65.21
	2015	52.97	41.23	52.78	64.33
	2020	52.7	40.4	51.95	63.5
	2025	52.44	39.61	51.16	62.71
	2030	52.18	38.9	50.45	62.01
Brazil	2010	55.76	43.25	54.81	66.36
	2015	55.43	41.91	53.46	65.01
	2020	55.1	40.7	52.25	63.8
	2025	54.77	39.62	51.17	62.72
	2030	54.44	38.68	50.23	61.78
Cambodia	2010	56.55	44.2	55.76	67.31
	2015	55.42	39.53	51.08	62.64
	2020	54.31	34.93	46.48	58.03
	2025	53.22	30.64	42.19	53.74
	2030	52.16	26.62	38.17	49.72
Cameroon	2010	44.25	32.09	43.64	55.19
	2015	43.81	30.05	41.6	53.15
	2020	43.37	28.06	39.61	51.16
	2025	42.94	26.16	37.71	49.27
	2030	42.51	24.35	35.9	47.45

Country	Year	Historical	Mixed models		
			Lower 95% confidence limit	Predictions	Upper 95% confidence limit
Colombia	2010	58.44	41.9	53.45	65
	2015	58.38	41.81	53.36	64.91
	2020	58.32	41.72	53.28	64.83
	2025	58.27	41.64	53.2	64.75
	2030	58.21	41.57	53.12	64.67
Democratic Republic of the Congo	2010	56.79	27.09	38.64	50.2
	2015	56.67	28.23	39.78	51.33
	2020	56.56	29.48	41.04	52.59
	2025	56.45	30.86	42.41	53.97
	2030	56.33	32.35	43.91	55.46
CostaRica	2010	46.85	14.98	26.53	38.08
	2015	46.89	9.88	21.43	32.98
	2020	46.94	4.26	15.81	27.36
	2025	46.99	0	9.75	21.3
	2030	47.03	0	3.34	14.89
Cote d'Ivoire	2010	32.73	55.11	66.67	78.22
	2015	32.77	55.02	66.58	78.13
	2020	32.8	54.92	66.47	78.02
	2025	32.83	54.8	66.35	77.91
	2030	32.86	54.67	66.22	77.77
Ecuador	2010	37.65	24.75	36.3	47.86
	2015	37.01	21.56	33.11	44.66
	2020	36.38	18.6	30.15	41.7
	2025	35.76	15.94	27.5	39.05
	2030	35.15	13.59	25.14	36.69
Ethiopia	2010	11.67	0.45	12	23.55
	2015	11.54	0	11.03	22.58
	2020	11.41	0	10.03	21.58
	2025	11.29	0	9.01	20.56
	2030	11.17	0	8	19.55

Country	Year	Historical	Mixed models		
			Lower 95% confidence limit	Predictions	Upper 95% confidence limit
Guatemala	2010	35.83	24.25	35.8	47.35
	2015	35.36	22.75	34.31	45.86
	2020	34.9	21.3	32.86	44.41
	2025	34.45	19.89	31.44	42.99
	2030	34	18.53	30.08	41.63
Honduras	2010	40.21	22.04	33.59	45.14
	2015	38.97	14.36	25.91	37.47
	2020	37.76	6.99	18.54	30.09
	2025	36.59	0.07	11.62	23.17
	2030	35.45	0	5.32	16.87
Indonesia	2010	45.57	32.56	44.11	55.66
	2015	44.66	28.45	40	51.56
	2020	43.77	25.09	36.65	48.2
	2025	42.89	22.17	33.72	45.27
	2030	42.03	19.53	31.08	42.63
Korea	2010	51.25	38.36	49.91	61.46
	2015	51.2	36.07	47.62	59.18
	2020	51.15	33.6	45.15	56.71
	2025	51.1	31.29	42.85	54.4
	2030	51.04	29.79	41.34	52.89
Liberia	2010	32.11	14.02	25.57	37.13
	2015	31.53	10.19	21.74	33.29
	2020	30.97	5.63	17.18	28.73
	2025	30.41	0.17	11.73	23.28
	2030	29.86	0	5.37	16.93
Madagascar	2010	22.03	9.52	21.07	32.62
	2015	21.97	8.9	20.45	32
	2020	21.9	8.26	19.81	31.36
	2025	21.84	7.59	19.15	30.7
	2030	21.77	6.92	18.48	30.03

