Potential for Carbon Finance in the Land Use Sector of the Hindu Kush-Himalayan Region

A Preliminary Scoping Study

ICIMOD

FOR MOUNTAINS AND PEOPLE

Preface

Carbon finance for the reduction of emissions from the land use sector is currently at the top of the global agenda and being promoted vigorously as a core mitigation strategy for global climate change. In particular 'reduced emissions from deforestation and degradation' (REDD), in which developing countries are compensated for improved protection of existing forests, has emerged as a central component of the global climate protection regime currently being negotiated to replace the Kyoto Protocol. Decisions taken in December 2007 in Bali, at the United Nations Framework Convention for Climate Change (UNFCCC) Conference of the Parties (COP 13) put into motion a process aimed towards achieving an agreement on REDD by COP 15 in Copenhagen in December 2009. The possibility of significant international transfers of funds under a post-Kyoto agreement to finance emission reductions from the land use sector has attracted the attention of policy makers and the public within developing countries, with significant interest recently from countries within the Hindu Kush-Himalayan (HKH) region.

Estimates of both the global potential and the regional value of carbon payments vary widely depending on the underlying assumptions. However, past experience has shown that benefits can be elusive for developing countries lacking the capacity to implement and participate in complex international agreements. Our current knowledge of forest cover, carbon budgets, and ecosystem change processes is especially lacking in highly heterogeneous and diverse mountainous regions such as the HKH. As in other developing countries and poor remote mountainous regions, high levels of uncertainty exist regarding land use changes, trends, deforestation rates, and carbon budgets. As a result, the potential opportunities for carbon finance are also uncertain. Although the HKH has significant deforestation and forest degradation issues which need to be addressed, it has been assumed that a strict interpretation of a REDD finance mechanism limited to protection of existing forests based on historical deforestation rates would provide relatively few benefits to the countries within the HKH region. Enhanced forest management (REDD+), historical conservation, and broader landscape approaches, in particular those including more of the land use sectors such as agriculture, agroforestry, and rangelands, have all recently been highlighted for discussion. This more comprehensive approach, referred to as 'agriculture, forestry, and other land uses' (AFOLU) or REDD++, promises a greater basket of benefits for non-tropical forests and mountainous countries where forest degradation can be a more significant ongoing process than outright deforestation. Furthermore, it is assumed that intervention in the agricultural sector could add significantly to the food security and sustainable development goals of carbon finance, providing important synergies with the adaptation needs and priorities of the various countries within the HKH region.

This report was commissioned by the International Centre for Integrated Mountain Development (ICIMOD) in order to provide an initial assessment of the various carbon finance schemes that will allow for a more informed discussion and provide policy guidance within the region. This preliminary assessment focuses on the potential for carbon finance within the various land use sectors. It is an exploratory study based on available statistics, primarily from FAO and other literature sources, using a modelling approach based on broad stratification to characterise the HKH region and a series of literature-referenced assumptions to reach the difficult goal of carbon sequestration estimates for the various land use sectors and carbon finance schemes across the region. As such, the results presented here can only be taken as relative indicators of the potential of carbon finance giving some indication of the areas, amounts, and level of funding involved – 'ballpark' figures and not operational guidelines. Nevertheless, the results allow a comparative analysis and provide a first approximation of the magnitude of carbon finance potential within the region. This assessment is intended to help provide an informed and better understanding of the implications of current and future UNFCCC negotiations and carbon finance schemes for the various countries in the region.

Among the most important findings is that adaptation and mitigation are complementary, not mutually exclusive, approaches. Adaptation and land-based mitigation are intimately linked in the region. Mitigation activities must be seen as an important complement to adaptation and as such need to be supported by regional policy and enabling frameworks. Whereas the biophysical mitigation potential in the region is substantial, it is highly fragmented into small patch sizes across the highly heterogeneous terrain. A holistic landscape approach is recommended as the appropriate mitigation strategy for the highly diverse landscapes of the region. Approaches (such as REDD+, REDD++ or AFOLU) which include a spectrum of land uses are therefore more appropriate for the region than pure REDD schemes or approaches focusing on a single form of land-use. In addition, 'good carbon governance' is deemed as important as high biophysical mitigation potentials. To ensure that proposed carbon finance within the HKH region contributes meaningfully to the goals of sustainable development, biodiversity conservation, and improved livelihoods for the poor, especially those directly affected such as forest users and local communities, requires that significant regional and national level capacity building take place, particularly the development of institutional and policy frameworks. A brief overview is provided of the important components of carbon governance that need to be considered.

Andreas Schild, PhD
Director General, ICIMOD

Potential for Carbon Finance in the Land Use Sector of the Hindu Kush-Himalayan Region

A Preliminary Scoping Study

Contents

Four take home messages

Adaptation and mitigation are complementary and should not be perceived as mutually exclusive approaches: In the HKH region, adaptation and land-based mitigation are intimately linked and are not mutually exclusive; mitigation activities can become an important complement to adaptation initiatives and, as such, should be supported by regional policy and enabling frameworks.

The biophysical mitigation potential in the region is substantial, but highly dispersed: The study identifies the biophysical potential for a series of land uses. Mitigation options exist throughout the HKH region but their nature varies from country to country. The mitigation potential for each of these land uses alone remains low if seen in isolation, in many cases too low to justify the high transaction costs for the formulation, implementation and monitoring of landuse-based carbon sequestration projects.

Holistic approach to mitigation at landscape level, not the promotion of individual land uses, is the appropriate mitigation approach for the highly diverse landscapes of the region: Approaches such as 'agricultural, forestry and other land uses' (AFOLU), which include a series of land uses are more appropriate for the region than a narrow focus on 'reduced emissions from deforestation and degradation' (REDD) schemes or approaches focusing on a single form of land-use.

'Good carbon governance' is as important as high biophysical mitigation potentials; this issue will take on increasing importance within the region and needs to be addressed early: Carbon finance schemes involve a multitude of stakeholders, interests and regulatory mechanisms. Next to the biophysical potential of land-use systems, it will have to be assessed how existing institutional frameworks support 'good carbon governance', i.e. facilitating mitigation projects that are workable, credible, and legitimate.

Key findings

1: The biophysical potential

The whole of the HKH region is made up of a remarkable mosaic of landscapes, shaped by natural and/or human processes. The different broad land-use classes used in the analysis are, in reality, expanded to multiple, highly complex land-use systems with often no clear distinction possible between them. A clear indication for these overlaps and interactions between land-use systems is the data inconsistency found in the literature concerning the area distribution of land uses such as forests and its distinction from, say, agricultural land. Nevertheless, the study revealed some clear messages that can be drawn from the results with regard to the biophysical potentials of carbon mitigation in the HKH region.

An agriculture, forestry and other land use (AFOLU) approach greatly expands the potential for carbon sequestration in the land-use sector with greater benefits for the countries of the HKH. Comparative analysis of the biophysical potential of the various mitigation activities in the region draws a clear picture showing that only a mitigation approach combining activities in different land-uses provides benefits for all countries in the region, and sufficient incentive for all countries to show interest. With regard to the political debate on whether to establish a broader landuse mitigation mechanism for the forthcoming post-Kyoto commitment period, the results for the region favour developing a regional approach integrating most land-uses into one mechanism, along the lines of proposed AFOLU (sometimes referred to as REDD++) approaches.

With respect to avoided deforestation and avoided forest degradation (REDD) Myanmar and Nepal have the highest potential. Despite being proportionally smaller than the big HKH countries China and India, Myanmar and Nepal have the highest potential on a per hectare basis with regard to avoided unplanned deforestation (AUD). The potential for avoided forest degradation (AFD) has certainly been both over- and under-estimated in some of the countries, but the results indicate a definite potential throughout the whole region. Due to its high percentage of pristine tropical rainforests, Myanmar can be seen as a 'classical' country for future REDD project activities.

Improved forest management (IFM) and afforestation, reforestation or revegetation (ARR) activities have high potentials in China and India as well as in Nepal. The large areas of waste and marginal land in India and China suggest potentially higher reforestation activities. The potential of IFM, which is dependent on existing forestry institutions, is concentrated in China, where vast areas of forest plantations (mainly pine) need to be silviculturally improved. To some extent, this also applies to India. In Nepal, there is a high potential for IFM within the forest areas under the community forest management regime. According to FAO (2009f), in Nepal about 75% of the forest in the mid hills and 15% in the Terai will be managed directly by local forest user groups by the year 2020. Bhutan, though the smallest country in the region, also has considerable potential for IFM due to the high proportion of forested areas.

Rangeland management activities, notably in the Qinghai-Tibet plateau in China, in north-western India and in Afghanistan, show high carbon mitigation potential. Studies from Tibet show that grasslands are overstocked and carbon finance could play a role in providing herders with an incentive to reduce stocking rates (Tennigkeit and Wilkes 2008), thus leading to a high biophysical potential. In the semi-arid rangelands of India and Afghanistan, the activities of vegetation cultivation for increased biomass could lead to additional potentials (not considered in this study).

Promotion of sustainable agricultural land management (ALM) practices is well suited for regional project approaches covering whole landscapes. Soil carbon sequestration potentials are dependent on cropping systems (maize-based, rice-based), management systems (tillage, manure application), soil types, and climate factors. Thus a systems-based, regional project approach should be favoured in maize-based farming systems (e.g. focusing on residue management in mixed farming/livestock systems in the Indian and Nepali mid-hills). But projects in the agricultural commodity sector, such as tea, rice, and sugarcane, are also of particular interest.

Synergetic approaches: mitigation activities, particularly within a landscape approach, are clearly synergetic with adaption strategies to climate change. The HKH region, notably prone to climate change impacts with far-reaching consequences for ecosystems and livelihoods, needs clear adaptation strategies in the whole land-use sector. Promoting mitigation activities, especially as a holistic approach, can also be considered an adaption strategy since the reversing of land degradation, enhancement of the natural resource base, and increased crop productivity and food security are among the important potential co-benefits, apart from generating carbon credits.

2: Good carbon governance

Increasing recognition for the importance of 'good carbon governance'

'Good carbon governance' is increasingly recognised as an important factor determining the overall potential of any carbon project. However, there is little firsthand (i.e. project-based) experience from the region to provide guidance on the minimum requirements needed to secure good carbon governance. A preliminary review of relevant project experiences worldwide hint at the following overarching elements that have to be considered when designing carbon/REDD projects.

Stakeholders' safeguards

Participation

- Clarify who is eligible to participate in carbon/REDD activities.
- Clarify any restrictions on foreign participation.
- Clarify if local landowners have to be participants or otherwise grant consent.
- Identify which government department or institution(s) will be responsible for the design, implementation, and measuring, reporting, and verification (MRV) of carbon projects.

Relationship among national/sub-national/project level activities

- Specify how sub-national and/or project level activities will relate to national baseline crediting, including what activities will be deemed to contribute to the achievement of national-level goals;
- how credits earned at a national level will be allocated to (and among) sub-national or project-level activities; and
- how project participants or participants in sub-national activities will be compensated if the failure to obtain credits is the result of under-performance at the national level.

Powers of the responsible institution

- Provide certainty about the responsible institution governing REDD: who will be responsible for decision making; will their decisions be reviewable; what types of powers will they have in respect of monitoring and enforcement.

Competing interests

- Clarify the hierarchy between different types of interests in land and resources.
- Spell out legislative restrictions on conducting carbon/REDD activities in specific areas.

Institutional safeguards

Regulatory mechanisms

- Identify the mechanisms through which carbon revenues will be shared (who will benefit and how).
- Ensure institutions are capable of enforcing rights in their jurisdiction.
- Recognise mechanisms that have been put in place to resolve competing interests in land and resources.

Nature of rights in forest/environmental benefits

- Determine ownership and de jure/de facto responsibility for natural resources
- Determine where the right to carbon and reaping environmental benefits sits (separate proprietary interest or linked to the proprietary interest in the forest or land).
- Clarify who has the original right or interest to the carbon rights or environmental benefits – the government or the landowner.

Funding and crediting mechanisms

- Determine who will receive payment for maintaining the (forest) resources.
- Determine who will be eligible to receive credits from either the international body overseeing REDD, or from another crediting body (e.g., in the voluntary market or from a national government).

Rights of forest-dependent communities and indigenous peoples

- National legislative frameworks should be consistent with a country's commitment to the UN Declaration on the Rights of Indigenous Peoples.
- Specify rights of forest-dependent communities and/or indigenous peoples to be consulted in advance of any project-level activity; to give (or withhold) their free prior and informed consent to such activity; and to receive a secured share in the economic benefits of any payments.
- Specify a procedure whereby participants in carbon mitigation/REDD activities can establish that they have satisfied any applicable requirements with respect to forest-dependent communities and/or indigenous peoples.

Taxes and state payments

- Provide clarity on whether payments are required to be made to the national government in the form of taxes or royalties.
- Consider if the national government will be eligible to receive a share of credits from REDD activities to be channelled into other climate change related activities.

Introduction

The International Centre for Integrated Mountain Development (ICIMOD) is a regional knowledge development and learning centre based in Kathmandu, Nepal that serves the eight regional member countries of the Hindu Kush-Himalayas (HKH) – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. Climate change is recognised as a major threat for the fragile mountain ecosystems and the livelihoods of mountain people in the HKH region. Therefore, climate change adaptation is a major cross-cutting topic and priority for both ICIMOD and the region. Equally, the improved management of natural resources for mitigation and carbon sequestration has also been recognised as a necessary part of the global efforts to avoid extreme climate change.

In L'Aquila in July 2009, the 16 major economies and emission producers agreed to limit global warming to 2°C or below (relative to pre-industrial levels) to reduce climate change risks, impacts, and damage. This defines that between now and the year 2050 not more than 750 billion tons of carbon dioxide may be emitted if extreme climate change is to be avoided. Assuming that a climate convention will be adopted in December 2009 aiming to limit global warming risks along the agreed maximum emission budget, all possible mitigation options will need to be explored, in order to balance the risks of climate change and the costs for mitigation that are currently considered to be $ 600 billion per year in the developing countries alone (WBGU 2009).

The land use, land use change, and forestry (LULUCF), or agriculture, forestry, and other land use (AFOLU), sector is a major contributor to global carbon emissions, contributing 31% of the total (Figure 1). Forestry, mainly deforestation, contributes 17% to global emissions while agriculture accounts for 14%. However, according to the International Panel of Climate Change (IPCC), both the agricultural and the forestry sector have significant economic mitigation potential (Figure 2).

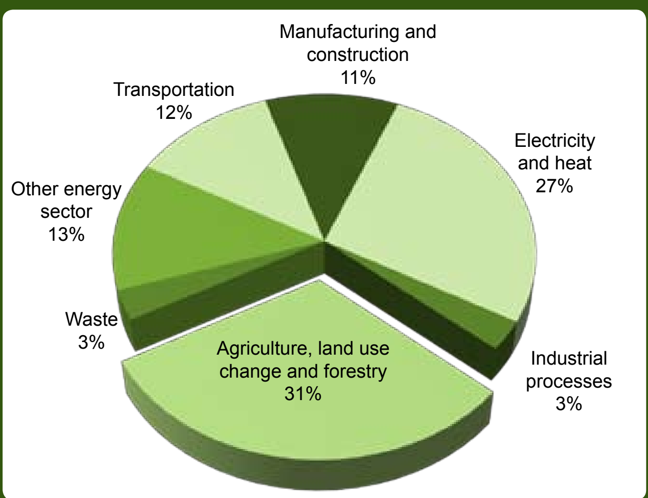
Figure 3 shows the relative emissions from AFOLU for four countries in the HKH region. The figure highlights that the relative amount of land use and agricultural production related emissions is higher in the less-developed countries in the region. Notably, in Nepal more than 75% of all emissions are from land-use change and forestry. Emissions from agriculture in China are mainly related to the inefficient use of high levels of fertiliser. China uses approximately 250 kg N/ha compared to 85 kg N/ha in the United States (FAO 2009c). On the other hand, using more fertiliser in Nepal, Pakistan, and some parts of India would contribute to additional biomass production and related soil carbon sequestration (considering embodied fertiliser emissions).

Purpose and scope of this study

The purpose of this scoping study is to assist ICIMOD member countries to identify biophysical and economic mitigation opportunities related to land use and related financing options. Based on this paper, ICIMOD will consult widely with member countries in order to develop a joint approach and, if found to be valuable and relevant, land-based mitigation initiatives that have strong climate change adaptation benefits. The purpose of the study is to provide

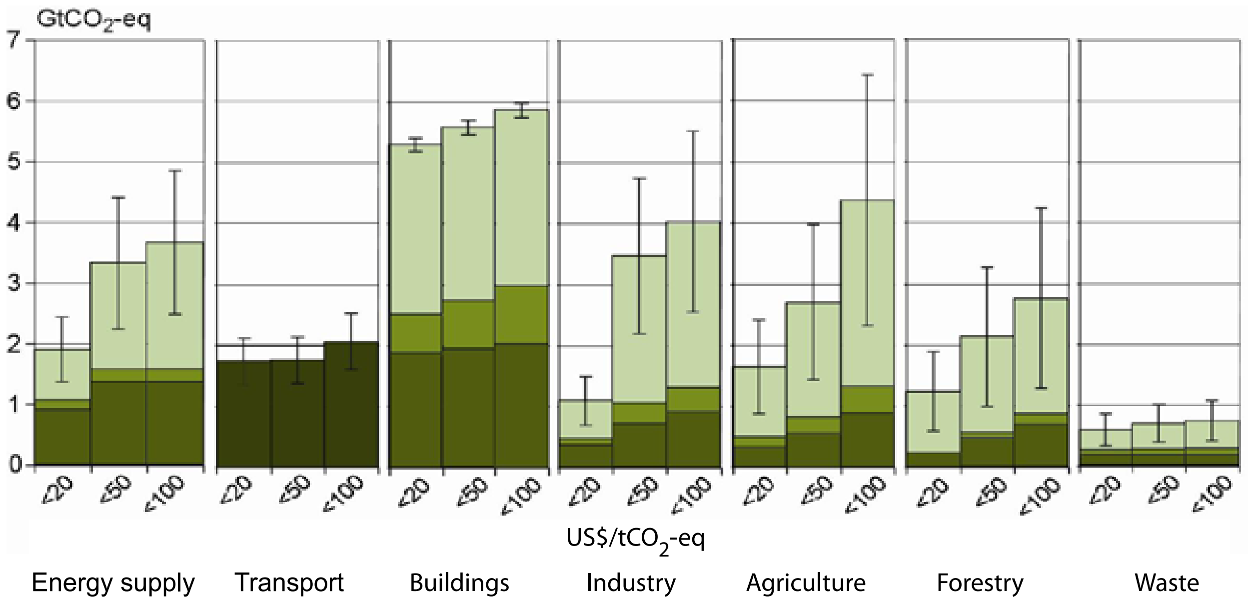
- a global analysis of the current state of REDD, CDM-AR, and AFOLU carbon finance, as relevant to the HKH;
- preliminary estimates of carbon sequestration potential, including REDD, in the land use sectors of the HKH;
- an identification of regional/national conditions, constraints, and potential within on-going and proposed mechanisms, including both compliance and voluntary carbon trading markets;
- a delineation of constraints, options, and a way forward for the countries of the HKH; and
- an overview of policy needs and recommendations for the HKH, including providing clarity on appropriate and useful positions regarding on-going UNFCCC negotiations.