Country	Year	Historical	Mixed models		
			Lower 95% confidence limit	Predictions	Upper 95% confidence limit
Malaysia	2010	62.96	51.11	62.67	74.22
	2015	62.52	49.98	61.53	73.08
	2020	62.08	48.9	60.45	72
	2025	61.64	47.92	59.47	71.02
	2030	61.21	47.08	58.63	70.18
Mexico	2010	32.67	20.48	32.03	43.59
	2015	32.54	19.79	31.34	42.89
	2020	32.41	19.14	30.69	42.24
	2025	32.28	18.58	30.13	41.68
	2030	32.15	18.13	29.68	41.23
Myanmar	2010	46.93	35.58	47.13	58.68
	2015	46.28	33.39	44.94	56.49
	2020	45.63	31.29	42.85	54.4
	2025	44.99	29.33	40.89	52.44
	2030	44.36	27.7	39.25	50.8
Nepal	2010	25.04	9.57	21.12	32.67
	2015	24.69	5.77	17.33	28.88
	2020	24.35	1.25	12.8	24.35
	2025	24.01	0	7.52	19.07
	2030	23.67	0	1.49	13.04
Nicaragua	2010	42.14	24.62	36.18	47.73
	2015	41.6	21.56	33.11	44.67
	2020	41.06	18.97	30.53	42.08
	2025	40.52	17.08	28.63	40.19
	2030	40	15.69	27.24	38.8
Nigeria	2010	11.6	0	9.91	21.46
	2015	11.22	0	7.59	19.14
	2020	10.85	0	5.27	16.83
	2025	10.49	0	3.02	14.57
	2030	10.15	0	0.81	12.36

Country	Year	Historical	Mixed models		
			Lower 95% confidence limit	Predictions	Upper 95% confidence limit
Panama	2010	57.64	44.74	56.3	67.85
	2015	57.58	44.38	55.93	67.48
	2020	57.53	44.03	55.58	67.14
	2025	57.47	43.7	55.25	66.81
	2030	57.41	43.4	54.95	66.5
Papua	2010	63.28	52.38	63.93	75.48
	2015	62.97	51.12	62.67	74.22
	2020	62.65	49.8	61.35	72.9
	2025	62.34	48.43	59.98	71.54
	2030	62.03	47.13	58.68	70.23
Paraguay	2010	44.99	32.95	44.5	56.06
	2015	44.59	30.71	42.26	53.81
	2020	44.19	28.48	40.03	51.58
	2025	43.79	26.3	37.85	49.4
	2030	43.39	24.18	35.73	47.29
Peru	2010	53.45	41.35	52.9	64.45
	2015	53.39	40.91	52.46	64.01
	2020	53.34	40.47	52.03	63.58
	2025	53.29	40.07	51.62	63.17
	2030	53.23	39.71	51.26	62.81
Philippines	2010	23.4	8.67	20.22	31.77
	2015	22.91	5.34	16.89	28.45
	2020	22.43	2.19	13.75	25.3
	2025	21.95	0	10.9	22.45
	2030	21.49	0	8.45	20
Sudan	2010	26.68	15.76	27.31	38.86
	2015	26.47	14.56	26.12	37.67
	2020	26.26	13.46	25.01	36.56
	2025	26.05	12.35	23.91	35.46
	2030	25.84	11.26	22.82	34.37