Figure 1: **Sector wide global anthropogenic GHG emissions**



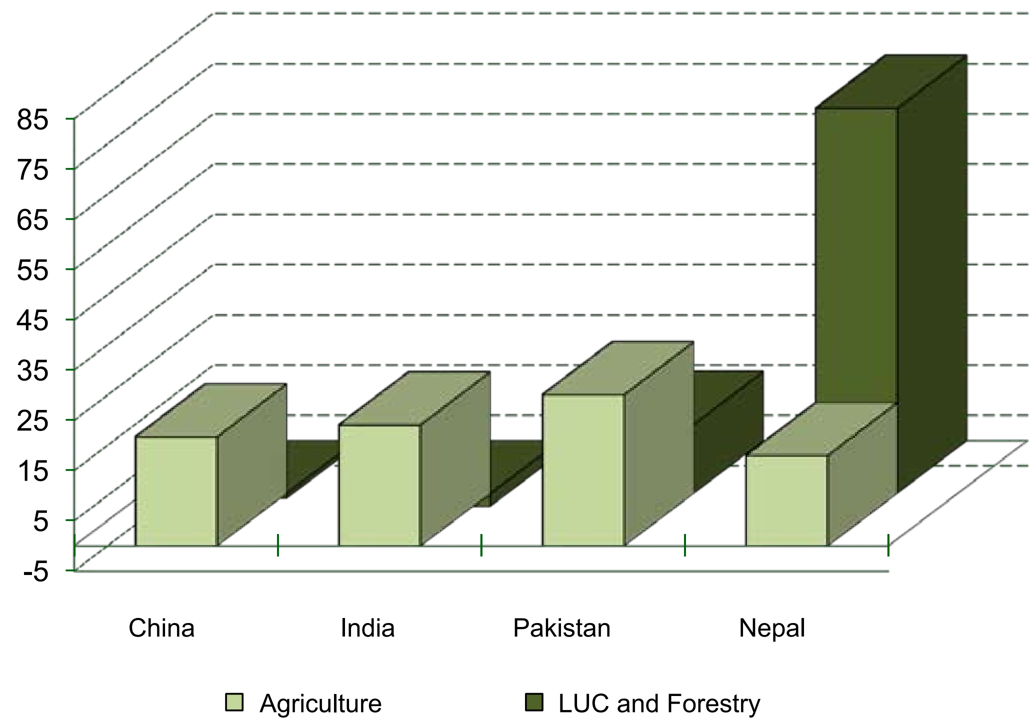
Data source: WRI 2009

Figure 2: **Global economic mitigation potential of economic sectors at three different carbon price levels**



Source: IPCC 2007

Figure 3: **GHG emissions in four countries of the HKH region**
(Note: The entire country is considered, not only the areas located in the HKH region)



Data source: WRI 2009

Land-based carbon finance activities

Types of project activities

Carbon finance projects are unique in the way that they offer the possibility to mitigate climate change while at the same time addressing other pressing social and economic challenges, providing a possibility to contribute to more sustainable development by enhancing natural resource management.

Despite their clear potential, LULUCF/AFOLU projects can be quite challenging to design, implement, and monitor (VCS 2008). Fortunately, widely recognised best practice guidance exists for the different project activities. In particular, this study follows the defined solutions and guiding documentation of the Voluntary Carbon Standard (VCS), with cross reference to the IPCC Good Practice Guidelines (Penman et al. 2003). Following the terminology and the guidelines of VCS, eligible project activities considered in this study are

- ARR: afforestation, reforestation and revegetation,
- ALM: agricultural land management including rangeland management,
- IFM: improved forest management, and
- REDD: reduced emissions from deforestation and forest degradation.

Each of the broad project categories is further defined in a later section and included in the feasibility assessment.

Key concepts of land-based carbon offset projects

There are four core and interlinked key concepts that must be taken into account when considering projects sequestering measurable carbon which will qualify as marketable credits:

- Additionality: The carbon offsets of a project must be additional. This means that only if the reductions in GHG emissions and/or increases in stores of carbon produced by the project would not have occurred without the project can the offsets of the project be claimed as real under a cap-and-trade system (Willey and Chameides 2007).

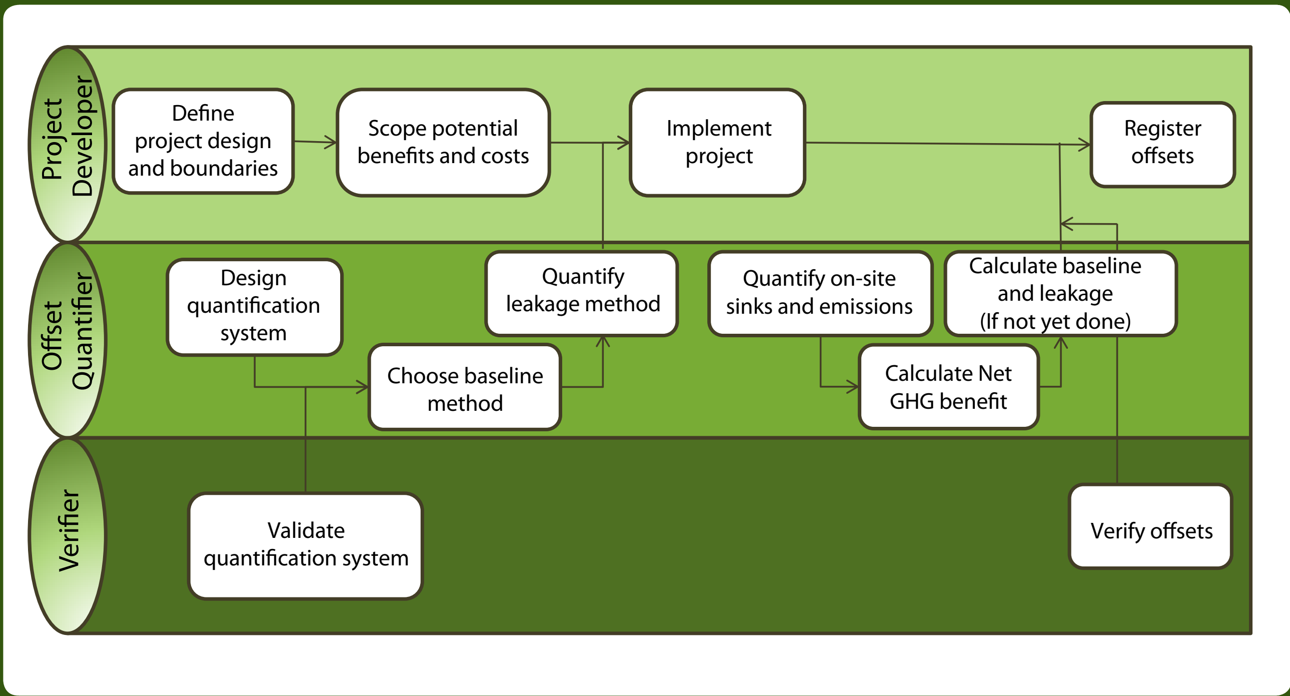
- Baseline Scenario: Equally important is the determination of the baseline. The GHG emissions from a project area that would have occurred in the absence of the project constitute the baseline. The baseline often changes over time due to changing management and environmental conditions, including climate change. The project's net GHG benefit is the difference between the baseline and the actual GHG emissions from lands and facilities during the project (referred to as the project scenario) (Willey and Chameides 2007). Baseline emissions in the project area are calculated based on historical land use trends (deforestation or degradation rates, agricultural management activities, and so on) in a reference region that is similar to the project area. The reference sites with similar conditions outside the project area also determine whether the project is additional or not. A common historical reference period mentioned under the VCS is 10 years before the starting date of the project.

- Leakage: All projects have to account for leakage, that is for the emissions displaced from inside the project's boundary to sources outside (Willey and Chameides 2007). A simple example is a project that reduces deforestation within the project boundaries, but leads to increased pressure to clear land outside the project boundaries. Adopting a holistic approach and good project design can often minimise or mitigate leakage.

- Permanence: The permanence risk is unique to land use projects, in that the credits issued for carbon sequestration are subject to a risk of re-emission, due to either human action or natural events such as wildfires (Pearson 2005). In contrast to the CDM mechanism, where credits arising from afforestation/reforestation projects are temporary, the VCS approach requires that projects maintain adequate buffer reserves of non-tradable carbon credits to cover unforeseen losses in carbon stocks (VCS 2008).

The chart in Figure 4 illustrates the complex series of steps that a carbon finance project in the land use sector must follow in order to produce certifiable carbon offsets

Figure 4: **The process of producing carbon offsets**



Source: based on Willey et al. 2007

Calculation of mitigation potentials – methodology and limitations

This section provides a brief overview on how to monitor carbon stock changes (emissions and removals) due to activities in the AFOLU sector. As per the IPCC guidelines, the annual carbon stock change is a function of gains and losses of carbon triggered by certain land-use activities. Generally, two data sets are required to estimate carbon changes.

1. The 'activity data' characterising the existing land-use, and the land-use change occurring with the carbon project, and delineating on how many hectares each of these activities are adopted.
2. The 'emission factor', or the mitigation potential in terms of carbon sequestration for each of these practices or any other activity (within one agro-ecological zone), which is estimated based on default reference carbon stocks and stock change factors. Most of the activities in the land-use sector and the carbon they sequester are climate, and to some extent soil dependent.

The IPCC terminology provides three methodological tiers for estimating GHG emissions and removals. The three tiers are a function of methodological complexity, regional specificity of the emission factors, and the extent and spatial resolution of the activity data. The three tiers progress from least to greatest level of certainty (IPCC 2006). Moving from lower to higher tiers will usually require increasing investments in terms of baseline establishment and monitoring costs as well as institutional and technical capacities. The three tiers comprise the following:

- Tier 1: Global default values for emission factors as provided by the IPCC
- Tier 2: Country specific default values elaborated based on carbon models and data with higher spatial resolution
- Tier 3: Process models applied to predict the carbon stock changes and detailed inventory measurements implemented to estimate the activity data

It is good practice to use methods that provide the highest levels of certainty, while using available resources as efficiently as possible (Penman et al. 2003). One approach often proposed for potential carbon finance projects in the AFOLU sector is a mixed Tier 2/Tier 3 certainty level, i.e., using regional default values leading to stratified emission factors tailored to specific project circumstances, and high resolution of activity data collected from the project area.

The following example of an agricultural carbon sequestration project illustrates this approach:

In the warm temperate moist agro-climatic zone of the western Himalayas (Himachal Pradesh, Uttaranchal) the baseline case is that arable land on a Nitosol soil type is under long-term wheat, maize, and rice cultivation on terraced uplands. The land is intensively tilled, the residues, especially maize, are fed to livestock and the external carbon input (manure is mainly used for heating) is low. There are signs of soil degradation and erosion.

Within a carbon sequestration project, the farmers in this particular region will be trained in adopting sustainable agricultural land management practices (ALM) like composting, mulching, improved terracing, and contour line tree planting. The project scenario would be identical with the baseline except that farmers now use these ALM practices.

For both, baseline and project scenario, the following information is needed to estimate the carbon stock change (Δcarbon) for this particular land-use change system (Figure 5):

- **Activity data in hectares** – how many hectares of this land-use change system can be found within the specified agro-ecological zone and Nitosol soil type?
- **The emission factor** – consists of a mixture of directly measured data and calculated data based on local default values. The soil organic carbon (SOC) will be estimated using three different factors reflecting the site, land-use, and management conditions.
    1. **SOC Reference$_{\text{SOIL TYPE}}$** is a factor related to reference soil organic carbon stock of the specific soil type at the beginning of the project. In the example above, a factor is required for Nitosol within the specific agro-ecological zone.
    2. **Factor$_{\text{LAND-USE}}$** is a factor related to the particular land-use system affecting the soil organic carbon, i.e. arable land under long-term maize cultivation.
    3. **Factor$_{\text{MANAGEMENT}}$** is a factor related to management practices (tillage, composting mulching, and so on)

These three factors (default values) are not measured directly, but are estimated using simple carbon-modelling systems based on baseline data from the inventory and published local data or other literature, mainly IPCC reports. With reference to the tier certainty levels it is important to note, that local defaults should be preferred in comparison to the global default values of the IPCC.

Following the methodology, the emission factor represents the net mitigation potential. Therefore, the default baseline soil organic carbon (SOC) stock must be deducted from the default project SOC stock.

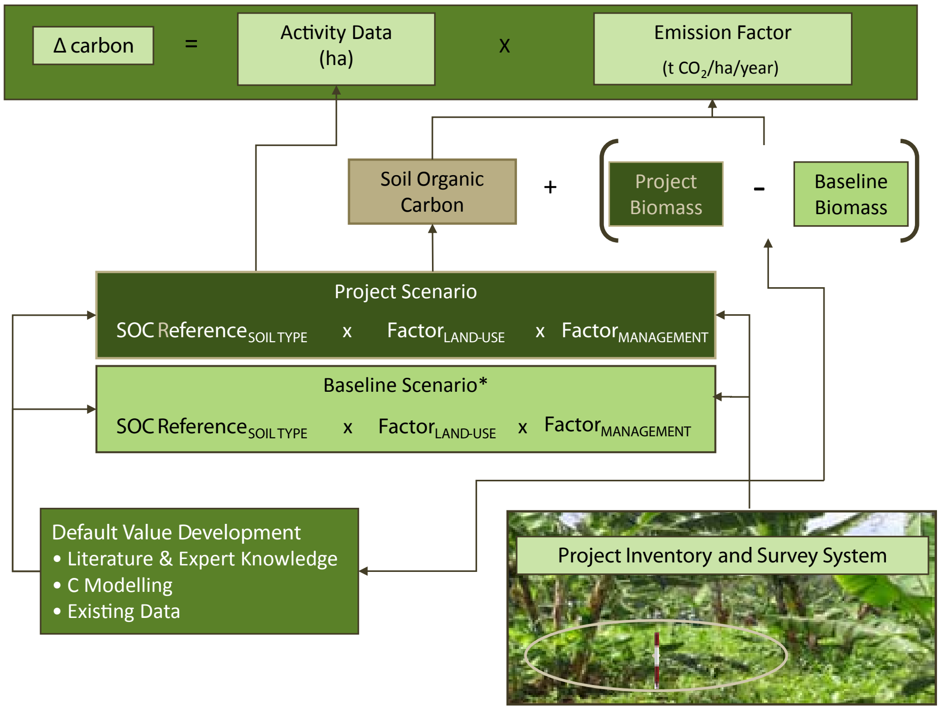
If a decreasing baseline scenario (on-going soil degradation) is anticipated, a fourth default factor could be added to the baseline scenario which accounts for the gradual decrease of the SOC Reference SOIL TYPE value over time.

In addition to the soil carbon stock and stock changes, living biomass will have to be included especially when agroforestry practices are part of the project's ALM package. Various tools and allometric equations are available to convert directly measured tree volumes into biomass, and further into above- and below-ground biomass and carbon contents respectively.

Finally, leakage must be accounted for and deducted from the project SOC stock. Equally, any project emissions occurring during the lifetime of the project must be considered.

In agriculture the main mitigation potential is based on soil carbon sequestration. The quantification of these emission reductions does not necessarily depend on expensive soil carbon measurements. Currently, two projects in Kenya funded by the World Bank BioCarbon Fund are using an activity based carbon baseline and monitoring approach. The amount of carbon sequestered is calculated using default values for carbon stock changes depending on agro-ecological zones and soil types. The carbon stock changes in the soil due to a change of management practices in the project area are calculated using a model approach. The soil model used for this purpose is the carbon model

Figure 5: **Flowchart of carbon stock change estimation (Δ carbon)**



RothC. It calculates the soil carbon stock changes due to changes of inputs of crop residues and manure in the soil. The increase or decrease of SOC in the soil is the result of the decomposition of the added organic materials. The inputs required by the model are clay content in the soil; climate parameters: monthly mean, minimum, maximum temperature, monthly precipitation, and monthly radiation; additional residue inputs due to crop management changes; and additional manure inputs due to manure management changes.

The methodology developed for this has been submitted to the voluntary carbon standard (VCS) for approval (see http://www.v-c-s.org/methodology_salm.html), and following approval, should be applicable to ALM activities in the HKH region.

Biophysical mitigation potential

Introduction

For any meaningful analysis of carbon sequestration at a regional level, it is essential to have an in depth knowledge of sequestration dynamics in the HKH region as affected by land uses and land-use changes, as well as forest and soil degradation processes. This understanding of complex biophysical processes in terms of carbon released or sequestered gains further complexity through the consideration of diverse socioeconomic conditions and characteristics that change dynamically over time. The biophysical potential of carbon mitigation activities for different land-uses is assessed in the following.

Land use types in the HKH region

The HKH region extends from Afghanistan to south-western China (over 4000 km) with mountain chains stretching across portions of Pakistan, India, Nepal, Bhutan, Bangladesh and Myanmar. The whole region covers an area of approx. 3.4 million km² and acts as a major source of livelihood and ecosystem services for the approximately 210 million inhabitants (Figure 6), and provides water and other essential ecosystem services to the 1.3 billion people living downstream in the ten major river basins which originate in the region (ICIMOD 2009).

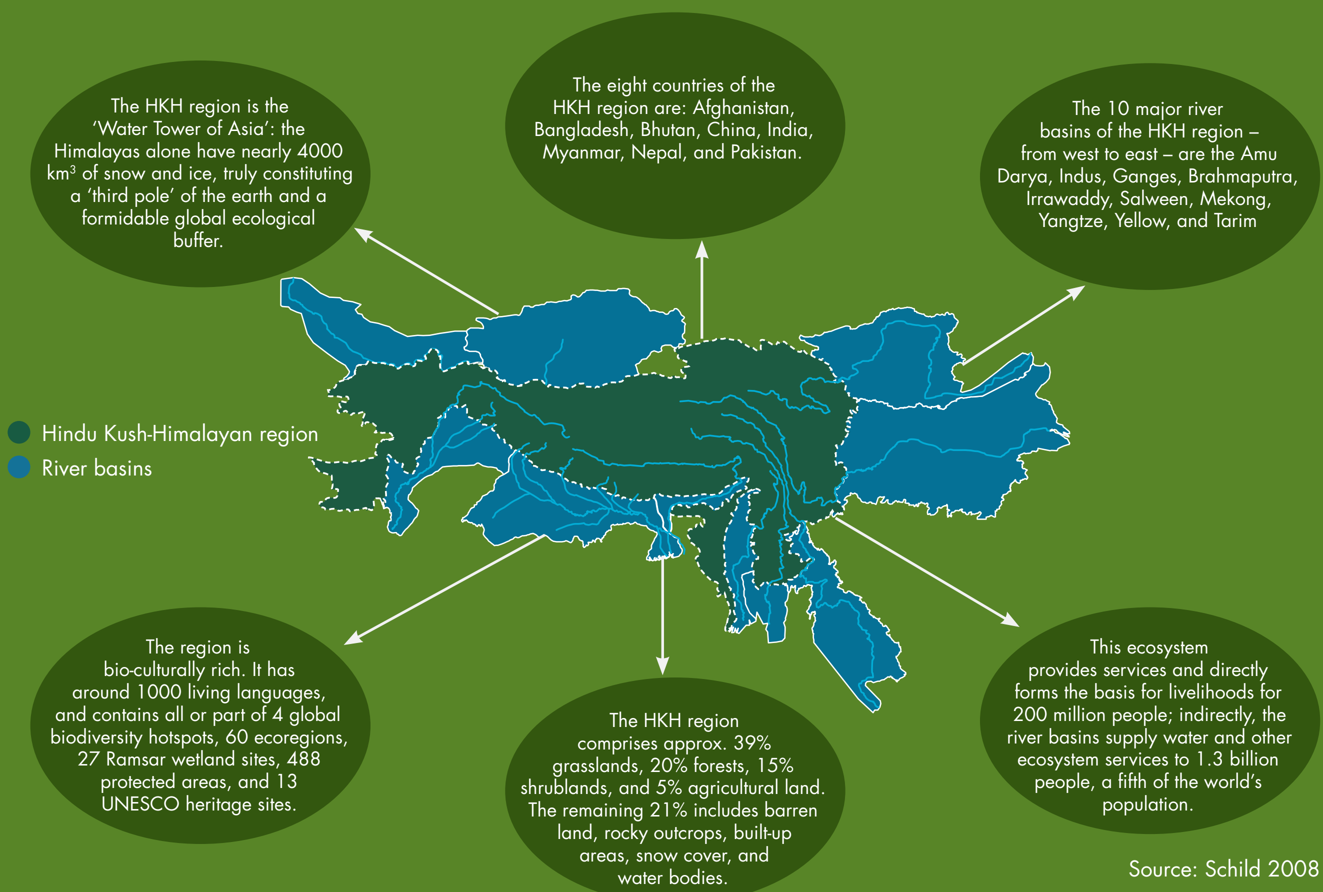
Based on a dataset from 2000 (Upadhyay 2005), the geographical proportion of each of the most relevant land use types within the eight HKH countries was calculated and projected to 2007 (Tables 1 and 2) using land use data and land use changes from FAOSTAT (FAO 2009c). According to this, 48% of the HKH region is located in China followed by India (14%), Pakistan (12%) and Afghanistan (11%). Of the three land use types relevant for this study in the HKH region, agricultural land is relatively evenly distributed in Afghanistan, the Indian Himalayas, Pakistan, Myanmar, Nepal and China with 21%, 20%, 17%, 14%, 14%, and 11% respectively. China has 49% of the forest land in the HKH, followed by India (23%) and Myanmar (16%). Nearly 70% of the pasture land in the region is located in China; while Afghanistan and India have a considerable share with 14% and 12% respectively.