Country	Year	Historical	Mixed models		
			Lower 95% confidence limit	Predictions	Upper 95% confidence limit
Tanzania	2010	36.89	26.58	38.13	49.69
	2015	36.48	24.55	36.1	47.65
	2020	36.08	22.57	34.12	45.67
	2025	35.69	20.65	32.2	43.75
	2030	35.29	18.83	30.38	41.93
Thailand	2010	28.29	15.38	26.93	38.48
	2015	28.17	13.89	25.44	36.99
	2020	28.06	12.02	23.57	35.12
	2025	27.95	9.69	21.24	32.79
	2030	27.84	7.05	18.6	30.15
Uganda	2010	18	1.7	13.25	24.8
	2015	17.6	0	11.41	22.96
	2020	17.21	0	9.66	21.21
	2025	16.83	0	8.05	19.61
	2030	16.46	0	6.63	18.18
Venezuela	2010	51.99	41.01	52.56	64.11
	2015	51.67	39.53	51.08	62.63
	2020	51.36	38.13	49.68	61.23
	2025	51.06	36.84	48.39	59.94
	2030	50.75	35.67	47.23	58.78
Vietnam	2010	39.98	30.74	42.29	53.84
	2015	40.78	33.96	45.51	57.06
	2020	41.6	36.93	48.48	60.03
	2025	42.43	39.61	51.16	62.71
	2030	43.28	41.9	53.45	65
Zambia	2010	47.32	43.85	55.4	66.95
	2015	46.85	41.17	52.72	64.27
	2020	46.38	38.21	49.76	61.31
	2025	45.92	35.23	46.78	58.33
	2030	45.46	32.27	43.82	55.38
Zimbabwe	2010	81.49	33.66	45.22	56.77
	2015	80.11	31.96	43.52	55.07
	2020	78.74	30.53	42.08	53.63
	2025	77.4	29.33	40.88	52.43
	2030	76.09	28.19	39.74	51.29

Annex 3: Countries hosting REDD projects and involved in national REDD readiness activities (including RPIN preparation)

Country	**Forest Carbon Partnership Facility Country**	**RPIN Submitted**	**UN REDD Program Country**	**FLEG Country**	**FLEGT Process Country**	**FLEGT Process Details**
Argentina	*	*				
Belize						
Bolivia	*	*	*			
Brazil						
Cambodia						
Cameroon	*	*		*	*	Engaged in the FLEGT process since 2004
Central African Republic		*		*	*	In pre-negotiation stage
China		*				
Colombia						
Costa Rica	*	*				
Democratic Republic of Congo	*	*	*	*		Potential engagement in FLEGT
Ecuador						Expressed an interest in joining
El Salvador						
Equatorial Guinea		*				
Ethiopia	*	*				
Gabon	*	*		*		In pre-negotiation stage
Ghana	*	*		*	*	
Guatemala						
Guyana	*	*				
Honduras						
Indonesia			*	*	*	Negotiations are currently underway
Ivory Coast						Expressed an interest in joining
Kenya	*	*		*		
Lao PDR	*	*				

Country	**Forest Carbon Partnership Facility Country**	**RPIN Submitted**	**UN REDD Program Country**	**FLEG Country**	**FLEGT Process Country**	**FLEGT Process Details**
Liberia	*	*				In pre-negotiation stage
Madagascar	*	*				Expressed an interest in joining
Mexico	*	*				
Mozambique						
Nepal	*	*			*	
Nicaragua	*	*				
Panama	*	*	*			
Papua New Guinea	*	*	*			Expressed an interest in joining
Paraguay	*	*	*			
Peru	*	*				
Philippines						
Republic of Congo	*	*		*	*	Negotiations are currently underway
Tanzania			*			
Thailand						
Uganda	*	*				
Vanuatu	*	*				
Venezuela						
Vietnam	*	*	*	*		In pre-negotiation stage
Zambia			*			