Table 2 shows the absolute areas in hectares by land use types in each of the HKH countries (together with the estimated population, population density, and forest area per capita). According to this, pasture land covers an area of nearly 1.3 million sq.km or 37% of the total HKH region, while forests cover 0.8 million sq.km (25%) and agricultural land is represented with 0.2 million sq.km (6%). The remaining area is shared by shrubland (15%), high mountainous (alpine) areas, glaciation (approx. 0.1 million sq.km), and alpine meadow ecosystems or barren land with sparse vegetation. Wasteland, wetlands, and urban areas are included in the remaining area category.

Agro-ecological zoning (AEZ)

As mentioned above, most of the land-use activities, be it in the baseline or in a carbon project scenario, and their effect on carbon stock changes within the significant carbon pools (SOC, above ground biomass, and so on), are particularly sensitive to specific climate and site conditions. For example, the SOC concentration increases with

Figure 6: **The Hindu Kush-Himalayan region**



Source: Schild 2008

Table 1: **Estimated geographical distribution of different land use types in the HKH region in 2007. Agricultural land includes arable land and permanent crop. Pasture land is defined as permanent pasture land.**

Country	Agricultural land (% of HKH)	Forest (% of HKH)	Pasture (% of HKH)	Proportion of country (%)	Proportion of total HKH (%)
Afghanistan	21.4	0.6	14.1	60	11.3
Bangladesh	0.5	1.0	0.0	9	0.4
Bhutan	1.4	2.7	0.0	100	1.1
China	11.2	48.5	68.9	17	47.9
India	20.2	23.3	12.4	14	14.0
Myanmar	14.1	16.1	0.1	47	9.2
Nepal	13.8	5.2	1.4	100	4.3
Pakistan	17.3	2.6	3.2	51	11.7
Total	**100.0**	**100.0**	**100.0**		**100.0**

Source: FAO 2009c

Table 2: **Estimated areas of different land use types in the HKH region in 2007 ('000 ha)**

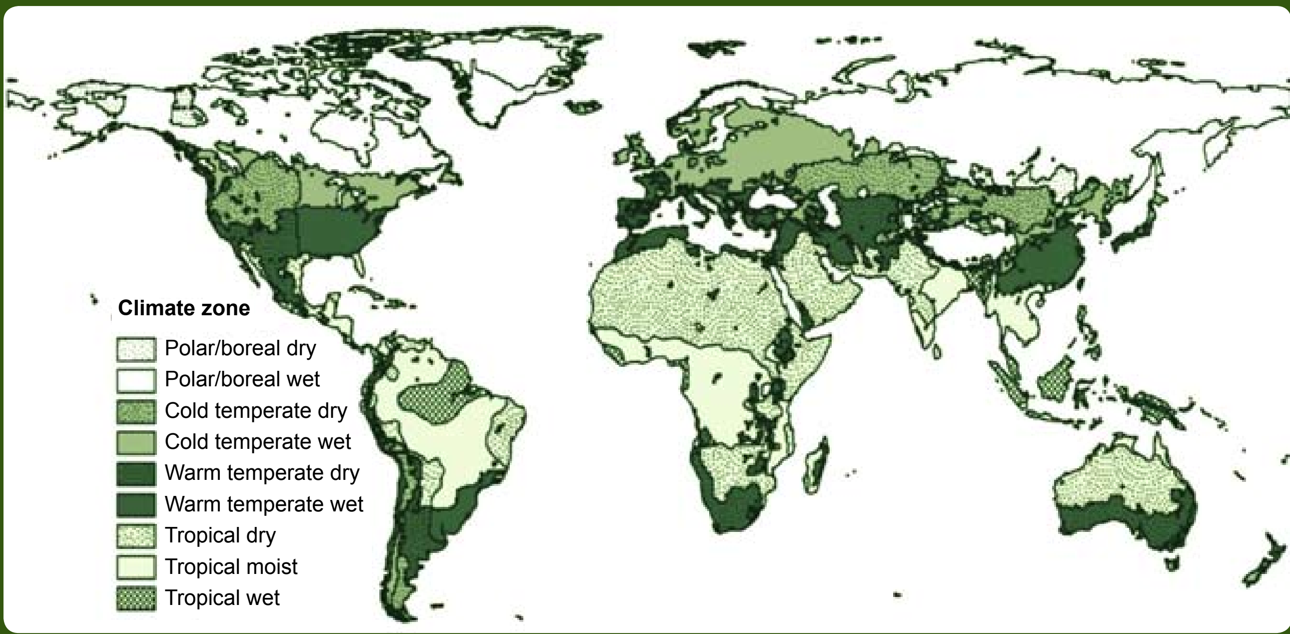
Country	Total area ('000 ha)	Agricultural land ('000 ha)	Forest ('000 ha)	Pasture ('000 ha)	Est. population (million)	Pop. density (per km^2)	Forest area per capita (ha)
Afghanistan	39,048	4,227	541	17,962	28.5	73	0.02
Bangladesh	1,319	106	850	29	1.3	100	0.64
Bhutan	3,839	285	2,334	63	0.7	15	3.29
China	164,773	2,222	41,975	87,989	29.5	17	1.42
India	48,292	3,997	20,181	15,792	72.4	150	0.28
Myanmar	31,764	2,792	13,937	79	11.0	34	1.27
Nepal	14,718	2,727	4,528	1,730	27.8	189	0.16
Pakistan	40,419	3,427	2,211	4,082	39.4	97	0.06
Total HKH	**344,172**	**19,781**	**86,558**	**127,725**	**210.5**	**84**	**0.89**

clay content and rainfall, and decreases with increase in mean annual temperature (Lal 2004). Therefore, when developing or choosing default values of emission factors, the specificity of the site type (soil type) and the climate must be taken into account. The IPCC has set a general delineation of the major climatic zones on a global level for which global default values are available (IPCC 2006). Figure 7 provides this global delineation and Figure 8 shows a soil map of the HKH region from the Harmonized World Soil Database (FAO/IIASA/ISRIC/ISSCAS/JRC 2009).

This agro-ecological zoning is part of a necessary stratification process for the potential project areas, taking place preliminary to the data collection within the project. The zoning will increase the accuracy and precision of the baseline and allows for the development of strata based carbon sequestration default values. The table provided in Annex 2 shows a preliminary stratification of the HKH region according to existing country specific agro-ecological zoning. Information regarding temperature, precipitation, site and soil type, and major crops or land uses can be identified easily. Further, similar conditions can be grouped together, thus refining the stratification.

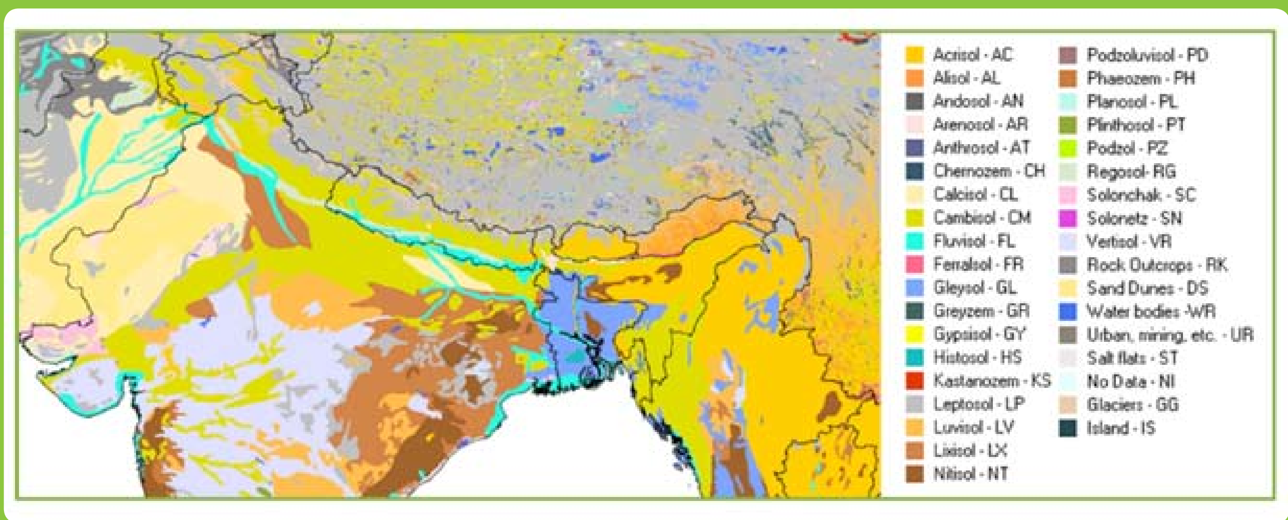
Note that the table in Annex 2 was compiled using different sources and is therefore not fully consistent. For the present study of potential carbon finance activities in the HKH region, the specific agro-ecological zones (AEZ) were translated into the IPCC global climatic zones. Potential mitigation activities identified in this study within the different land uses were stratified according to these zones. The three land use types mentioned above, and as defined in this study, are described briefly below.

Figure 7: **Delineation of major climatic zones**
The zones are defined by mean annual temperature (MAT) as polar/boreal (MAT<0°C), cold temperate (MAT 0-10°C), warm temperate (MAT 10-20°C) and tropical (MAT>20°C). Moisture regimes for boreal and temperate zones are defined by the ratio of mean annual precipitation (MAP) and potential evapo-transpiration (PET) as dry (MAP/PET < 1) and wet (MAP/PET > 1); and for tropical zones by precipitation alone as dry (MAP < 1000 mm), moist (MAP 1000-2000 mm), and wet (MAP > 2000 mm).



Source: IPCC 2006

Figure 8: **Soil types in the HKH region**



Source: FAO/IIASA/ISRIC/ISSCAS/JRC 2009

Importance of individual land use types

Agriculture

The vast majority of people in the HKH are farmers practising subsistence farming on highly fragmented, small farms (more than 75% of land holdings are smaller than 1 ha). For example, in Nepal nearly 80% of the total labour force generates 37% of the GDP (Encyclopaedia Britannica 2009). However, with regard to the rising economies in the HKH, the major portion of the region is in transition from subsistence to open economies with integration to regional and even global markets. These processes are responsible for different types of land uses and their rapid change over time (Upadhyay 2005). Traditionally, Himalayan farmers have tilled the hillsides and valley bottoms over centuries to grow grain such as rice, wheat, millet, barley, and buckwheat. Maize is grown throughout the region, often in mixed cropping systems. The farmers have shaped the slopes into cascades of terraces that support crops and distribute irrigation water. Because of the steepness of the land and the erosive force of the monsoon rain, loss of topsoil is an ever-present problem (ICIMOD 2005).

The agricultural cropping systems found across the region are highly diverse, due to the extreme range and high level of geographic diversity. In the western parts of the region, farming is mainly only possible under irrigation. In the dry regions in Pakistan, Afghanistan, and some parts of northwest India (Ladakh), centuries-old irrigation systems still support agricultural production, alongside more modern schemes. The main irrigated crops are wheat, rice, sugarcane, and cotton. In the western Indian Himalayas and in Nepal, farming is dominated by rainfed agriculture (70% of the area in Nepal is rainfed), and the most common cropping systems are maize-based in the hills and rice-based in the valleys and plains. Rice is grown on the hills if terraces and irrigation facilities are available. In terms of agro-climates, rice farming is dominant in subtropical climates, followed by wheat, sugarcane, and others. In warm-temperate climates, the maize-based cropping system is more abundant with wheat, potatoes, and vegetables. The terraced uplands are cultivated for rice and/or horticultural plantation crops.

The eastern Himalayan region is more sub-tropical/tropical, receives more precipitation, and has an extensive traditional shifting cultivation system (jhum) with mixed cropping on steep slopes under rainfed conditions and 3-4 year rotation intervals. (This has been reduced from the former 7-15 years or more rotation as a result of changing frame conditions [Kerkhoff and Sharma 2006].) About 450,000 families in India's northeast cultivate approximately 10,000 sq.km of forest area annually. The total area affected by jhum is believed to be 44,000 sq.km (Lele et al. 2008). Millets are grown on upland terraces and potato, maize, millets, and rice in the valleys. In the hilly areas plantation crops, especially tea, are cultivated on terraces.

Shifting cultivation is also found further to the east, in the north-eastern hills of India (Puryachal mountains), the Chittagong Hill Tracts in Bangladesh, and the Chin state in Myanmar, with rice becoming the most dominant crop, along with maize and wheat. Tea plantations are established in the hill areas.

In the sub-tropical zones in Bhutan, maize and rice are cultivated as major crops (maize accounts for 49% of total domestic cereal cultivation, and rice for 43%). In the higher elevations, agricultural production is more dependent on livestock.

The Qinghai-Tibet Plateau, the world's largest high plateau, is dominated by grassland (see rangeland section). Agriculture plays only a minor role, with 'qingke' barley and wheat the predominant crops grown. Some significant agricultural areas are located in the south-eastern subtropical parts of the Plateau (Northern Yunnan, Sichuan) with agro-silvopastoral systems (economic tree plantations) and irrigated rice terraces.

In the Indian and Nepali Himalayas, the major agricultural region in the HKH, the pressure on land is increasing due to increase in population and limited arable land for cultivation, while outmigration is responsible for labour shortages and abandonment of existing farmland in some locales. The cultivation of marginal lands together with agricultural intensification on existing land have not only resulted in decline in productivity (Ladha et al. 2003), but also contributed to various other issues impacting on farming, e.g., continuously changing land uses, limited choices of crop rotations, high cropping intensities, fragmentation of landholdings, scarcity of arable land, little crop diversity, insufficient agricultural produce, decline in fallow periods from 6 to 3 months, increase in soil acidification, reduced external organic inputs, and expansion of cultivation on steep slopes (Shrestha et al. 2006).

Previous studies have described the prevalent cropping patterns and low production, with accompanying adverse ecological effects, in the central, western, and north-eastern parts of the Himalayas (Kuniyal 2003). Figure 9, based on FAOSTAT (2009c) data, shows the average yield of cereals between 1997 and 2007 by country. Since most of the high yielding cropping regions are located outside of the HKH region (e.g., in China or Bangladesh), the yields of Nepal perhaps best reflect the low crop productivity in the HKH, which is well below the world average.

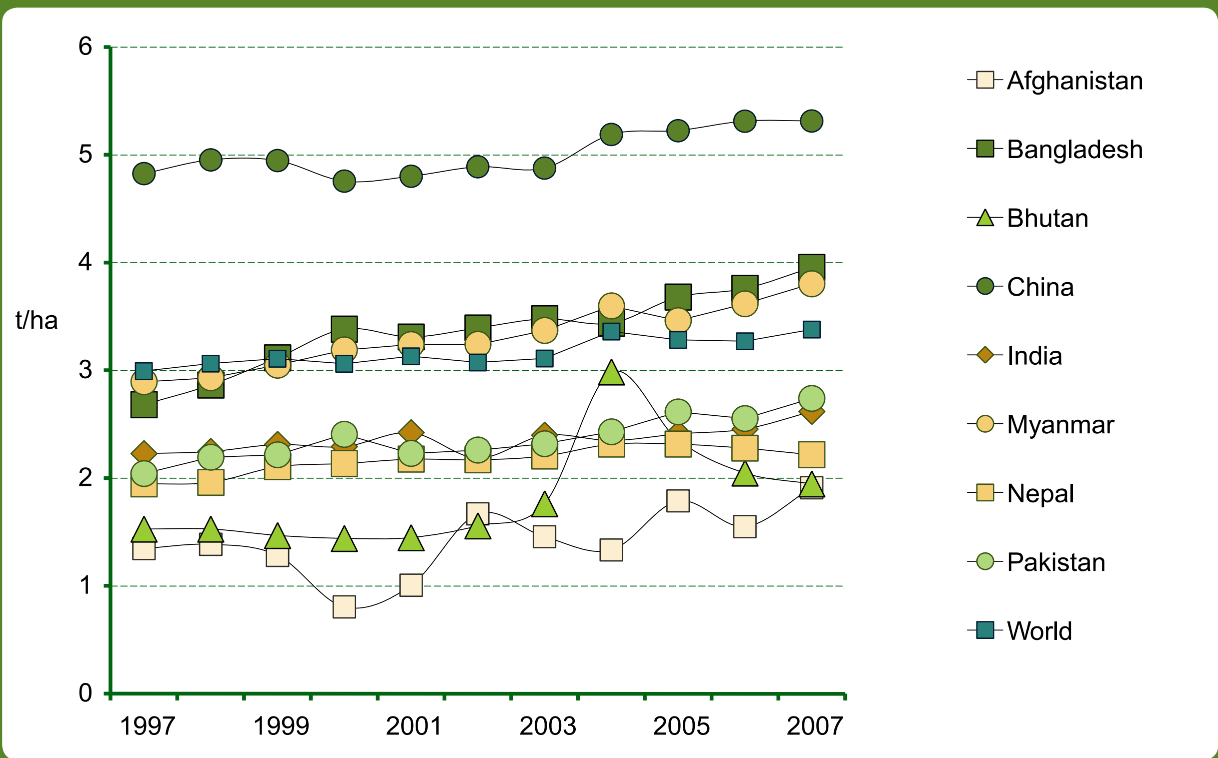
In Nepal, the majority of farmers (>85%) apply farmyard manure and/or compost in their fields (Maskey et al. 2002). However, a decline in the soil organic carbon pools is observed due to changes in land use, intensive cultivation, and poor organic manure management (Gami et al. 2001; Upadhyay et al. 2005). Generally, the SOC concentrations in most agricultural soils in the HKH is low, attributed to poor fertility management, excessive tillage, soil erosion, imbalance in fertiliser use, little or no crop residues returned to the soil, and severe soil degradation (Lal 2004).

Forest

The vast extent of the HKH region, in combination with extreme climatic and altitudinal variations, has resulted in the existence of extremely varied forest ecosystems that range from wet tropical to alpine forests. In the central Himalayan region, typical lowland tropical broadleaf forests include the sal tree (*Shorea robusta*), which is widespread across the range. At intermediate elevations, subtropical pines (*Pinus roxburghii*) occur up to elevations of 2,000 m, giving way to temperate hardwood forests (oak and rhododendron). Temperate forests in the western parts of the ranges include pine and cypress species. The sub-tropical and tropical forest formations in north-eastern parts, one of the recognised global biodiversity hotspots, range from tropical wet evergreen to sub-tropical pine forests at higher elevations. Conifers and rhododendron are widespread in the sub-alpine zones of the range (ICIMOD 2005).

However, the composition (and condition) of forests in the HKH region is not only a result of natural geographic factors, but above all is shaped by the varied use of the local population and, to a lesser extent, by commercial

Figure 9: **Cereal yield production per ha between 1997 and 2007 in the HKH countries in comparison to the world's average. Country data is for the entire area within national boundaries, i.e. includes portions outside the HKH**



Data source: FAO 2009c

logging. In almost all regions, the forest area is decreasing (Table 3), with an estimated rate of 0.8% across the entire region, and with the highest estimated declines in Afghanistan, Pakistan (note that these two countries already have a very low forest cover, 1.4% and 5.5% respectively), Nepal, and Myanmar. There are various studies indicating a trend towards gradual degradation of forests rather than a complete loss. For instance, a decline of forest area in Nepal from 37% in 1986 to 29% in 2001 is reflected in increasing shrub area (from 5 to 10.6%) during this period (Upadhyay 2005).