Annex 4: REDD Project and National Readiness Activities

REDD Project Name	Country	National-level strategy	Start Date	End Date	Supporting Institution(s)
AL-REDDI project	Indonesia	*	2009	2012	World Agroforestry Centre (ICRAF)
Alto Mayo Forest	Peru				Alto Mayo Special Project (PEAM)
					Conservation International
					GTZ
					INRENA
Amazon Fund	Brazil	*	2008	2015	Amazon Fund, Brazil
					Amazonia Association
					Government of Brazil
					Government of Norway
Amerindian Act	Guyana	*			Government of Guyana
Andean Bear Framework	Venezuela		2003		Fundación Andígena
					Universidad Simón Bolívar, Venezuela
					Wildlife Research Group, University of Cambridge
Ankeneny-Mantadia-Zahamena Corridor Project	Madagascar		2006	2036	Conservation International
					Development Alternatives Inc. (DAI)
					Fondation Tany Meva
					Government of Madagascar
					Madagascar Biodiversity and Conservation (MBG)
					National Association for Environmental Action (ANAE)
					USAID
Ankeneny-Mantadia-Zahamena Corridor Project	Madagascar		2006	2036	World Bank BioCarbon Fund
April Salome	Papua New Guinea		1996		AccióNatura
					CeroCO2
					Fundación Ecología y Desarrollo
Araucaria Forest	Brazil				Society for Wildlife Research and Environmental Education (SPVS)
Ashaninka	Peru		2008		Ashaninka tribe of Cultivireni
					Cool Earth
					Ecotribal
					Tropicana
Awacachi Corridor	Ecuador		2008		Cool Earth
					Tropicana
Bale Mountain Ecoregion Emission Reduction Assets	Ethiopia		2007		Farm Africa
					SOS Sahel Ethiopia
Berau, East	Indonesia		2008		Berau Indigenous Groups

Kalimantan					
					Bornean Government Agencies
					The Nature Conservancy
Bobiri Forest Area	Ghana		2008		Environmental Protection Agency, Ghana - Climate Change Unit
					Faculty of Renewable Natural Resources, Kwame Nkrumah University of Science and Technology
					Forest Services Division, Ghana - Forestry Commission
Bolsa Floresta	Brazil		2007		Amazonas Sustainable Foundation (FAS)
					Bradesco Bank
					Government of the State of Amazonas (GSA)
					State Secretariat for the Environment & Sustainable Development of Amazonas
Borneo (New Forests)	Indonesia		2009		Generation Investment Management
					New Forests
Brazzaville Area	Democratic Republic of Congo				National Reforestation Service, Republic of Congo
Buenaventura	Ecuador		2005	2025	Fundación Jocotoco
Calha Norte	Brazil				Conservation International
					Gordon and Betty Moore Foundation
					Ministry of the Environment (MMA), Brazil
					Museu Paraense Emílio Goeldi (MPEG)
					Planet Action
Cameroon REDD Readiness	Cameroon	*	2007		Comission for the Forest of C. Africa
					European Space Agency (ESA)
					Fundacion Amigos de la Naturaleza (FAN)
					GAF AG Consulting, Germany
					GTZ
					Joanneum University
					KFW
					Ministry of Agriculture and Rural Development, Cameroon
					Ministry of Environment, Cameroon
					Ministry of Forests and Fauna (MINFOF), Cameroon
					Ministry of Mines, Cameroon
					Ministry of Planning, Cameroon
Carbon Seguro	Brazil	Nein			Iniciativa Verde
CBMAP II Panama	Panama	*			National authority of the Environment (ANAM)
					Panama Atlantic Mesoamerican Biological Corridor (CBMAP)
					World Bank - GEF
Coffee Forest	El Salvador		2007		Multisectoral Investment Bank