Table 3: **Land use change in the HKH region between 1997 and 2007**

	Agriculture (%)	Forest (%)	Pasture (%)	Pop. Trend (2000-2005)
Afghanistan	0.82	-3.07	0	2.6
Bangladesh	0.25	-0.19	0	1.7
Bhutan	-0.24	0.34	0.17	2.3
China	1.24	1.85	0	0.5
India	-0.03	0.19	-0.03	1.6
Myanmar	1.41	-1.38	-1.70	0.9
Nepal	0.29	-1.66	-0.12	2.1
Pakistan	0.87	-2.07	0	2.2

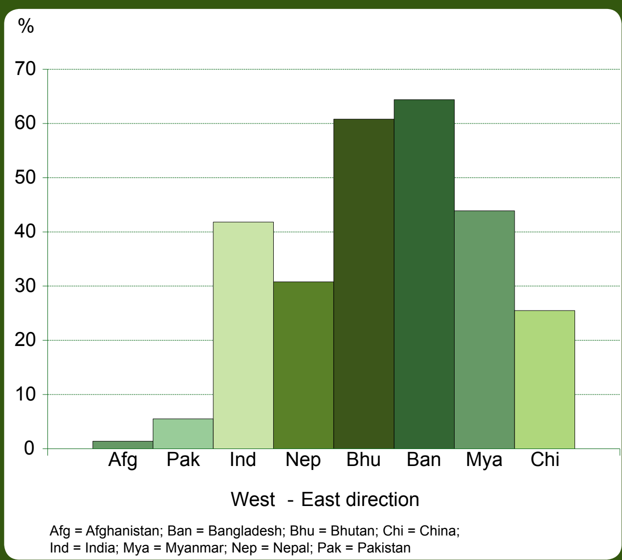
Source: FAO 2009c

A major driver behind this forest decline and forest degradation is the demand for fuelwood and other biomass by local populations. On the whole, nearly 80% of the energy needs of people living in the region are met by wood (ICIMOD 2005). In contrast to the adjoining plains, the agricultural production in the region largely depends on a fertility transfer from forests and pastures to maintain productivity on farm. It has been calculated that each unit of energy derived from crops in the region involves an expenditure of 9 units of energy from adjacent forests (Singh et al. 1984).

The main uses of forests are collecting of fuelwood, fodder, which involves tree lopping, leaf litter, and some non-timber forest products. In the Garhwal Himalaya, the average annual fuelwood consumption has been reported as 629 kg per person (Bhatt et al. 1994), which is significantly higher than the average recorded (275-315 kg) for the total rural area found in Bangladesh, India, and Pakistan (Leach 1987). The collection of fuelwood is traditionally free, and/or comes with land user rights. Another demand is timber for local house construction and agricultural implements. At certain intervals (e.g., 3-7 years), households in India are entitled to harvest timber from forests, a legal right of the local people administered by the forest service (Negi et al. 1999).

The graph of distribution of forest cover (Figure 10) across the HKH countries shows an increase of cover from west to east. The regions in Bhutan, Bangladesh and Myanmar have the highest forest cover with 64%, 61% and 44% respectively. Likewise, the Indian States with the highest forest cover are located in the northeast. According to the Indian State of the Forest Report (FSI 2005), the forest cover in the North-Eastern states is 66.7%, being the highest in Mizoram with approx. 90% cover. However, comparable to the situation in Nepal, the main trend is towards forest degradation as opposed to a complete loss of forest areas. The overall change in forest cover in these states remained more or less stable between 2003

Figure 10: **Distribution of forest cover across the countries of the HKH region**



and 2005. Remarkable, however, is an increase of the open forest class (crown cover of 10-40%), while moderately dense forests (crown cover 40-70%) decreased by 1% during this short period indicating heavy forest fragmentation and degradation.

The Tibet Qinghai Plateau has the largest forest area in the HKH region in absolute terms with approx. 420,000 sq.km. The forest areas here are mainly found in the eastern and south-eastern parts of the plateau (northern Yunnan) and in western Sichuan. Forest types range from alpine, temperate, and subtropical to tropical.

Rangeland

Livestock and pastures are among the principle components of many livelihood systems throughout the HKH region. Generally, the grazing of cattle, sheep, goats, and yak in forests and highland pastures can be found throughout the region (ICIMOD 2005). However, permanent pastures where rangeland activities are more important than agricultural farming are mainly distributed in arid zones of the Himalayan range. In areal terms, vast areas of pastures are located mainly on the Qinghai-Tibet Plateau. Grasslands are the predominant vegetation type, representing one of the largest continuous grassland regions in the world. The grasslands store some 25% of China's total soil carbon (Wang 2002). The Plateau has a critical influence on regional weather systems. Grasslands cover more than half of the Plateau's total land area. The more than 100 million ha of grassland are the basis for the pastoral and agropastoral livelihoods of more than 5 million people (Wilkes 2008). Almost 75% of these grasslands fall into the two categories of alpine meadow (58.8 million ha) and alpine steppe (37.8 million ha), following a declining precipitation gradient going from east to west (Figure 11).

The productivity (biomass yield) of these grasslands is highly influenced by summer rains. Primary productivity in this cold arid region is low compared to more temperate, moist regions (Figure 12). Consequently, these rangelands are prone to overutilisation and degradation. A frequently repeated statistic is that 90% of China's grasslands are degraded to some extent (Harris 2009) and studies from Qinghai and Tibet report that 23% and 17.2% of the total grassland areas are moderately or severely degraded.

Other significant pasture areas in the HKH region are located in Afghanistan (17.9 million ha), in the Indian Himalayas (16.4 million ha) mainly in the north-western dry mountains, and in Pakistan (4-5 million ha). Especially in Afghanistan, the greater part of the land area is extensive grazing land, however due to the cold arid conditions and infertile soils, it is estimated that only 40% is suitable for winter grazing. The vast majority of this grassland is dominated by Artemisia steppe (FAO 2009b).

Studies from all of these pasture regions report that the productivity of rangelands has been adversely affected due to misuse and overgrazing. For instance, rangelands in Pakistan are producing only 10-15% of their potential (FAO 2009b).

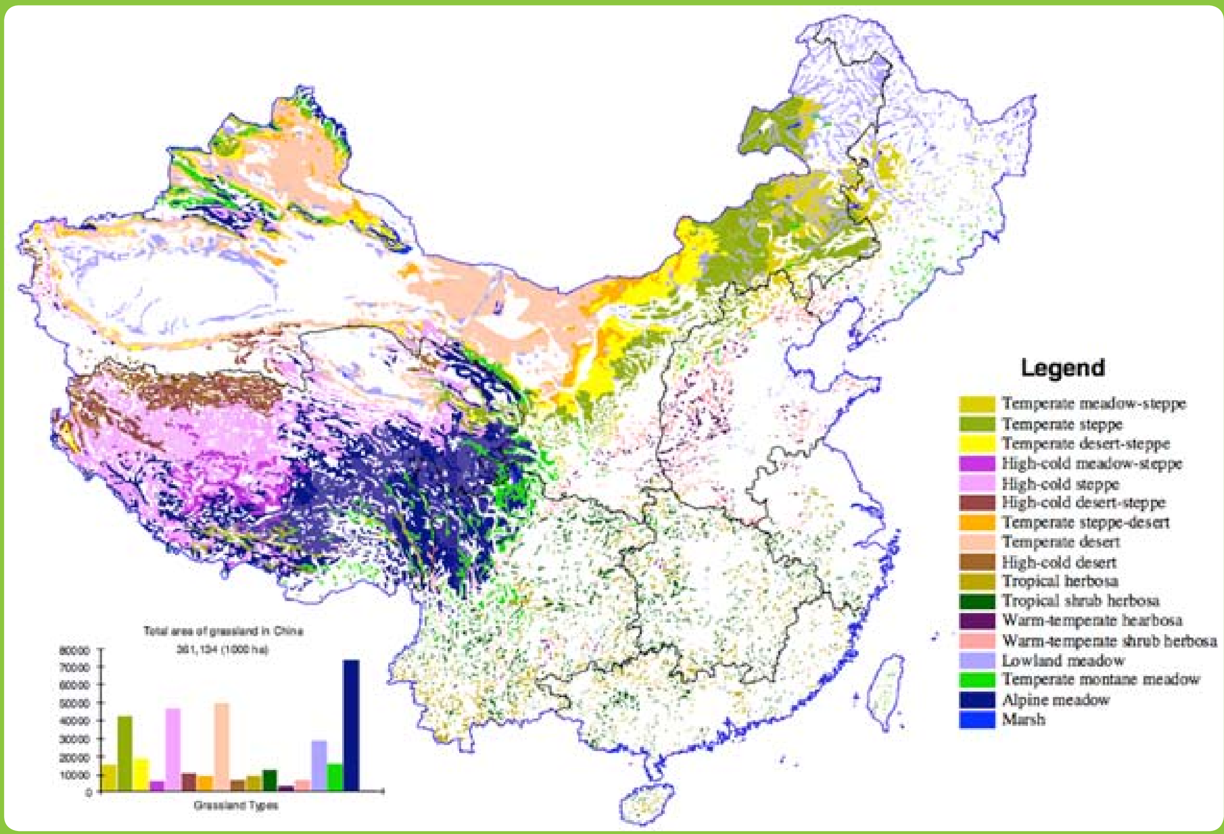
Wetlands

In general, the specific characteristics of wetlands lead to the accumulation of organic matter in the soil and sediment serving as carbon sinks and making them one of the most effective ecosystems for storing soil carbon (Schlensinger 1997). According to global estimates, wetland ecosystems store 20-25% of the world's organic soil carbon (Gorham 1998). However, carbon fluxes and pools vary widely in different wetlands, and only limited studies have been conducted to assess the potential role of these ecosystems in carbon sequestration. There are major knowledge gaps in accurately quantifying carbon stocks and carbon sequestration potentials (Adhikari 2009).

The Qinghai-Tibet Plateau leads the HKH region in wetland acreage with more than 6 million hectares in total, making up 4.9 percent of the total plateau area. Often described as the 'the kidney of the plateau', wetlands in Tibet not only play a crucial role in protecting groundwater, moderating flood water in rainy seasons, and maintaining the ecological balance, they are also a major source of oxygen. However, there are clear signs of degradation and destruction of Tibet's wetlands due to overgrazing and urban construction.

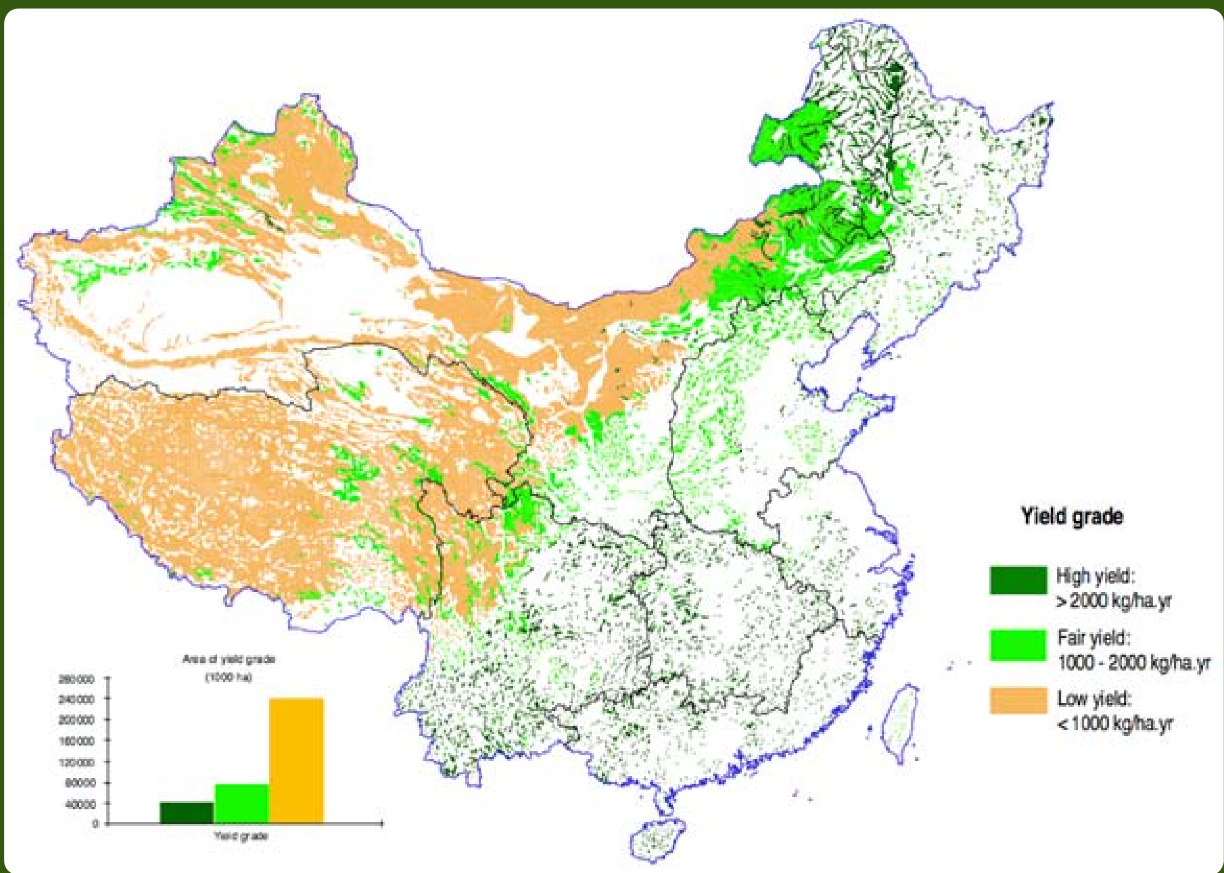
Of particular importance in this region is the permafrost zone. Approximately 90% of China's permafrost is found on the Plateau (almost 2 million km^2). However, due to climate warming, the permafrost at the source of the Yangtze river is melting away. Without the base of the permafrost, the water in the wetlands will seep into the ground and

Figure 11: **Distribution of different grassland types in China**



Source: Chen et al. 1998 reproduced with permission from the International Institute for Applied Systems Analysis

Figure 12: **Productivity of grasslands in China**



Source: Chen et al. 1998 reproduced with permission from the International Institute for Applied Systems Analysis eventually disappear. The Qinghai Climate Data Centre and Qinghai Meteorological Research Institution report that the average temperature at the source of the Yangtze river is increasing by 0.24°C every 10 years. High temperatures have quickened the melting of the permafrost, thus quickening the degeneration of the wetlands.

The following country information is taken from various sources available from the website of the Ramsar Convention (www.ramsar.org).

According to this, Bhutan possesses very few wetlands other than its river systems and a scattering of small, high altitude glacial lakes in the Himalayan range.

For Afghanistan there is no information available, though Pakistan, comparable to some extent, is characterised by a great variety of wetlands distributed throughout the country.

In the northern part of India, two wetland ecosystems are of main importance: the flood plain of the Brahmaputra and the marshes and swamps in the hills of northeast India and the Himalayan foothills, as well as the lakes and rivers of the montane region of Kashmir and Ladakh.

Nepal has relatively few wetlands other than fast-flowing rivers and streams. There are some small areas of marshy grassland in the river valleys; the most extensive marshes occur in the lowlands, on the flood plains of the three major rivers. However, seasonal wetlands and marshy meadows are found at high altitude, along with various mountain lakes.

There is a lack of studies on carbon sequestration in wetlands and no scientifically sound global or regional emission factors (default values) are readily available that can help to quantify the potential for carbon sequestration. Therefore the potential carbon finance options in wetlands have been excluded from this analysis. However, there is an absolute need for further analysis with regard to this, notably within the context of the crucial importance of integrated water resource management in the HKH region. In this sense, ICIMOD has coordinated and implemented the project 'Support for the conservation of high altitude wetlands through application of the Asian wetland inventory approach and stakeholder-led catchment management in Bhutan, China, India, and Nepal'.

Data quality and assumptions made in this study

This study, and particularly the analysis of biophysical carbon mitigation potential, was done as a desk study. Most of the basic statistics (like land-use change rates, or country specific aerial land-use data) are based on available FAO data. In addition, a literature review was conducted to gather specific information on the HKH regional portions of the countries concerned. The literature included a wide body of scientific publications such as ICIMOD papers and reports, FAO publications, country profiles and other reports (WRI, UNEP, IPCC, IIASA), as well as official thematic publications from the respective HKH countries. Given the vast differences regarding data availability, many assumptions are made for the HKH region based on representative case studies, scenarios, or other scientific findings. These assumptions, as delineated for each of the mitigation activities and land-use classes, are summarised briefly in the following overview of some key methodological issues.

General

The total area of the proportion of each of the eight countries within the HKH region, as well as the country-wise proportion of the major land-use classes, are based on data provided by Banskota et al. (2000). These figures were projected to the year 2007 (the latest year for available data) by using the annual FAO land-use change rates between 1997 and 2007.

All carbon revenues are calculated with a carbon price of 10 US$ per ton CO_2e.

General conversion factors used in this study are: t carbon → t CO_2e = 3.667; and carbon fraction of t dm living biomass = 0.47.

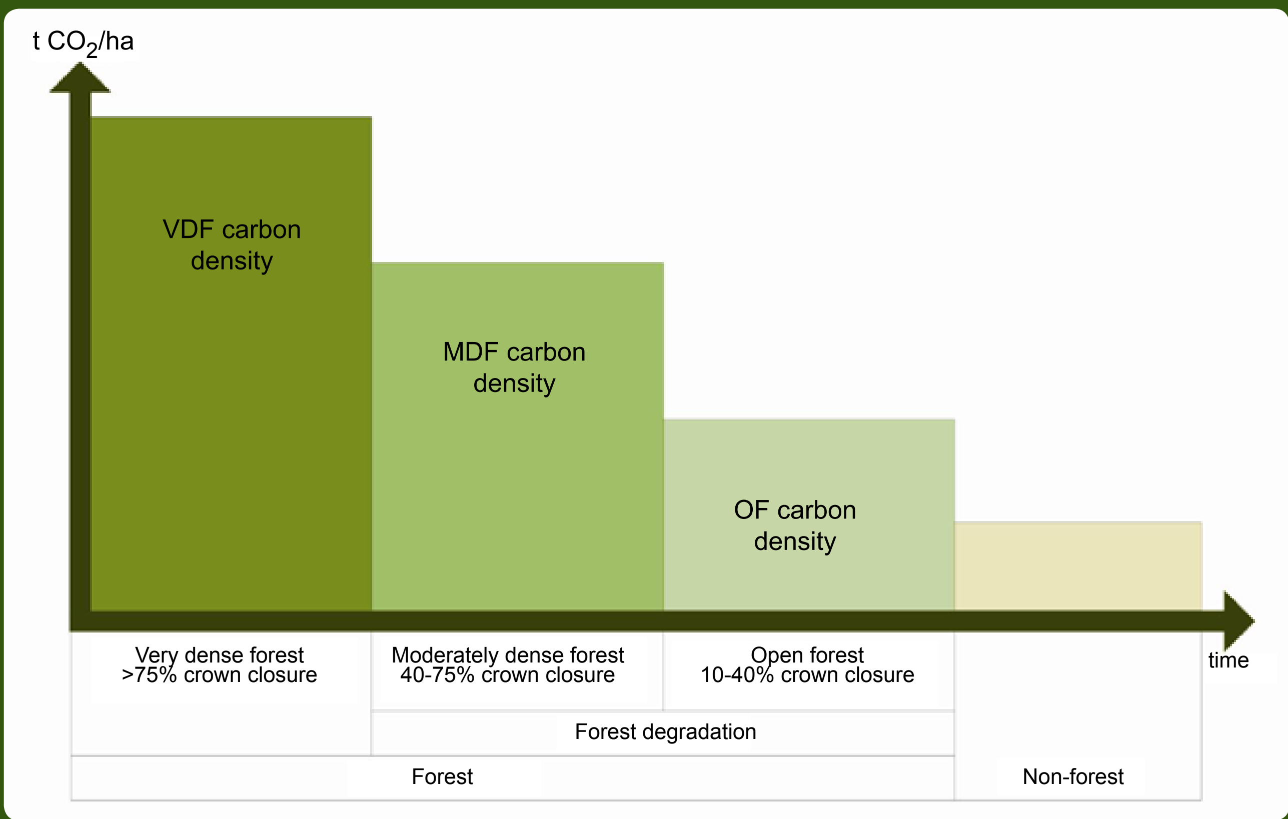
Assumptions as to REDD

- The forests in the HKH region were stratified into three crown cover classes: 'very dense forest' (VDF), 'medium dense forest' (MDF), and 'open forest' (OF) based upon the classification scheme used by the Forest Survey of India (FSI 2005) and assuming that crown cover is linearly correlated with the carbon density of forests (Figure 13).
- The crown cover classes were further stratified into forest types based upon the relative abundance of particular forest types within each country (Prasad et al. 2003), again using the FSI (2005) classification system. This was based upon the assumption that the Indian Himalaya covers the majority of representative climatic and site-specific zones occurring in the HKH region. Average forest biomass values were assigned to each of the forest types based on the same reference (Prasad et al. 2003).
- Avoided unplanned deforestation scenario (AUD): The potential of reduced deforestation was estimated using the deforestation rates between 1997 and 2007, derived from FAOSTAT (FAO 2009c). Total deforestation avoidance over 20 years is based upon these deforestation rates. This is justifiable since the deforestation of natural forests is significantly higher in most cases than the FAO data (the afforestation efforts in the countries often balance the FAO data).
- Avoided forest degradation scenario (AFD): By applying the crown cover forest classes it is assumed that over a period of 20 years, 50% of the medium dense forests further degrade to open forests in each country. The very dense forests are not included since it is assumed that most of the forest areas belonging to this class are not within the vicinity of settlements, therefore the pressure of degradation is comparably low. The mitigation potential for each country is estimated based on the avoidance of this forest degradation scenario.

Assumptions as to improved forest management (IFM)

- In order to identify eligible forest areas for IFM activities, only areas defined as "productive plantation" and "semi-natural forests" according to the FAO classification were considered. According to FAO, these forest categories are under intensive forest management regimes, hence would qualify for IFM activities.

Figure 13: **Three forest carbon density classes as identified by the Forest Survey of India (2005) and as used in this study**



- In the case of Bhutan, 50% of the total forest area is assumed eligible for IFM. Based on expert interviews, this was considered realistic, taking into account current as well as future trends of forest policy in Bhutan (the remaining 50% will be protection forests).
- The IFM eligible areas are stratified into different climatic zones.

Assumptions as to sustainable agricultural land management (ALM)

- Only the areas of the primary crops have been taken into account, based on FAOSTAT (FAO 2009c), and stratified by climatic zones.
- Mitigation potentials have been calibrated based on region-specific soil and land degradation studies.
- Areas with high residue crops (particularly maize-dominated systems) have high mitigation potentials, through improved residue management.
- Suitable ALM practices for each country have been identified according to published case studies.
- The adoption rate of ALM practices is assumed as 75% over a default period of 20 years, based on experiences in Africa.

Assumptions as to afforestation, reforestation and revegetation (ARR)

- Potential area for ARR is identified based on Zomer et al. (2008a). This area represents the land technically suitable for ARR.
- Based on a case study in India, only 70% of the technically suitable land is available for ARR activities due to socio-economic factors. Based upon this, the technically suitable ARR area in the HKH region was reduced by 30% in each country.
- With regard to additionality, the baseline scenario was estimated for each country based on FAOSTAT (FAO 2009c) and then deducted from the potential ARR land.
- Based on experiences in India, the eligible ARR land was further stratified into climatic zones, and plantations with short rotations or long rotations. Average sequestration values are assigned to these plantations using the same reference, i.e., FAOSTAT (FAO 2009b).

Assumptions as to rangeland management

- The areas identified as grasslands are defined as permanent pastures according to FAO.
- The grasslands were stratified according to their productivity, i.e. high yielding, fair yielding and low yielding grasslands, based on a Chen et al. (1998). Productivity is also dependent on grassland types, and the information on this was taken from FAO livestock and pasture country profiles (2009b).
- Only the default value for grazing management was applied, representing the medium yield class.

Potential mitigation activities

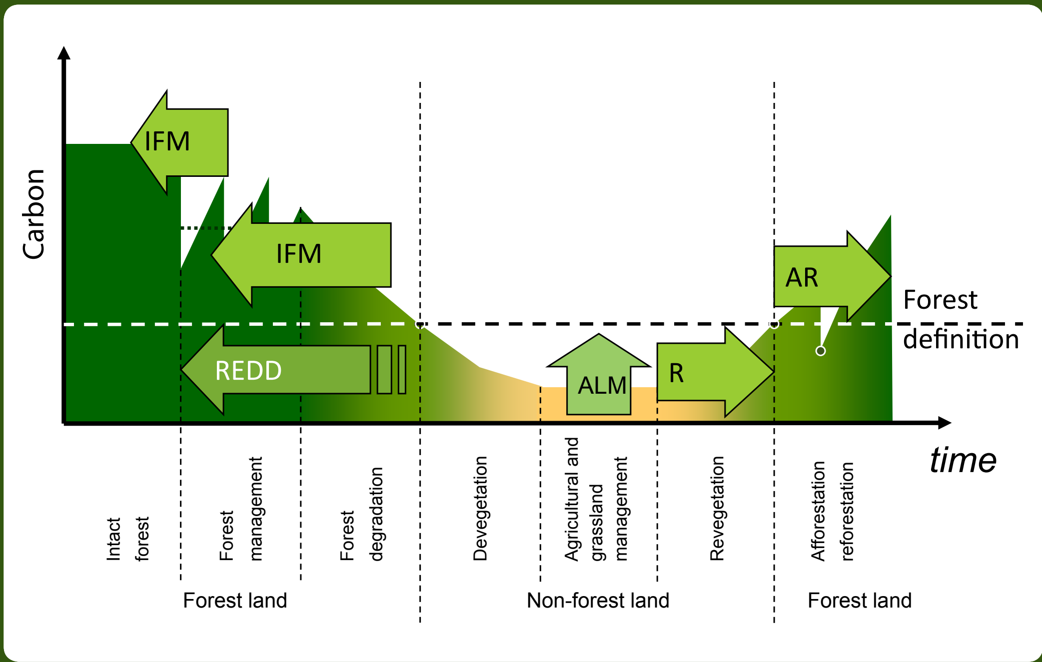
Carbon densities and mitigation potentials

Figure 14 shows the different land-based carbon finance activities presented in more detail according to the VCS terminology. The figure shows the correlation between carbon stock density and changes in carbon stocks due to different land uses and land use changes. Generally, an intact forest ecosystem has the highest carbon density, while agricultural land has the lowest carbon density. The arrows indicate possible mitigation activities. Note, that ALM – agricultural land management – is the only activity where no explicit land use change occurs.

Afforestation, reforestation, and revegetation (ARR)

Eligible activities in the ARR project category consist of establishing, increasing, or restoring vegetative cover through planting, sowing or human-assisted natural regeneration of woody vegetation to increase carbon stocks in woody biomass and, in certain cases, soils (VCS 2008). Typical ARR project activities include reforestation of forest reserves, reforestation or revegetation of protected areas, afforestation of wastelands, reforestation of degraded lands, and rotation forestry with long harvesting cycles. In contrast to the CDM mechanism, where afforestation activities are not eligible if project areas were cleared (of native ecosystems) within the period after 1990, the VCS requires a ten-year period preceding the project start. This less strict criterion allows for more potential ARR areas in the region.

Figure 14: **Land use and carbon finance activities in the AFOLU sector and their effects on carbon densities**



Source: Carbon Decisions International 2009

Sustainable agricultural land management (ALM)

According to Smith et al. (2008), mitigation activities in cropland management that sequester carbon in soils, and above and below ground biomass, include the following partly overlapping categories:

- **Agronomy:** Practices that increase yields and generate higher inputs of carbon from residues, for instance using improved crop varieties, extending crop rotations (use of perennial crops), using cover crops (green manuring), multiple cropping/crop rotation (e.g., planting cereals, legumes, and root crops in a sequence), or multiple cropping/intercropping (two or more crops planted on the same field).
- **Nutrient management:** Where inorganic fertiliser is not used efficiently, improving fertiliser use efficiency is one suitable practice. Further, use and management of manure and compost as organic fertiliser has high soil carbon sequestration potential.
- **Tillage/residue management:** Recent studies on tillage show that conservation tillage (reduced tillage or no-till agriculture) increases soil carbon in the upper layers of the soil. Proper management of crop residues which combines mulching, composting, and integrated livestock and manure management tends to increase soil carbon, since plant residues converted into organic matter are the major source of carbon in soil.
- **Water management:** This category includes the promotion of terracing, particularly in hill regions with high soil erosion risk, and the improvement of water harvesting and irrigation structures.
- **Agroforestry:** This refers to a systematic land use system in which woody perennials (trees, shrubs) are deliberately used in the same land management unit as agricultural crops, or there is significant tree cover found within the agricultural landscape matrix. Systems include agro-silvicultural practices (selected tree species grown on cropland) as well as planting of trees (shrubs) as wind-breaks, boundaries, hedges, and along contour lines.

Rangeland management

Comparable to ALM practices, soil carbon sequestration is the main carbon pool of interest. It is estimated that in grassland ecosystems, with limited above ground biomass, as much as 98% of carbon is stored below ground (Hungate et al. 1997). Soil carbon pools of rangeland ecosystems are highly sensitive to disturbance by management practices such as grazing, having major impacts on rates of organic matter input, decomposition rates, and soil respiration (Tennigkeit and Wilkes 2008). Generally, the following broad categories of rangeland activities with potential to increase carbon sequestration can be distinguished:

- Grazing management: Various studies report that grazing can have a positive as well as negative impact on rangeland vegetation and soils, depending on climatic characteristics and historical grazing practices (Milchunas 1989). Management leading to potential carbon sequestration includes stocking rate management (considering the carrying capacity of grasslands), rotational, planned or adaptive grazing, and enclosure from livestock grazing. Especially excluding livestock from degraded grasslands has a high potential for positive carbon sequestration.
- Vegetation management and production for increased biomass: Studies report that cultivation of grasses and legumes, and management of vegetation community structure may increase rangeland soil carbon stocks (Tennigkeit and Wilkes 2008). Especially shrubs and thickets in many semi-arid rangelands increase water infiltration and carbon sequestration (Ludwig et al. 2000).
- Fire management: Fire, as an integral part of many rangeland ecosystems, suppresses woody vegetation, which limits carbon sequestration in above ground biomass and soils, and releases GHG during burning. Fire management entails reducing the frequency or extent of fires, reducing the fuel load through litter management, and management of the timing of burns (Korontzi et al. 2003). Fire management has been shown to sequester up to 9.2 t CO_2e/ha/year (Bird et al. 2000)

Improved forest management (IFM)

This category includes activities related to improved forest management implemented on forest land and managed for wood products such as sawn timber, pulpwood, and fuelwood. Only areas that have been designated, sanctioned, or approved for such activities by national or local regulatory bodies are eligible under this category (VCS 2008). The VCS proposes the following management practices in natural as well as plantation forests:

- Conversion from conventional logging to reduced impact logging: These management systems can potentially reduce carbon emissions, especially during timber harvesting (reduction in damage to the remaining stand, positive selection of future crop trees, more effective planning, and design of forest infrastructure).
- Conversion of logged forests to protected forests: This would generally reduce emissions caused by any logging activities simply by protecting forests from further logging or protecting unlogged forests from initial logging. Carbon stock densities are increased through forest (re)growth.
- Extension of the rotation age of evenly aged managed forests, for example pine, teak or Chinese fir plantations. Extending the current rotational patterns will increase carbon stocks.
- Conversion of low-productive forests to high-productive forests: This is the most promising management category with regards to the conditions in the HKH region. Basically, this entails improving the stocking of poorly stocked forests, which increases the carbon stocks. The forest areas usually satisfy one of the following conditions: they are qualified as forest as defined by the host country, but do not contain much timber of commercial value; they are either degraded or in the process of degradation due to frequent disturbance such as fire, animal grazing or gathering fuelwood; they have a very slow growth rate or low crown cover. Project activities can include enrichment planting and mitigation of disturbance events (VCS 2008).

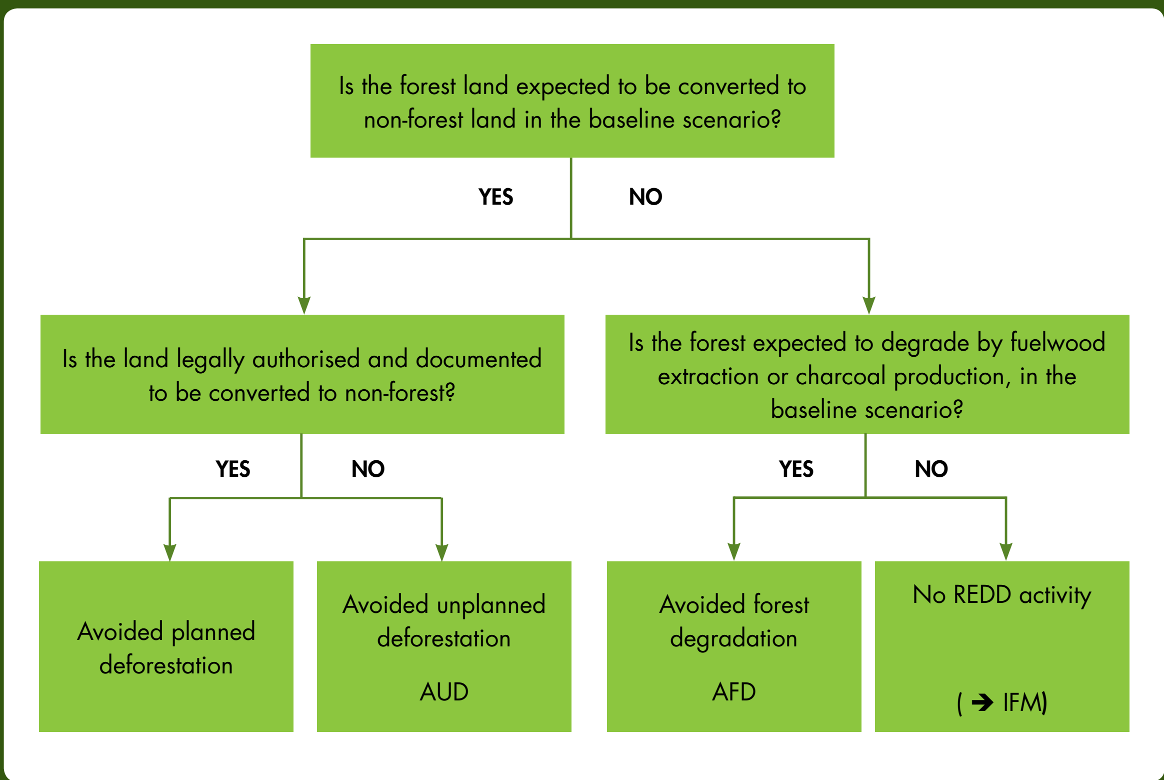
Reduced emissions from deforestation and degradation (REDD)

This currently much discussed approach includes all measures to stop or reduce the conversion of native or natural forests to non-forest land, most often coupled with activities that reduce forest degradation and enhance carbon stocks of degraded and/or secondary forests that would be deforested in the absence of the REDD project (VCS 2008). Deforestation is defined as direct, human-induced conversion of forest land to non-forest land, and consequently is always affected by the specific definition of 'forest'. Under the Kyoto Protocol, forests are defined according to the three parameters: minimum forest area, tree height, and level of crown cover (Zomer et al. 2008b). Regarding the eligibility of REDD projects, forests must meet the internationally accepted definition of forests based on UNFCCC host-county thresholds or FAO definitions (VCS 2008).

Regarding forest degradation, the thresholds have still not been set by the IPCC or UNFCCC, but it can be generally considered as gradual loss of carbon on forest land as a consequence of direct human intervention (e.g., logging, fuelwood or fodder collection, fire, over-grazing, and so on). However, it remains as forest land. The project activities of reducing forest degradation and enhancing carbon stocks resemble the IFM category. The key distinction between these two is whether degradation is caused by the forest being legally sanctioned for logging or whether it is illegally being logged and degraded (VCS 2008). If the logging activity is not sanctioned and is part of the cause of deforestation and degradation then it qualifies under REDD, otherwise it is eligible under IFM. The VCS categorises REDD activities into three broad classes and provides methodological guidance for each individually (see the decision tree in Figure 15 to identify the eligible REDD category).

- **Avoided planned deforestation (APD):** Stopping deforestation on forest lands that are legally authorised and documented to be converted to non-forest land.
- **Avoided unplanned deforestation (AUD):** This is typically the avoidance of deforestation of degraded to mature forests at the forest frontier that has been expanding historically, and will further expand, as a result of improved forest access.
- **Avoided forest degradation (AFD):** Where population pressure is high, and local land use practices produce a patchwork of cleared lands, forest patches and degraded secondary forests, deforestation occurs more as forest degradation within a landscape mosaic pattern. The agents of degradation typically live within the region to be protected. It is readily apparent that this REDD category suits perfectly the situation of vast areas within the HKH region.

Figure 15: **Flowchart for different eligible REDD project activities**



Source: adapted from Avoided Deforestation Partners 2009

Promising project types and regions

Major mitigation activities

After introducing the AFOLU project activities, the most promising options will be analysed and quantified in terms of biophysical potential for the HKH region. The matrix shown in Table 4 summarises the major mitigation activities for each of the land use types.

In order to account for the highly complex and multiple land uses existent in the HKH region, with often no clear distinction between the different land uses, carbon mitigation projects may combine a variety of activities into a single project description and verification event (VCS 2008). This in return will also foster more cost-effective integrated projects. For example, some agroforestry or enrichment planting under the ARR category and community forestry practices (under IFM) can be combined into a single project. Similarly, forest conservation (REDD) most likely will have to be combined with forest management (IFM), or with fast growing woodlot establishment (ARR) or introduction of agricultural practices (ALM). This will maximise the project efficiency and lead to a synergetic effect within a single project approach.

However, it must be kept in mind that for different project activities separate methodologies and risk assessments must be applied. The VCS clearly supports the combined project activity approach with its modular methodology, using a framework methodology and specific modules and tools for the different project activities.

Following the methodology given above, default values of sequestration rates were used to assess the biophysical potentials. For this study, a review of literature was done to identify regional sequestration rates for the different IPCC climatic zones occurring in the HKH region. Where no regional values were found, global IPCC defaults were used (global ALM and rangeland defaults). Table 5 illustrates the range of sequestration rates indicating different activities (in the case of ALM and Rangeland), different rotations (ARR), or different management scenarios (IFM).

Table 4: **Major AFOLU mitigation activities on different land use types (*wetland mitigation activities have been excluded from further analysis due to lack of data)**

Land use type	Preventing land use change	Degradation avoidance	Improved management	Land rehabilitation
Forest Lands	Deforestation avoidance	Avoiding over utilisation	Improving forest management	Afforestation, reforestation, revegetation
Croplands		Residue management Avoided erosion	Nutrient management Fertiliser use efficiency	Agroforestry
Rangelands	Avoided cultivation		Enclosure stocking management	Silvo-pastoral Agroforestry
Wetlands*	Wetland	Avoided cultivation	Stopping drainage	Restoration

Table 5: **Estimated mitigation potentials for different project activities and climatic zones in the HKH region**

Climatic zone	IFM ($t\ CO_2\ ha^{-1}\ yr^{-1}$)	ALM ($t\ CO_2\ ha^{-1}\ yr^{-1}$)	Rangeland ($t\ CO_2\ ha^{-1}\ yr^{-1}$)	ARR ($t\ CO_2\ ha^{-1}\ yr^{-1}$)
Warm temperate dry	0.26-1.5	0.15-3.45	0.40-9.39	6.27/12.69
Warm temperate wet	0.26-1.5	0.51-3.45		8.76/15.07
Tropical moist	0.27-4	0.55-3.45		8.76/15.07
Tropical wet	0.27-4	0.55-3.45		8.76/15.07
Cold temperate wet	0.27-1.5	0.51-3.45	0.40-9.39	6.27/12.69
Polar/boreal wet			0.40-9.39	

Notes and sources: Rates for IFM refer to biomass carbon pools and were taken from Banskota (2007) and Kahrl (2009); potentials for ALM and Rangeland include soil carbon and are drawn from Smith (2008) and Tennigkeit and Wilkes (2008); ARR sequestration rates for short rotation/long rotation (biomass) are drawn from Ravindranath (2007)

The values show average mitigation potentials. However, it must be noted that sequestration rates for individual management practices can vary highly on an area basis. The choice of regional values was influenced by the regional preferences within the HKH region. For instance, the values for IFM are drawn from studies in Nepal and China, both preferred regions for this project activity. Cells left blank indicate that the project activity is not suitable to be applied on a significant scale within this particular climatic zone due to low potentials or low areal applicability.

REDD activities and potentials are not included in the default values table since the potential is more dependent on deforestation/degradation rates and specific biomass values of existing forests. Therefore a different methodological approach is used in this study to assess the biophysical potential of REDD in the HKH (see next section).