					(BMI)
					Scientific Certification Systems (SCS)
					SGS Environmental Services Inc.
					The Salvadoran Coffee Council
Community-based Forestry in Nepal	Nepal	*			UK Department for International Development (DFID)
					USAID
Congo Basin (under COMIFAC)	Cameroon, Central African Republic, Democratic Republic of Congo, Gabon, Republic of Congo	*	2000		Agence Francaise de Developpement
					Comission for the Forest of C. Africa
					Congo Basin Forest Fund
					Conservation International
					GTZ
					Wildlife Conservation Society
					Woods Hole Research Center
					World Wildlife Fund
Costa Rica's PES Program	Costa Rica	*	1990	2021	Government of Costa Rica
ECOLAND: Piedras Blancas National Park	Costa Rica		1995	2010	Conservación y Manejo de Bosques Tropicales (COMBOS)
					Ministry of Environment and Energy (MINAE), Costa Rica
					National Fish and Wildlife Foundation (NFWF)
					National Park Service, Costa Rica
					Regenwald der Osterreicher
					Tenaska Washington Partners II, L.P
					USIJI
Ecomarkets II Project	Costa Rica	*			Global Environment Facility
Embera Wounaan Region	Panama		2008	2033	Edinburgh Center for Carbon Management
					HSBC
					McGill
					National authority of the Environment (ANAM)
					Organization for Unity and Development of the Community Ipeti-Embera
					Smithsonian Tropical Research Institute (STRI)
					World Wildlife Fund
Exelon Amazon	Bolivia, Ecuador, Peru		2008		Exelon Corporation
					Field Museum
For. Resources Mngmt for C-Sequestration (FORMACS)	Indonesia				Canadian International Development Agency (CIDA)
					CARE International
					World Agroforestry Centre (ICRAF)
FORECA	Madagascar	*	2006	2009	ESSA-Forest
					GTZ

					Intercooperation
					Ministry of Environment, Forest and Tourism (MEFT), Madagascar
					Swiss Agency for Development and Cooperation (SDC)
					vTI Hamburg
Forest and Environmental Sector Programme (PSFE)	Cameroon	*	1999		GTZ
Forestry Law	Lao PDR	*	2007		Department of Forestry (MAFF), Laos
					Swedish International Development Cooperation Agency (SIDA)
Genesis Forest Project, Tocantins State	Brazil				Cantor CO2e Brazil
					Carbon Fund
					Ecologica Institute – IE (Instituto Ecológica)
					Hyundai
Gorongosa National Park	Mozambique				Carbon Neutral
					Envirotrade Ltd.
					N'hambita community
					Plan Vivo
					The Edinburgh Centre for Carbon Management
Guaraquecaba Climate Action Project	Brazil		1998	2038	American Electric Power
					Society for Wildlife Research and Environmental Education (SPVS)
					The Nature Conservancy
Guatemala PES scheme development	Guatemala	*	2007		Instituto Nacional de Bosques (INAB), Guatemala
					Intercooperation
Guyana's Memorandum of Understanding with Norway	Guyana	*	2009		Government of Guyana
					Government of Norway
Guyana's REDD Secretariat	Guyana	*	2009		Conservation International
					Government of Guyana
					Guyana Forestry Commission (GFC)
Holistic Conservation Programme for Forests	Madagascar		2008	2011	GoodPlanet
					Ministry of Environment, Forest and Tourism (MEFT), Madagascar
					World Wildlife Fund
Huila	Colombia		2008		Corporacion autonoma regional del alto magdalena (CAM)
					French Fund for Global Environment (FFEM)
					ONF International
					Planet Action
IDEAM vegetation cover	Colombia	*	1994	2001	Hydrology, Meteorology and Environmental Studies Institute

					(IDEAM)
Indigenous Amazon REDD Program	Bolivia		2008	2011	Fundacion Amigos de la Naturaleza (FAN)
					Gordon and Betty Moore Foundation
					Government of Norway
Indonesia - Australia FCP	Indonesia	*	2008		Government of Australia
Indonesia's REDD National Strategy	Indonesia	*	2007		Carbon Conservation Ltd.
					Fauna and Flora International
					National Council on Climate Change, Indonesia
Inhutani I in Mamuju	Indonesia		2008		KeepTheHabitat
					PT Inhutani I
Iwokrama Reserve	Guyana		2008		Canopy Capital
					Iwokrama International Centre for Rainforest Conservation and Development (IIC)
Juma Sustainable Development Reserve	Brazil		2006	2050	Amazonas Sustainable Foundation (FAS)
					Banco de Planeta
					Bradesco Bank
					Climate, Community & Biodiversity Alliance
					Government of the State of Amazonas (GSA)
					Institute for Conservation and Sustainable Development of Amazonas (IDESAM)
					Marriott International
					State Secretariat for the Environment & Sustainable Development of Amazonas
					TÜV SÜD Industrie Service GmbH
Kalimantan Forests and Climate Partnership	Indonesia	*	2008		Government of Australia
Kapuas Hulu	Indonesia		2009		Fauna and Flora International
					Government of Indonesia
					Kapuas Hulu Local Stakeholders
					Macquarie Capital
Ketapang (& Sungai Putri)	Indonesia		2009		Fauna and Flora International
					Government of Indonesia
					Ketapang Local Stakeholders
					Macquarie Capital
La Cojolita Selva Lacandona Carbon Initiative	Mexico				Conservation International
Land Cover and Indigenous Land Tenure	Costa Rica	*	2000		National Aeronautics and Space Administration (NASA)
					The National Center of high Technology (CENAT)
Law on the Valuation	Paraguay	*	2006		World Wildlife Fund

and Retribution of ES					
Liberia Protected Areas Network	Liberia	*			Clark Labs
					Conservation International
					Fauna and Flora International
					Forest Development Authority, Liberia
					McCall MacBain Foundation
					South Dakota State University
Madagascar Wildlife Corridors	Madagascar	*			Climate, Community & Biodiversity Alliance
Madre de Dios	Peru	*			World Wildlife Fund
Makira Forest Project	Madagascar				BP Amoco
					Conservation International
					Government of Madagascar
					Mitsubishi Group
					NavTech
					Pearl Jam
					SC Johnson
					Wildlife Conservation Society
Malinau Project	Indonesia				Global Eco Rescue (GER)
Malua Wildlife Habitat Conservation Bank	Indonesia		2008	2058	Eco Products Fund
					Equator Environmental, LLC
					New Forests
					Sabah Forestry Department
					Sabah Foundation
					Sabah State Government, Indonesia
					TZ1 Limited
Mamberamo Basin	Indonesia				Conservation International
Mato Grosso Certified Beef	Brazil		2008		Aliança da Terra
Mawas Peatlands Conservation Project	Indonesia				Borneo Orangutan Survival Foundation (BOS)
					Shell
Maya Biosphere Reserve	Guatemala		1990		Conservation International
					Government of Guatemala
					Wildlife Conservation Society
Mekong Valley	Cambodia, Lao PDR, Thailand, Vietnam	*			Ministry of Agriculture and Rural Development (MARD), Vietnam
Mexico's PES Program	Mexico	*	2004		Government of Mexico
Mount Cameroon	Cameroon		2010		GFA Envest
					KFW
					UK Department for International Development (DFID)
Muriqui Habitat Corridor Forest Carbon Initiative	Brazil				Conservation International
National Forestry Development Plan (NFDP)	Colombia				United Nations Forum on Forests (UNFF)
National Strategy for PES	Colombia	*			Conservation International

					The Nature Conservancy
					World Wildlife Fund
Natural Regeneration in Sierra Gorda	Mexico				World Land Trust
Noel Kempff Climate Action Project	Bolivia		1997	2027	American Electric Power
					BP Amoco
					Climate, Community & Biodiversity Alliance
					Fundacion Amigos de la Naturaleza (FAN)
					Government of Bolivia
					GTZ
					PacifiCorp
					Scientific Certification Systems (SCS)
					SGS Environmental Services Inc.
					The Nature Conservancy
					Winrock International
Panama REDD Readiness ANAM activities	Panama	*			National authority of the Environment (ANAM)
Papua (New Forests)	Indonesia		2008	2018	Emerald Forest
					Government of Papua
					New Forests
Papua New Guinea-Australia FCP	Papua New Guinea	*	2008		Government of Australia
Papua New Guinea's PES Scheme	Papua New Guinea	*			Government of Papua New Guinea
Pico Bonito Forest Restoration	Honduras			2017	Bosques Pico Bonito
					Brinkman Associates
					Corporación Hondureña de Desarrollo Forestal
					EcoLogic Development Fund
					Forest Stewardship Council
					Pico Bonito community
					Pico Bonito National Park Foundation (FUPNAPIB)
					World Bank BioCarbon Fund
Proambiente Program	Brazil	*	2000		Ministry of Agrarian Development (MDA), Brazil
					Ministry of the Environment (MMA), Brazil
Prog. Of Conformance with the Forest Legislation	Paraguay	*			World Wildlife Fund
Programme for Belize	Belize	*			European Union
					Programme for Belize
					World Land Trust
PT Inhutani II East Kalimantan	Indonesia		2008		Global Eco Rescue (GER)
					Malinau Regency
					PT Inhutani II
					Winrock International
REDD Pilot Projects;	Indonesia	*	2007		Government of Indonesia