Biophysical potential of REDD in the HKH

Generally, the updated IPCC GHG guidelines include two approaches in estimating carbon stock changes. The first is termed process-based or gain-loss method, which was introduced above. This approach estimates the net balance of additions to and removals from a carbon pool. In the REDD context, this method can be used when annual data on information such as growth rates and wood harvests are available.

Since such data were unavailable for this study, the assessment of REDD potential in the HKH region followed the logic of the second approach, stock-based or stock-difference approach. Using this approach, differences in carbon stocks due to deforestation and forest degradation are estimated in a particular pool at two moments in time. This method can be used when carbon stocks have been measured and estimated over time, such as in national forest inventories. For this study, the units of forest land of the HKH countries, as defined in Table 2, were allocated to different forest classes, with each class having a specific carbon density lower (or higher) than the previous one depending on the magnitude of forest degradation. Since there is clear correlation between the biomass of forests (and thus carbon content) and crown density of forest stands, a crown closure forest classification was used.

The total forest area of each HKH country was stratified according to the forest classification scheme of the Forest Survey of India. The classification scheme includes three classes, as shown in Table 6. Sources used to identify these classes include the Forest Survey of India (FSI 2005) and the Earth Trends Country Profiles (WRI 2009) (the crown classes were interpolated from deviant crown classes in the case of the WRI data source).

For the REDD assessment, the assumption is that the VDF class represents an undisturbed forest with the highest biomass density (of the three forest classes). If this forest is subject to degradation, the forest is allocated to MDF and OF classes over time. Carbon emissions are increasing due to successive biomass losses (see Figure 13).

In order to account for the vast climatic differences in the HKH region with highly diverse forest ecosystems and forest biomasses, the areas of the VDF class were further stratified and multiplied by regional biomass default values taken from Prasad et al. (2003), verified by global IPCC default values. According to the AEZ classification in the table 'Major agro ecological regions in the HKH region' (see Annex 2), the following forest types and biomass values in tons of dry matter per hectare shown in Table 7 were identified as the most significant in the HKH region.

Note that the biomass values in the table include above-ground and below-ground biomass. The below-ground biomass was calculated using IPCC conversion factors. The biomass values of the forest types within the 'degraded' forest classes MDF and OF were reduced proportionally in relation to crown closure, that is:

- MDF ➔ 55% of the VDF biomass value
- OF ➔ 25% of the VDF biomass value

Table 6: **The three forest classes used in this study, based on the Forest Survey of India (2005)**

Forest class	Definition	Acronym
Very dense forest	Forests having tree cover with canopy density > 70%	VDF
Moderately dense forest	Forests having tree cover with canopy density 40% - 70%	MDF
Open forest	Forests having tree cover with canopy density 10% - 40%	OF

Table 7: **The most abundant forest types in the HKH region**

Forest type	Forest biomass (t dm ha^{-1})
Alpine moist forest	127
Alpine dry forest	44
Montane warm temperate forest	237
Subtropical dry forest	159
Tropical moist deciduous forest	409
Tropical semi-evergreen forests	468

Source: Prasad 2003

The total forest biomass in the HKH countries and the shares of each forest class are illustrated in Table 8. India is further stratified into western/central and eastern regions, since the forest types and their biomass vary significantly.

According to this, the highest total forest biomass is found in Myanmar. One reason is that all forests in Myanmar within the HKH region are classified as either semi-evergreen tropical forests (468 t dm/ha) or tropical moist deciduous forest (409 t dm/ha). Further, 73% of these forests are classified as undisturbed VDF. Consequently Myanmar has the highest per ha forest biomass with 339 t dm, followed by Bangladesh (189 t dm/ha), Bhutan (177 t dm/ha), India, and Nepal (114 t dm/ha). The forest biomass in China, Pakistan, and Afghanistan is very low with 70, 47 and 41 t dm/ha respectively. To convert tons of biomass into tons of carbon, a conversion factor of 0.47 was used (IPCC 2006). Carbon was converted into CO_2eq. by means of the factor 3.66.

The mitigation potentials for two different REDD scenarios were estimated for each HKH country:

Scenario I: Avoided unplanned deforestation (AUD)

The biophysical potential of avoiding deforestation is estimated using the country deforestation rates calculated from the FAO data for the 10-year period 1997 to 2007 (see Table 3). The baseline assumption is that deforestation takes place over a period of 20 years in all three forest classes, which means that independent from the initial class, the forests are logged until the crown closure is below 10%. Therefore, the carbon stock change is estimated using the total forest biomass values. For countries that do not have a negative forest area change according to FAO (e.g., India, China), this scenario was not applicable (Table 9).

Table 8: **Total forest biomass and biomass distribution in different carbon density classes (forest classes) in metric tons of dry matter (t dm)**

HKH Countries	Total forest biomass (t dm)	Total forest biomass VDF (t dm)	Total forest biomass MDF (t dm)	Total forest biomass OF (t dm)
Afghanistan	22.3	1.4 (6%)	5.0 (22%)	16.0 (72%)
Bangladesh	161.4	52.5 (33%)	44.2 (27%)	64.7 (40%)
Bhutan	414.9	335.6 (81%)	50.5 (12%)	28.7 (7%)
China	3655.8	1621.8 (44%)	1067.5 (29%)	966.6 (27%)
India W/Cent.	1040.2	212.1 (20%)	585.3 (57%)	242.7 (23%)
India East	1265.4	258.1 (20%)	712.1 (57%)	295.2 (23%)
Myanmar	4343.3	3155.7 (72%)	685.2 (16%)	502.4 (12%)
Nepal	679.9	261.1 (38%)	222.3 (33%)	196.5 (29%)
Pakistan	104.1	10.0 (10%)	18.5 (18%)	75.6 (72%)

Table 9: **Mitigation potential of two REDD scenarios in the HKH countries**

Countries	Total carbon Stored	Scenario I: Avoided deforestation (AUD)		Scenario II: Avoided degradation (AFD)	
		AUD Cumulative emission reduction (20 years)	AUD Emissions reduction per annum	AFD Cumulative emission reduction (20 years)	AFD Emissions reduction per annum
	(million t C)	(million t CO_2)	(t CO_2 ha^{-1} yr-)	(million t CO_2)	(t CO_2 ha^{-1} yr-)
Afghanistan	11	17	1.6	2	1.5
Bangladesh	76	10	0.6	17	5.1
Bhutan	195	n.a.	n.a.	20	2.7
China	1718	n.a.	n.a.	418	2.0
India W/Cent.	489	n.a.	n.a.	229	1.9
India East	595	n.a.	n.a.	279	4.0
Myanmar	2041	1737	6.2	268	5.3
Nepal	319	320	3.5	87	3.4
Pakistan	49	59	1.3	7	1.7

Scenario II: Avoided forest degradation (AFD)

A wide range of studies indicate that degradation is the predominant forest land use change process in the HKH region, and a more relevant scenario than the complete loss of forest cover, i.e., deforestation. Thus, the baseline assumption is that within a period of 20 years, 50% of the MDF forest area will have degraded to the OF forest class. The VDF class is not affected since it is assumed that most of the undisturbed forests are protected or are located in remote areas with little access. The MDF class is assumed to be highly prone to further degradation due to increasing population pressure and energy demand. The project scenario implies that this 50% area of degradation is avoided, or equal areas are at the same time improved to MDF likewise.

Table 9 shows the biophysical potential of these two REDD scenarios. Not surprisingly, Myanmar has by far the highest potential with regard to avoided deforestation (6.2 t CO_2 ha^{-1} yr^{-1}) followed by Nepal and Afghanistan (3.5 and 1.6 t CO_2 ha^{-1} yr^{-1} respectively). In Nepal, possible annual revenues from avoided deforestation still result in 160 million US$ or 35 US$ per hectare (carbon price US$10/t CO_2). When considering forest degradation, there are more countries with a substantial mitigation potential on a per hectare basis. Myanmar still ranks first with 5.3 t CO_2 ha^{-1} yr- followed by Bangladesh and eastern India (5.1 and 4 t CO_2 ha^{-1} yr- respectively). Total annual revenues for these three regions result in 37, 2.4 and 38 million US$.

Regarding absolute mitigation potentials and possible revenues, the avoided deforestation scenario in Myanmar has the highest potential with 1,736 million t CO_2 over 20 years or 868 million US$ annual revenues, followed by Nepal with 319.6 million t CO_2, and the degradation scenarios in China, NE India and Myanmar.

Improved forest management

Bearing in mind the eligibility of activities under this category, not all forest areas within the HKH region are eligible for IFM project activities. Project developers of an IFM activity must provide information on the documented history of forest management for at least 5 to 10 years (e.g., data could include forest management plans, harvesting and timber volume levels, or property documents).

Typical IFM activities eligible and conceivable in forests of the HKH include improving logging practices (RIL), extending the rotation age of evenly aged forests (plantations), and conversion of low-productive forests (very dense forests, low stocking, poor site-species matching, and so on) to high-productive forest stands.

For the purpose of this study, only forest areas defined as 'productive plantation' and 'semi-natural forests' (FAO 2006) are considered as eligible for IFM, since these forest categories are under intensive forest management according to the FAO classification. Table 10 illustrates forest areas eligible for IFM (also shown as percentage of the total HKH forest area in the country), the default value range (mitigation potential), the annual average biophysical potential and the potential, annual revenues in US$.

The default value range is taken from Table 5; if two ranges are shown, different climate zones were considered (forest areas were estimated from FAOSTAT forest area statistics, source: FAO 2009c; based on a carbon price of US$ 10 per ton of CO_2).

The Chinese forest stands in the HKH region have the highest potential regarding IFM activities with an average annual potential of 29.8 million t CO_2, resulting in 298 million US$ in revenues per year. This seems realistic, considering the specific conditions in the Chinese forests concerned, which have a high proportion of secondary forests and monoculture plantations (dominated by pine species), most of them young, in qualitatively poor condition, and with low stocking volumes. Kahrl et al. (2009) estimate that 52.8 t CO_2 can be sequestered over a 20 year management period for an IFM scenario in a pine plantation in Yunnan. The baseline scenario assumes an initial stand age of 11 years, overstocked with declining annual increment. The project scenario relies on sustainable forest management (SFM) with thinning events every five years. A medium tree response is assumed.

India and Nepal both have significant potentials regarding IFM activities. This potential, however, is predominantly concentrated on the semi-natural forests, which account for nearly all of the IFM eligible areas in Table 10. These forest areas are highly impacted by local communities and crucial as a resource base for their livelihoods. Existing and traditional institutions of forest management in these forest areas facilitate the implementation of IFM activities. In

Table 10: **Biophysical potential of IFM activities in the HKH region**

Country	Eligible forest area for IMF activities ('000 ha) (% total forest area)	Mitigation potential (t CO_2 ha^{-1} yr^{-})	Biophysical potential (million t CO_2 yr^{-1})	Potential annual revenues (US$ in millions)
Afghanistan	0	n.a	n.a	n.a.
Bangladesh	191 (23%)	0.27-4	0.4	4
Bhutan	1050 (45%)	0.27-4	2.7	28
China	13,995 (33%)	0.27-4	29.8	298
India	9,705 (48%)	0.26-1.5/0.27-4	13.4	133
Myanmar	310 (2.2%)	0.27-4.0	0.7	6.6
Nepal	3,711 (81.9%)	0.26-1.5/0.27-4	5.6	55.8
Pakistan	387 (17.5%)	0.27-4	0.8	8.2

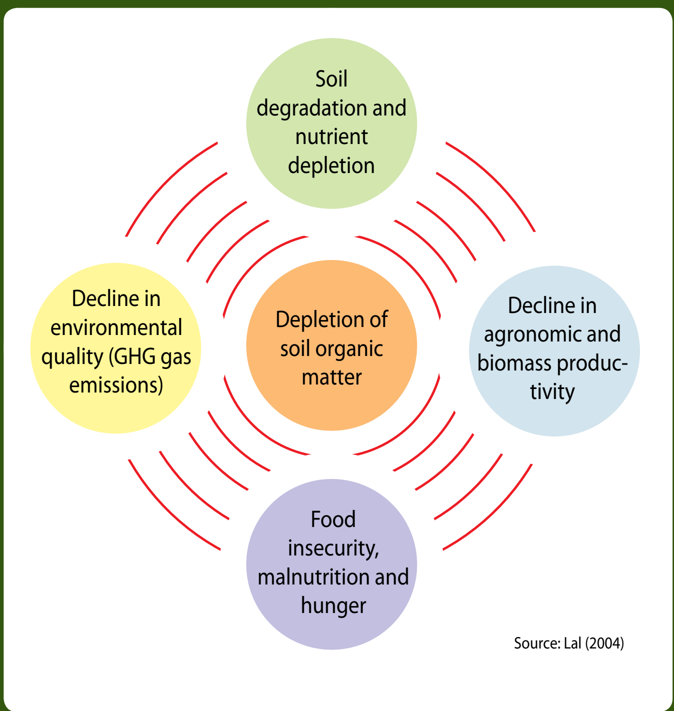
The default value range is taken from Table 5; if two ranges are shown, different climate zones were considered; forest areas were estimated from FAOSTAT forest area statistics (source: FAO 2009c); based on a carbon price of US$ 10 per ton of CO_2

fact, the paradigm shift towards more decentralised community forest management (CFM) can be seen as a viable option for IFM activities. Revenues from carbon sequestration could be valuable in reducing the opportunity costs of conserving and managing community forests (Banskota 2007).

Agriculture

There is a broad consensus among scholars and experts that soil fertility is declining in many parts of the HKH region, and that soil degradation and declining crop yields have far-reaching consequences for food security and socioeconomic development in the region (Figure 16). Climate variability and change are further exacerbating these challenges. At the same time, agricultural carbon sequestration could provide a rare win-win-win situation that offers greenhouse gas mitigation, food security and socioeconomic development, and climate change adaptation benefits.

Figure 16: **The vicious cycle of depletion of soil organic matter**



Source: UNEP/GRID 2009 (*Riccardo Pravettoni*, UNEP/GRID-Arendal)

The principal cause of decline in soil organic matter and soil organic carbon (SOC) is a reduction in biomass productivity and the low amount of crop residue and roots returned to the soil (Lal 2004). Soil erosion further depletes the SOC through loss of the nutrient and carbon rich top layers of the soil. Signs of heavy erosion (particularly water erosion) are common throughout the HKH region.

There is a strong linkage between low SOC in agricultural land and the widespread problem of soil degradation. The adoption of ALM practices, such as no-till farming, composting, use of crop residue mulch, rotational cropping, and contour hedgerows on sloping land have been proposed to reverse this trend, while increasing the overall SOC concentration.

In this context, agricultural carbon sequestration is perceived to have four non-exclusive benefits (Tennigkeit et al. 2009):

- **Food security and productivity:** Soil fertility enhancements that accompany soil carbon sequestration.

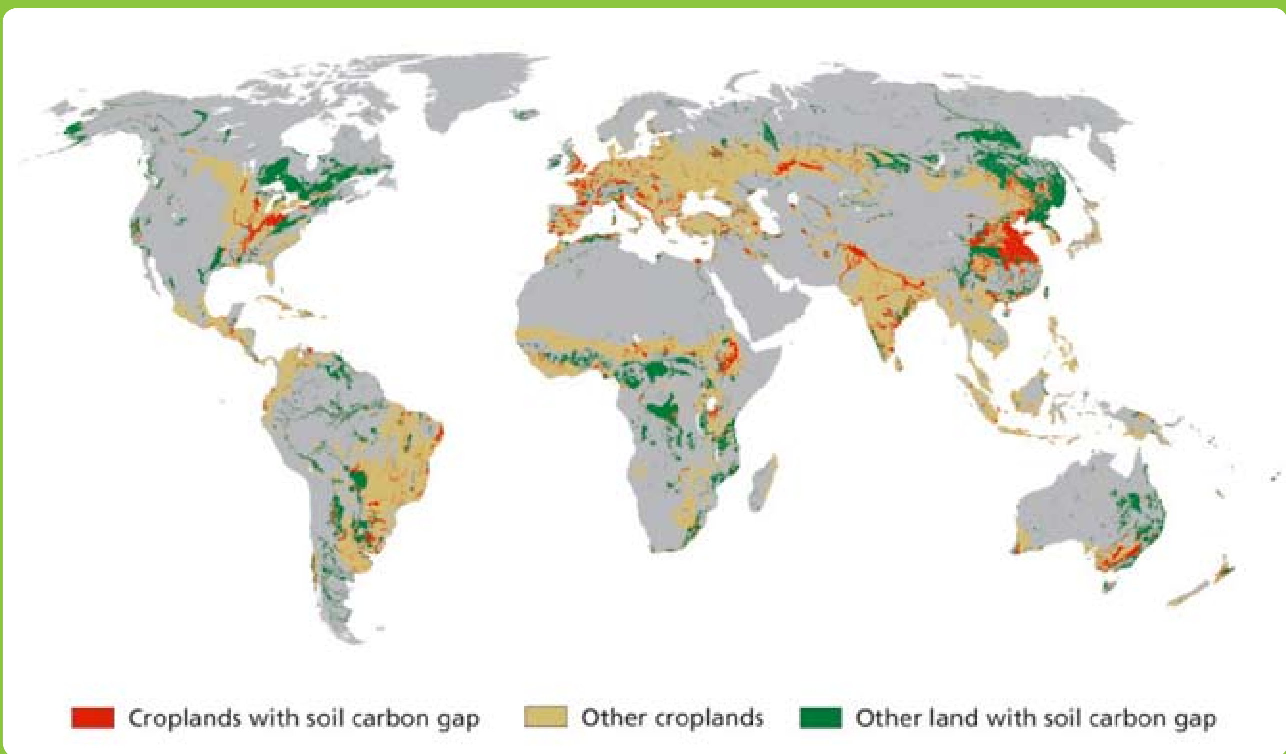
- **Rural development:** Payments for carbon sequestration could provide smallholder farmers with an additional source of income.
- **Climate change adaptation:** Soil restoration can improve agro-ecosystem resilience to changes in the climate.
- **Climate change mitigation:** Agricultural carbon sequestration offers a near-term strategy for reducing CO_2 concentrations.

The FAO (2007) presents a global view of areas with significant potential to sequester additional carbon in soils (Figure 17). This potential, referred to as the 'soil carbon gap', indicates locations where soil carbon levels are currently low but medium-to-high technical potential for sequestration exists, depending on soil type, climate soil moisture, and land cover conditions. In the map, all areas indicated with red, represent areas with a potential to sequester carbon in soils. Although the map is based on global databases at a coarse scale of resolution and with variable accuracy, it at least indicates that, in particular, along the Indian Himalayas, in Nepal and in the Hindu Kush region (Pakistan, Afghanistan) there exists a significant biophysical as well as technical potential to sequester soil carbon in croplands.