sponsors unknown					
Rio Bravo Climate Action Project	Belize				Cinergy
					Detroit Edison
					Nexen
					PacifiCorp
					Programme for Belize
					Suncor
					The Nature Conservancy
					Utilitree Carbon Company
					Wisconsin Electric Power Company
San Martin	Peru				World Wildlife Fund
San Nicolas Agroforestry	Colombia			2017	Corporation for Sustainable Management of the Forests (MASBOSQUES)
San Nicolas Agroforestry	Colombia			2017	The Autonomous Regional Corporation for the Rionegra-Nare Region (CORNARE)
Scolel Te	Mexico		1996		AMBIO
					Carbon Neutral
					ECOSUR
					FIA Foundation
					Formula One
					Instituto National de Ecologia, Mexico
					Rainforest Alliance (SMARTWOOD)
					SGS Environmental Services Inc.
					UK DFIDs Forestry Research Programme
Scolel Te	Mexico		1996		World Bank
					World Rally
Sekala	Indonesia		2007		Fauna and Flora International
					Government of Papua
					Papua Civil Society Support Foundation (PCSSF)
					Sekala
					Telapak
SFM in Callería, Puerto Belen y Curiaca del Caco	Peru				Asociación para la Investigación y el Desarrollo Integral - AIDER
					Fondo Flamenco para Bosques Tropicales
Sierra Gordo Poverty Reduction	Mexico		1997		AccióNatura
					Bosque Sustentable, A.C.
					Fundación Ecología y Desarrollo
					Grupo Ecologico Sierra Gorda I.A.P.
					International Association for Society and Natural Resources
					LGT Venture Philanthropy
					Live Climate
					Rainforest Alliance

					(SMARTWOOD)
					Schwab Foundation
					Sierra Gorda Biosphere Reserve
					Triple Bottom Line Investing (TBLI)
					UN Foundation
					World Land Trust
Sierra Madre	Philippines				Conservation International
State of Amazonas	Brazil		2003		Government of the State of Amazonas (GSA)
Sumatra	Indonesia	*	2008		Government of Indonesia
					Government of Sumatra
					World Wildlife Fund
TAÏ National Park Pilot Project	Ivory Coast		2007		UNESCO
Takamanda Reserve Project	Cameroon		2002		Center for International Forestry Research (CIFOR)
					Wildlife Conservation Society
Tanzania REDD investment from Norway	Tanzania	*	2008		Government of Norway
Tapichalaca	Ecuador				World Land Trust
Ulu Masen Forest project	Indonesia				Carbon Conservation Ltd.
					Climate, Community & Biodiversity Alliance
					Fauna and Flora International
					Government of Aceh
					Merrill Lynch Commodities (Europe) Ltd.
Vanuatu Carbon Credits Project	Vanuatu	*	2006		Climate Focus
					ESA GOFC GOLD
					Government of Vanuatu
					GTripleC Global Climate Change Consultancy
					UK Strategic Programme Fund
					Victoria University
					Trust Fund for Forests (TFF)
Xingu River Basin	Brazil		2008	2009	Conservation International
					Electric Power Research Institute (EPRI)
					Environmental Defense Fund (EDF)
Yanacocha	Ecuador				World Land Trust
Zero Deforestation Law	Paraguay	*	2003		Government of Paraguay
					World Wildlife Fund

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