Table 11 summarises this potential of agricultural carbon sequestration in the HKH region as a result of adoption of ALM practices. The default value range for each country is based on the IPCC global default values (Table 5). The biophysical potential in million t CO_2 per year is the average default value multiplied with the crop production area. The choice of suitable default values for each of the HKH countries leading to the specific mitigation potentials was driven by the following process:

- The crop areas of the primary crops were stratified into different climatic zones.
- The state of soil degradation was assessed by means of the GLASOD study (FAO 1994) for each country. The assumptions is that higher soil degradation rates technically offer higher carbon sequestration potentials.
- Stratification into high-residue crops and low-residue crops. The idea behind this is that soil carbon models (Century, RothC) are highly sensitive to the amount of residues retained in the field, leading to higher sequestration.
- Suitable ALM practices to be adopted in each climatic zone were identified from the literature (Table 12).
- It is assumed that the adoption rate of the ALM practices is about 75%

Figure 17: **Potential to sequester additional carbon in soils on croplands**



Source: FAO 2007

Table 11: **Agricultural carbon sequestration potentials in the HKH region.** (Based on a carbon price of US$ 10/t of CO_2)

Country	Production area ('000 ha)	Mitigation potential (t CO_2 ha^{-1} yr^{-1})	Biophysical potential (million t CO_2 yr^{-1})	Potential annual revenues (million US$)	Average area per household (ha)
Afghanistan	3508	0.26-3.45	4.3	42.7	6.3
Bangladesh	87	0.55-3.45	0.14	1.4	0.8
Bhutan	207	0.26-3.45	0.44	4.4	1.4
China	1666	0.55-3.45	1	10	
India	3037	0.26-3.45	6.1	61	0.7
Myanmar	2317	0.55-3.45	4.8	47	2.5
Nepal	2372	0.26-3.45	5.3	53	0.6
Pakistan	2879	0.26-3.45	5.4	54	3.9

Table 12: **The principle status in the agricultural sector in the HKH countries and most promising ALM options**

Country	Baseline scenario	ALM project scenario
Afghanistan	• Moderate soil degradation • Main crops are wheat, barley and rice • Application of large amounts of inorganic fertilisers • Intensive tillage • No information on crop residue management and agroforestry systems ➔ assuming no such practices	• Reduced tillage • Mixed cropping systems • Green manure/cover crops • Improved fertiliser efficiency • Agroforestry • Retention of crop residues • Rice production – improved water management
Bangladesh	• Severe soil degradation • Main crops are rice and wheat • Shifting cultivation with 3-4 year cycles	• Longer cycles of shifting cultivation • Reducing biomass burned • Conversion to permanent agriculture/agroforestry systems
Bhutan	• Light to moderate soil degradation • Main crops are wheat, barley, potatoes in warm temperate regions, and rice and maize in tropical regions • Green manure and organic waste used • Crop residues for livestock • Use of manure and forest product residues	• Rice production – improved water management • Mixed cropping systems • Agroforestry
India	• Severe and very severe soil degradation • Main crops are wheat, maize, rice in warm temperate regions and rice in tropical regions • Shifting cultivation with 3-4 year cycles • Crop residues often burned	• Rice production – improved water management • Mixed cropping systems • Agroforestry • Green manure/cover crops • Improved fertiliser efficiency • Retention of crop residues • Longer shifting cultivation cycles
Myanmar	• Moderate to severe soil degradation • Main crops: sorghum, millet • Shifting cultivation	• Longer cycles of shifting cultivation • Reducing biomass burned • Conversion to permanent agriculture/agroforestry systems
Nepal	• Light to severe soil degradation • Main crops are rice wheat and maize • Shifting cultivation • Use of manure and forest product residues	• Longer cycles of shifting cultivation • Reducing biomass burned • Conversion to permanent agriculture/agroforestry systems • Rice production – improved water management • Retention of crop residues • Mixed cropping systems • Agroforestry
Pakistan	• Light to moderate soil degradation • Main crop wheat • Application of large amounts of non-biological fertilisers • Intensive tillage • No information on crop residue management and agroforestry systems – assuming no such practices	• Reduced tillage • Mixed cropping systems • Green manure/cover crops • Improved fertiliser efficiency • Agroforestry • Retention of crop residues

According to this, India has a high agricultural carbon mitigation potential with 6.1 million t CO_2 per year, and potential revenues of up to 60 million USD per year. Equally significant potentials are found in Pakistan, Nepal, Myanmar, and Afghanistan with 5.4, 5.3, 4.8 and 4.3 million t CO_2 per year respectively. In all of these countries, high potentials are assumed through nutrient management, particularly manure application and residue mulching. Water and erosion management practices in combination with agroforestry systems are also important.

The 'average area per household' is important for the institutional design of carbon sequestration projects, and also has strong economic implications. The smaller the individual farm size, the larger the number of farms that have to be aggregated in the framework of a carbon finance project. For instance, for a smallholder project in northern India with 25,000 ha of mixed agricultural fields, the project proponent/aggregator needs to provide project extension services to at least 35,700 farm households to sequester a minimum of 50,000 t CO_2/year. This size is considered to be the minimum size for a viable project targeting the international carbon market.

By comparison, a project proponent in Afghanistan needs an area of 41,000 ha, to attain the minimum of 50,000 t CO_2 sequestered per year, but provides extension to only about 6,700 farm households.

As already mentioned, the global sequestration rates used in this study for individual management practices vary by as much as two orders of magnitude on a per area basis. This significant range is driven by both site-specific conditions and the level of biomass additions associated with different practices. Since this variance is extremely important for the economic feasibility of a particular sequestration project, the need for regional sequestration rates becomes clear.

Afforestation, reforestation or revegetation (ARR)

For the assessment of the biophysical mitigation potential in this category, land potentially suitable for afforestation, reforestation, or revegetation activities was identified according to a study conducted by Zomer et al. (2008a). Following the crown cover forest classes mentioned above, only areas with a crown cover density threshold below 10% are considered as potential ARR land. The land use system in the majoritiy of these remaining areas is mainly wasteland, which is classified in India as degraded grassland, highly degraded forest land, scrub, and partly long-term fallow land. High elevation areas, very dry areas, urban areas, water bodies, cropland as well as recently deforested areas were excluded. These remaining identified area estimates were then reduced to their respective HKH specific proportions in each country.

This technically potential ARR land (Table 13) is then further reduced taking socioeconomic factors into account. It is assumed that certain areas of this land may not be available due to a number of barriers, such as tenure status, encroachment, and land required for grazing or other use (Ravindranath 2007). According to group discussion with village communities considering these competing land uses, Ravindranath assumes that about 70% of the technical potential area is available for ARR activities. This socioeconomic potential ARR land is estimated in the second column of Table 13.

Table 13: **Technical potential, socioeconomic potential and additional potential land for ARR mitigation activities in the HKH region**

Country	Technical potential ARR land ('000 ha)	Socioeconomic potential ARR land ('000 ha)	Average annual change in plantation area (2000-2005)	Additional ARR areas (considering baseline) ('000 ha)
Afghanistan	n.a.	n.a.	n.a.	n.a.
Bangladesh	252	176	0.2%	170
Bhutan	5	4	10.0%	0.5
China	9572	6701	4.7%	2685
India	5101	3571	2.6%	2165
Myanmar	395	276	4.1%	127
Nepal	1572	1100	0.4%	1020
Pakistan	368	257	1.4%	197

Data sources: Zomer et al. 2008a; FAO 2009c

Only project activities that are additional are eligible as climate mitigation projects. Consequently, the current afforestation and reforestation efforts in each country were assessed and projected for the next 20 years in order to set up the baseline scenario. From this, it is possible to estimate the additional potential ARR areas within the HKH region.

During the next step, the additional ARR areas were stratified according to different climate zones. The plantations were divided into short rotation (7 years, e.g. *Eucalyptus* spp., *Casuarina* spp., *Acacia* spp.) and long rotation or natural regeneration (40-50 years, *Tectona grandis*, *Shorea robusta*, *Pinus* spp.) forest plantations. A study from India (Ravindranath et al. 2007) was used as a reference in order to estimate the aerial shares of each plantation type and agro-ecological zone.

Table 14 illustrates the final estimation of biophysical potentials in the HKH region using the default sequestration values shown in Table 5.

Having the biggest areas of potential ARR land, China and India exhibit the highest annual mitigation potentials with 26.5 and 22.1 million t CO_2 respectively. Apart from this, Nepal has a significant potential with 10.4 million t CO_2 and potential annual revenues of 104 million US$ at a carbon price of 10 US$ per t CO_2.

Rangeland

The default value ranges shown in Table 5 indicate the average sequestration potentials for five different management practices, namely vegetation cultivation (9.39 t CO_2e/ha/yr), avoided land cover change (0.40 t CO_2e/ha/yr), grazing management (2.16 t CO_2e/ha/yr), fertilisation (1.76 t CO_2e/ha/yr), and fire control (2.68 t CO_2e/ha/yr). The figures are drawn from a database developed by Tennigkeit and Wilkes (2008).

The sequestration potentials of grassland are highly dependent on site-specific variables, such as vegetation, soil types, climate, and land use history. The first step of the analysis was to identify the productivity of the grasslands from literature, and then to stratify the permanent grassland areas into broad classes (Figure 12) as delineated by Chen et al. (1998), i.e., into high yield, fair yield, and low yield grassland types. Since most of the studies reviewed report significant degradation in the region caused by overstocking, the default value for grazing management was used for the purpose of this study, reduced accordingly dependent on the productivity (high yield class = 2.16, medium yield class = 1.43, low yield class=0.71).

Table 15 illustrates the annual carbon sequestration potentials within rangelands for each of the HKH countries. Not surprisingly, China possesses the highest annual potential with 64.1 million t CO_2, followed by Afghanistan (19.8 million t CO_2) and India (19.1 million t CO_2).

Table 14: **Biophysical potential of ARR activities in the HKH Countries**

Country	ARR available land/('000 ha)	Biophysical ARR potential (million t CO_2 yr^{-1})	Potential annual revenues (millions of US$)
Afghanistan	n.a.	n.a.	n.a.
Bangladesh	170	1.8	18
Bhutan	0.5	0	0
China	2685	26.5	265
India	2165	22.1	221
Myanmar	127	1.5	14.8
Nepal	1020	10.4	104
Pakistan	197	1.8	18

Data source: Ravindranath 2007

Table 15: **Rangeland area, annual carbon sequestration rates and resulting revenues for HKH regions**

Country	Rangeland area ('000 ha)	Biophysical rangeland potential (million t CO_2 yr^{-1})	Potential annual revenues (millions of US$)
Afghanistan	17,961.9	19.8	197.6
Bangladesh	29.0	0.1	0.6
Bhutan	62.5	0.1	0.7
China	79,189.7	64.1	641.4
India	15,791.7	19.1	190.9
Myanmar	79.1	0.2	1.7
Nepal	1,729.6	2.1	20.9
Pakistan	4,082.4	4.5	44.9

Source: FAO 2009b

Regional comparative analysis of biophysical mitigation potential

The whole of the HKH region is made up of a remarkable mosaic of landscapes, shaped by natural and/or human processes. The different broad land use classes used in the analysis are in reality expanded to multiple, highly complex land use systems with often no clear distinction possible between them. A clear indication for these overlaps and interactions between land use systems is the data inconsistency found in the literature concerning the area distribution of land uses such as forests and its distinction from, say, agricultural land. Nevertheless, the study revealed some clear messages that can be drawn from the results with regard to biophysical potentials of carbon mitigation in the HKH region.

The comparative analysis shows clearly that in most parts of the HKH, only a mitigation approach combining activities in different land uses provides benefits for all countries (Figure 18a). Likewise, it also suggests that only this type of a multi-sectoral landscape-based approach will provide sufficient incentive for all countries to show interest. With regard to the political debate on whether to establish a broader land use mitigation mechanism for the forthcoming post-Kyoto commitment period, the results favour developing a regional approach integrating most land uses into one mechanism, along the lines of proposed AFOLU (also sometimes referred to as REDD++) approaches.

With respect to avoided unplanned deforestation (AUD), Myanmar and Nepal have the highest potential on a per hectare basis (Figure 18b). Despite being proportionally smaller than the big regional countries China and India, Myanmar and Nepal have the highest potential on a per hectare basis with regard to AUD. The potential for reducing forest degradation (AFD) has been certainly both over- and under- estimated in some of the countries, but the results prescribe a definite potential throughout the whole region. Due to its high percentage of pristine tropical rainforests, Myanmar can be seen as a 'classical' country for future REDD project activities.

Improved forest management (IFM) and afforestation, reforestation or revegetation (ARR) activities have high potentials in China and India as well as in Nepal. Considering the large areas of waste- and marginal land in India and China allows the assumption of potentially higher reforestation activities. The potential of IFM, dependent on already existing forestry institutions, is concentrated in China, which is well reflected by the fact that vast areas of forest plantations (mainly pine) need to be silviculturally improved. To some extent, this also applies to India. In Nepal, a high potential exists for IFM within the forest areas under the community forest management regime. According to FAO (2009f), about 75% of the forest in the mid hills and 15% of the Terai will be managed directly by local forest user groups by the year 2020. Furthermore Bhutan, though the smallest country, still has a considerable potential for IFM.

Rangeland management activities on the Qinghai-Tibet plateau, in north-western India, and in Afghanistan show high carbon mitigation potentials. Studies from Tibet show that grasslands are overstocked and carbon finance could play a role in providing herders with an incentive to reduce stocking rates (Tennigkeit and Wilkes 2008), thus leading to a high biophysical potential. In the semi-arid rangelands of India and Afghanistan, the activities of vegetation cultivation for increased biomass could lead to additional potentials (not considered in this study).

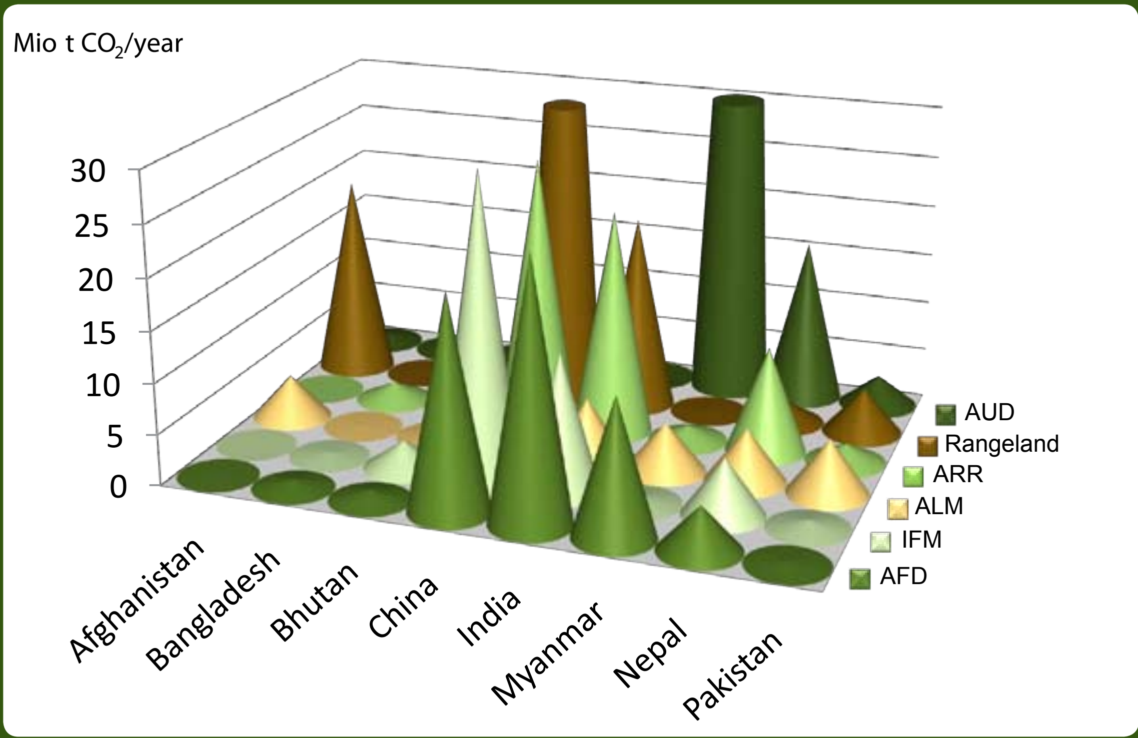
Promotion of sustainable agricultural land management (ALM) practices is well suited for regional project approaches covering whole landscapes. Since soil carbon sequestration potentials are dependent on cropping systems (maize-based, rice-based), management systems (tillage, manure application), soil types, and climate factors, a systems-based, regional project approach should be favoured in maize-based farming systems (e.g. focusing on residue management in mixed farming/livestock systems in the Indian and Nepali mid-hills). Projects in the agricultural commodity sector are also of particular interest, such as tea, rice, sugarcane, and agroforestry.

Mitigation activities, particularly within a broad multi-sectoral landscape approach, are clearly synergetic with adaption strategies to climate change. The HKH region, notably prone to climate changes with far-reaching consequences for ecosystems and livelihoods, needs clear adaptation strategies in the whole land use sector. Promoting mitigation activities, especially as a holistic approach, is also an adaptation strategy since the reversing of land degradation, enhancement of the natural resource base, and increased crop productivity and food security are among the important potential co-benefits apart from generating carbon credits.

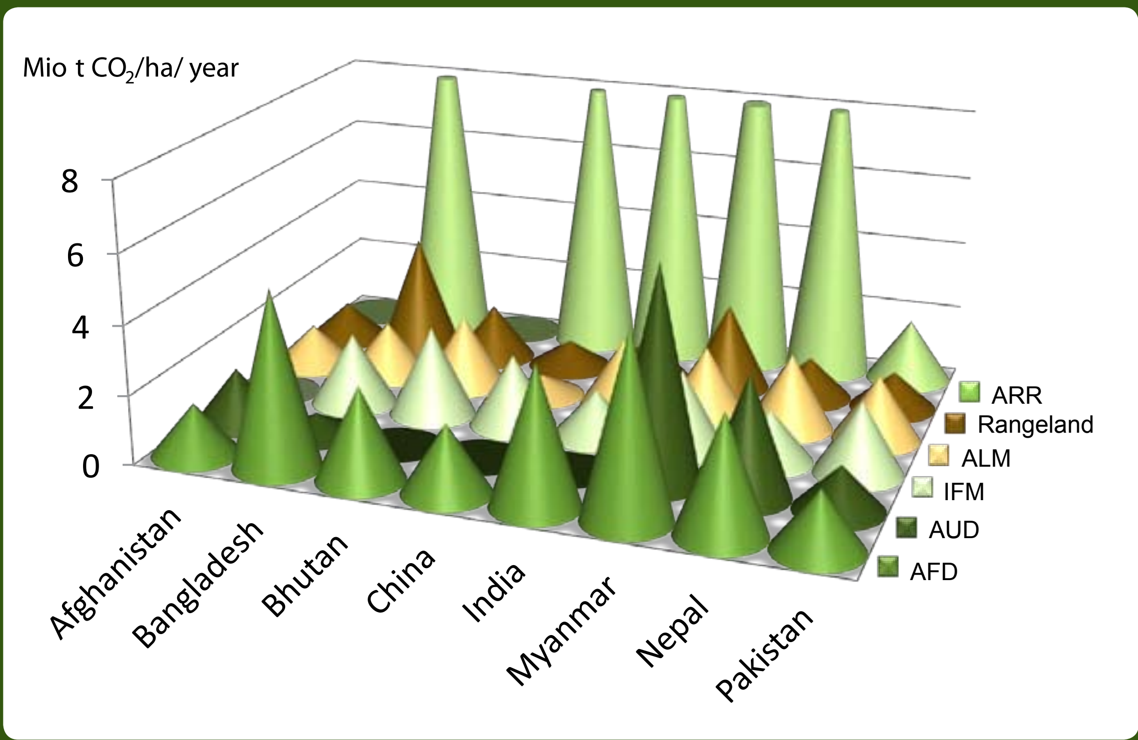
Figure 18: **Annual carbon mitigation potentials in the HKH region**

ARR = afforestation, reforestation, revegetation; Rangeland = rangeland management;
ALM = agricultural land management; IFM = improved forest management;
AUD = avoided unplanned deforestation; AFD = avoided forest degradation

a) in million t CO_2e total per year



b) in million t CO_2 per hectare per year



Institutional safeguards in view of 'good carbon governance'

In the following, we look at the institutional arrangements and good governance (GG) issues that have to be considered when promoting frameworks for REDD/REDD+ or other carbon finance schemes in the land use sector. Since discussion on institutional aspects and good governance in carbon projects has intensified only recently, there is only limited experience to draw upon. Some countries have started to consider and design institutional frameworks for the implementation of REDD. Due to the complex nature of REDD schemes, these frameworks have to be based on a comprehensive, country-specific analysis of the institutional setting (including organisational and legal as well as good resource governance). Reviews of these early activities provide first indications, but ultimately only an analysis of the specific institutional environment of various countries in the HKH region will provide the insights required to set up safeguards for carbon finance projects in the region.

It was beyond the scope of this present study to provide an in-depth analysis of the respective institutional arrangements or an assessment of resource governance in the various HKH countries. However, it is important to emphasise that carbon projects need to be embedded in a sound institutional environment, one which secures their contribution to wider 'sustainable development' beyond the mere sequestration of carbon (as it had been claimed for CDM projects previously).

Questions pertinent to the architecture of future carbon mitigation schemes have become particularly clear in early experiences with REDD projects. Debate continues on whether such schemes will be mainly supported by public funding or market driven investments. What is the right scale for carbon finance schemes? How will reference levels for REDD payments be set? How can leakage be dealt with? How to ensure permanence and assign liability? And How to measure, report, and verify (MRV) carbon emission reductions from forests? or How to achieve a maximum of co-benefits and avoid doing harm?

Whatever the answers to these questions will be, the appropriate institutional frameworks will be vital to make carbon finance or REDD projects workable, credible, and legitimate.

Workable, credible, and legitimate institutions

Critical to the ability to effectively implement land rights regimes (which are themselves critical to successful carbon finance) is the establishment of institutions that can enforce rights in each jurisdiction.

For example, there is no settled approach to institutional governance of forests – countries in the region mainly rely on their forestry departments as the exclusive state agencies in charge of managing their forest resources. Because the preconditions for carbon finance require multi-sectoral cooperation, a holistic approach to the issue of forest management is preferable. Agencies typically responsible for land title may differ from departments with responsibility for forest management and enforcement. However, there is significant interplay between the two areas in the implementation of REDD. Unless comprehensive land-use laws are enforced, forest laws alone can be ineffective and may result in both intentional and unintentional land use conversion and illegal logging.

To secure the viability of carbon mitigation and finance schemes the relevant institutions have to be able to

- register, monitor and enforce the transfer of interests in land;
- monitor and enforce forest activities both on national and project-by-project level;
- practice transparent, independent, and accountable reporting; and
- have predictable and certain regulations to mitigate permanence risks with respect to land-based carbon stocks.

Identifying eligible land and tenurial conflicts

Uncertainty surrounding land title is one of the most significant threats to any land-use carbon finance scheme. Such schemes must identify eligible and/or feasible areas of land for the mitigation activities and address problems of unclear and conflicting land tenure.

There are two separate components to this issue: establishment of legal certainty surrounding land titles; and enforcement of existing land titles.

National land-rights and land-use laws must be credible and capable of enforcement in each jurisdiction prior to the creation of a carbon scheme. Unless general land-use laws are capable of proper identification and enforcement, the potential for disputes will arise between conflicting interests, potentially undermining the schemes.

The schemes should also clearly locate those areas of land upon which the mitigation activities can take place and identify the types of concessions or licences required to carry them out. Where a country-wide approach is adopted, similar considerations will need to be given to how to determine which land-based activities will be part of the national baseline.

The granting of concessions and licences should be transparent and accountable and should fit with existing land rights regimes, particularly common property rights and other existing traditional arrangements. For example, a carbon finance project should specify if the consent of other governmental departments is required and/or what notice or consultation requirements might exist. This necessitates finalising and settling rights of appeal, entitlements, and other grounds for the assertion of legal interests in land.

In addition, managing competing interests in land will be critically important. Any carbon scheme should, where possible, identify priorities between competing land uses, and provide a mechanism to avoid future conflicts (e.g. requiring prior land use concessions to be cancelled before the project can take place) or to resolve disputes when conflicts arise.

Rights of interest in carbon

Clarity over tenure and resource rights together with the carbon asset is critical to prevent dispute between competing stakeholders. Carbon rights are intangible assets that are created by legislative and contractual arrangements. Clear legislative frameworks should be in place to provide for their creation and ownership.

Carbon rights should preferably be property rights that are registered against the land title and bind other interests in the land. This ensures that the carbon right is sufficiently enforceable and secure against the title for the carbon rights holder to participate within any trading scheme, and will grant the carbon rights holder with remedies against any inconsistent uses.

Land use based carbon finance schemes should therefore determine

- where the right to carbon and environmental benefits sits (separate proprietary interests vs. rights that are linked to the proprietary interest in the forest or land); if carbon credits are to be created, it is preferable to have a separate carbon right;
- clarify who has the original right or interest to the carbon rights or environmental benefits – is it the government or landowner; and
- determine if carbon rights can be transferred to third parties.

The selection of project partners and beneficiaries of carbon projects is crucial for the sustainability of any carbon project. To this end, clear and preferably nationally harmonised approaches need to be developed as to which entities are eligible to hold carbon rights and/or have other rights over forest resources. For example, will foreign owners be able to hold carbon rights in the land use sector?

Local communities and indigenous people

The way in which carbon finance schemes interact with communal and indigenous land tenures and rights needs to be determined. The schemes should specify what consents are required from indigenous landholders and who is entitled to participate. They should also spell out how any compensation, entitlements, or profits will be distributed. In particular, carbon schemes have to address the rights and remedies of indigenous peoples. Indigenous people should be consulted on the development of legal frameworks to ensure that their rights are respected, and where they have a proprietary, equitable, or customary interest in land and forest resources, their consent for carbon mitigation activities must be obtained in an informed manner. Indigenous people should also be involved in the benefit sharing from such activities.

Carbon finance schemes should specify what rights (if any) local natural resource dependent communities and/or indigenous peoples will have to be consulted in advance of any project-level activity and to give (or withhold) their prior consent to such activity, and if so, on what basis and through what procedure. Furthermore, a procedure needs to be specified whereby participants in carbon activities can establish that they have satisfied any applicable requirements with respect to local communities and indigenous people.

Why governance issues matter – the example of REDD

Key governance issues surrounding REDD schemes

Successful implementation of any land use based carbon finance project depends upon the will and ability of states to govern their natural resources effectively, especially in the case of REDD projects. There is a well-established consensus that failures of governance are major underlying causes of land/forest degradation and deforestation:

- Government policies often promote forest conversion for agriculture, settlements, or other land uses that lead to environmental degradation while contributing little to economic growth and poverty reduction.
- Governments do not effectively regulate the forest industry. Forestry concessions often go to the privileged elite, and corruption can be widespread. At the same time, forest laws, regulations, and procedures are often ambiguous and overlapping, and are characterised by a lack of transparency and weak enforcement and accountability; in addition efforts to decentralise authority are often incomplete (Kanninen et al. 2007; Larson and Ribot 2007).
- Traditional forest users lack secure property rights. Without secure tenure, these users lack the basis for sustainable management (Kanninen et al. 2007).
- When communities hold common or customary rights to forests, local institutions often lack the capacity to specify clear rights and responsibilities for managing forests as well as an ability to mediate disputes (Ostrom, cited in Kanninen et al. 2007). Rather than recognising common ownership, countries often provide individual titles or titles to a small part of communal territories.
- Because some indigenous people lack legal recognition as citizens, communities, or peoples, they face additional barriers in obtaining rights to their land (White et al. 2008).
- Disputes often result from discrepancies between customary and statutory land governance systems. In mid-2008, 71 violent conflicts over allocation of natural resources were recorded worldwide, around two-thirds of which were driven by contested land rights claims. Many of the conflicts occur in forests. 'Between 1990 and 2004, armed conflicts took place in almost 9 per cent of the world's dense, mainly tropical, forest; in Africa, over one-half of the continent's forests and 52 million people were affected' (White et al. 2008).

If governance issues are not addressed properly REDD (or any other carbon finance scheme, for that matter) are at serious risk. Conflict over who owns the forests and the value of forests complicates the process of making effective, efficient, and fair decisions about forest management and use. This is currently being debated with particular intensity with respect to the architecture of future REDD regimes. While there is the potential to improve forest governance, planning and implementation of REDD could fail to reduce forest emissions and even create perverse incentives to increase emissions and threaten the rights and livelihoods of forest-dependent communities, if governance issues are not addressed. It has been suggested that large financial flows under a national REDD programme could fuel conflict and create new opportunities for forest sector corruption. At the same time, the new value of forest lands for carbon storage could encourage governments and commercial interests to actively deny – or passively ignore – the rights of indigenous and forest-dependent communities to access and exert control over forest resources (Brown et al. 2008).

A recent review on the links between REDD and poverty found the implications of REDD proposals for the poor fall into three categories: 1) REDD could provide new benefits to the poor such as increased income or improved local environmental assets; 2) it could do no harm, but offer no new benefits (if there is no investment in areas or activities that relate to the poor); and 3) it could threaten the poor through elite capture of the benefits, lost access to environmental assets, and/or lack of voice in REDD decision-making (Peskett et al. 2008). Without clear land and carbon rights, the local co-benefits that could help ensure the permanence of forest emission reductions are unlikely to be realised.

Strengthening forest governance at national and sub-national levels

At national and sub-national levels, a carbon finance mechanism will need to integrate with and/or encourage forest governance reform processes that aim to clarify and secure the rights of forest-dependent communities, facilitate the equitable sharing of benefits, and promote sustainable forest management. We highlight five key elements of an enabling policy and institutional framework for planning and implementation of REDD(+) at national and sub-national levels:

1. Multi-stakeholder dialogue to design national and local policy and institutions to implement carbon finance
2. Integration of carbon finance into national development policy and planning processes
3. Reform of national forest policy, and legal and regulatory frameworks
4. Independent monitoring of carbon and governance
5. Procedural rights of public access to information, participation, and justice

Multi-stakeholder dialogue on carbon finance

Multi-stakeholder dialogue is widely proposed as the foundation for planning and implementation of carbon finance, for example through establishment of a multi-stakeholder national carbon finance working group. The Eliasch Review points to experience with multi-stakeholder dialogue processes under the National Forest Programme (NFP) approach and the European Union's Forest Law Enforcement, Governance and Trade Programme (FLEGT) as 'good models that can contribute to higher levels of trust between governments, the private sector, NGOs and community groups' (Eliasch 2008).

Institutional improvements

Institutional improvements can both promote good governance of carbon schemes and minimise their transaction costs. Transaction costs include all the time and money expended developing and implementing a carbon finance project. Of these two components, time is easily the one most often overlooked (unless someone is billing for it). These costs include the time required to

- assess which ecosystem services could be the focus of a carbon finance deal,
- compare them to other options,
- survey prospective buyers,
- negotiate an agreement,
- implement the agreement, and
- monitor and, if needed, verify that the agreement is being met.

At one extreme, and in cases where communities and land managers have little prior organisational expertise, start-up and transaction costs can absorb a significant portion of the seller's hoped for profit. It is therefore critical to estimate and review transaction costs throughout the process — a costly activity, and one made difficult by the fact that all costs will vary not only from project to project, but also throughout the lifecycle of many individual projects.

If the costs are too great, the carbon finance project developers should explore ways of covering them, or even adjust or halt the process to address expenditures.

Solutions may be quite simple. It's sometimes possible to add carbon finance implementation to other reliable, pre-existing conservation, or rural development/sustainable management projects that have already established an infra-structure for handling the detail-oriented and costly tasks of monitoring and managing.

References

Adhikari S; Bajracharaya RM; Bishal K (2009) 'A review of carbon dynamics and sequestration in wetlands.' *Journal of Wetlands Ecology* 2: 42-46

Angelsen, A (ed) (2008) *Moving ahead with REDD; issues, options and implications*. Bogor (Indonesia): CIFOR

Avoided Deforestation Partners (2009) *REDD methodology modules. A new methodology following a modular approach intended to be used for projects that reduce emissions from deforestation and degradation*. Washington, DC: Voluntary Carbon Standard Association. http://www.v-c-s.org/methodology_rmm.html

Banskota, K; Bhaskar, SK; Skutsch, M (2007) *Reducing carbon emissions through community-managed forests in the Himalaya*. Kathmandu: ICIMOD

Banskota, M (2000) 'The Hindu Kush-Himalayas: searching for viable socio-economic and environmental options.' In Banskota, M; Papola, TS; Rischter, J (eds) *Growth, Poverty Alleviation and Sustainable Resource Management in the Mountain Areas of South Asia*. Kathmandu: ICIMOD

Barik SK; Choudhury D; Darlong V; Gupta V; Palit S; Roy I; Singh I; Tiwari BK; Upadhyay S; Poffenberger M (eds) *Indigenous forest stewards of Northeast India*. South Lake Tahoe (CA, USA): Community Forestry International

Bhatt, BP; Negi, AK; Todaria, NP (1994) 'Fuelwood consumption pattern at different altitudes in Garhwal Himalaya.' *Energy* 19: 465-8

Bird, M; Veenendaal, E; Moyo, C; Lloyd, J; Frost, P. (2000) 'Effect of fire and soil texture on soil carbon in a sub-humid savanna, Matopos, Zimbabwe.' *Geoderma* 94: 71-90

Brown, S; Braatz, B (2008) 'Methods for estimating CO_2 emissions from deforestation and forest degradation.' In *GOFC-GOLD. Reducing greenhouse gas emissions from deforestation and degradation in developing countries: a sourcebook of methods and procedures for monitoring, measuring and reporting*, GOFC-GOLD, Report version COP 13-2. Alberta (Canada): GOFC-GOLD Project Office, Natural Resources Canada

Bujarbarua, P; Baruah, S. (2009) 'Vulnerability of fragile forest ecosystem of Northeast India in context with the global climate change: an ecological projection.' *IOP Conf. Series: Earth and Environmental Science* 6(7): 072016

Carbon Decisions International (2009) *Figure of carbon and landuse mitigation options*. Costa Rica: CDI

Chaudhary, RP (2000) 'Forest conservation and environmental management in Nepal: a review.' *Biodiversity and Conservation* 9: 1235-1260

Chen, Y; Fischer, G (1998) *A new digital geo-referenced database of grassland in China,* International Institute for Applied Systems Analysis Interim Report, IR-98-062. Laxenburg (Austria): IIASA

Chhabra, A; Palria, S; Dadhwal, VK (2002) 'Growing stock-based forest biomass estimate for India.' *Biomass and Bioenergy* 22: 187-194

Earthtrends (2003) *Country profiles: forests, grasslands, and drylands*. Washington, DC: WRI. http://earthtrends.wri.org/country_profiles/index.php?theme=9

Eliasch, J (2008) *Financing global forests ('Eliasch review')*. London: Office of Climate Change

Encyclopaedia Britannica (2008) 'World data.' In *Encyclopaedia Britannica*. Chicago: Encyclopaedia Britannica. http://www.britannica.com/

FAO (1994) *The Global Assessment of Soil Degradation (GLASOD): National soil degradation maps*. Rome: FAO http://www.fao.org/landandwater/agll/glasod//glasodmaps.jsp

FAO (2006) 'Country tables.' *In Global Forest Resources Assessment 2005*. Rome: FAO. http://www.fao.org/forestry/32085/en/

FAO (2007) *The state of food and agriculture 2007*. Rome: FAO. http://www.fao.org/docrep/010/a1200e/a1200e00.htm

FAO (2009a) *Bhutan forestry outlook study,* Asia-Pacific Forestry Sector Outlook Study II, Working Paper Series, Working Paper No. APFSOS II/WP/2009/04. Bangkok: FAO-ROAP

FAO (2009b) *Country pasture/forage resource profiles*. Rome: FAO. www.fao.org/ag/AGP/AGPC/doc/pasture/forage.htm

FAO (2009c) *FAOSTAT*. Rome: FAO. http://faostat.fao.org/default.aspx

FAO (2009d) *India forestry outlook study,* Asia-Pacific Forestry Sector Outlook Study II, Working Paper No. APFSOS II/WP/2009/06. Bangkok: FAO-ROAP

FAO (2009e) *Myanmar forestry outlook study,* Asia-Pacific Forestry Sector Outlook Study II, Working Paper No. APFSOS II/WP/2009/07. Bangkok: FAO-ROAP

FAO (2009f) *Nepal forestry outlook study,* Asia-Pacific Forestry Sector Outlook Study II, Working Paper No. APFSOS II/WP/2009/05. Bangkok: FAO-ROAP

FAO (2009g) *Pakistan forestry outlook study,* Asia-Pacific Forestry Sector Outlook Study II, Working Paper No. APFSOS II/WP/2009/28. Bangkok: FAO-ROAP

FAO/IIASA (2000) *Global agroecological zones*. Rome: FAO. http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm

FAO/IIASA/ISRIC/ISSCAS/JRC (2009) *Harmonized world soil database (version 1.1)*. Rome: FAO, and Laxenburg (Austria): IIASA

Forest Survey of India (1999) *State of Forest Report 1999*. Dehra Dun (India): FSI

Forest Survey of India (2001) *State of Forest Report 2001*. Dehra Dun (India): FSI

Forest Survey of India (2005) *State of Forest Report 2005*. Dehra Dun (India): FSI

Gami, S; Ladha, J; Pathak, H; Shah, M; Pasuquin, E; Pandey, S; Hobbs, P; Joshy, D; Mishra, R (2001) 'Long-term changes in yield and soil fertility in a twenty-year rice, wheat experiment in Nepal.' *Biology and Fertility of Soils* 34: 73-78

Gorham, E (1998) 'The biochemistry of northern peatlands and its possible responses to global warming.' In Woodwell, GM; Mackenzie, FT (eds) *Biotic feedbacks in the global climatic systems*. New York: Oxford University Press

Harris, RB (2009) 'Rangeland degradation on the Qinghai-Tibet plateau: A review of the evidence of its magnitude and causes.' *Journal of Arid Environments* 74 (1): 1-12

Hungate, B; Holland, E; Jackson, R; Chapin, F; Mooney, H; Field, C. (1997) 'The fate of carbon in grasslands under carbon dioxide enrichment.' *Nature* 388: 576-579

ICIMOD (2005) *Atlas of the Himalaya*. Kathmandu: ICIMOD

ICIMOD (2009) *Climate change in the Himalayas,* Information Sheet 03/09. Kathmandu: ICIMOD

IPCC (2006) 'Agriculture, forestry and other land use.' In Eggleston, HS; Buendia, L; Miwa, K; Ngara, T; Tanabe, K. (eds) *IPCC Guidelines for National Greenhouse Gas Inventories*. Hayama (Japan): IPCC/IGES

IPCC (2007) *Climate Change 2007: Mitigation of Climate Change,* Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press

Islam, KR; Ahmed, MR; Bhuiyan, MK; Badruddin, A (2001) 'Deforestation effects on vegetative regeneration and soil quality in tropical semi-evergreen degraded and protected forests of Bangladesh.' *Land Degradation & Development* 12: 45-56

Kahrl, F; Yufang, S; Tennigkeit, T; Mei, Y (2009) 'China's forests as a carbon resource: an options assessment.' In *Proceedings 17th European Biomass Conference in Hamburg, Germany, 28 June – 3 July 2009*. Florence (Italy): ETA-Renewable Energies

Kanninen, M; Murdiyarso, D; Seymour, F; Angelsen, A; Wunder, S; German, L (2007) *Do trees grow on money? The implications of deforestation research for policies to promote REDD*. Bogor (Indonesia): Center for International Forestry Research (CIFOR)

Kerkhoff, E; Sharma, E (2006) *Debating shifting cultivation in the Eastern Himalayas*. Kathmandu: ICIMOD

Korontzi, S; Justice, C; Scholes, R (2003) 'Influence of timing and spatial extent of savanna fires in Southern Africa on atmospheric emissions.' *Journal of Arid Environments* 54: 395-404

Kuniyal, JC (2003) 'Regional imbalances and sustainable crop farming in the Uttaranchal Himalaya, India.' *Ecological Economics* 46: 419-435

Ladha, JK; Dawe, D; Pathak, H; Padre, AT, Yadav, RL; Singh, B; Singh, Y; Singh, P; Kundu, AL; Sakal, R; Ram, N; Regmi, AP; Gami, SK; Bhandari, AL; Amin, R; Yadav, CR; Bhattarai, EM; Das, S; Aggrawal, HP; Gupta, RK; Hobbs PR (2003) 'How extensive are yield declines in long-term rice-wheat experiments in Asia?' *Field Crops Research* 81: 159-180

Lal, R (2004) 'Soil carbon sequestration in India.' *Climate Change* 65: 277-296

Leach, G (1987) 'Household energy in South Asia.' *Biomass* 155: 84

Leimgruber, P; Kelly, DS; Steininger MK; Brunner J; Müller T; Songer M (2005) 'Forest cover change patterns in Myanmar (Burma) 1990-2000.' *Environmental Conservation* 32 (4): 356-364

Lele, N; Joshi, PK (2008) 'Analyzing deforestation rates, spatial forest cover changes and identifying critical areas of forest cover changes in North-East India during 1972-1999.' *Environmental Monitoring and Assessment* 156: 159-170

Ludwig, J; Wiens, J; Tongway, D (2000) 'A scaling rule for landscape patches and how it applies to conserving soil resources in savannas.' *Ecosystems* 3: 84-97

Maskey, S; Shrestha, RK; Shrestha, B; Tripathi, BP; Bhattarai, EM; Munankarmy, RC; Khadka, YG (2002). *Strategies for soil fertility research in the hills of Nepal*. Kathmandu (Nepal): Soil Science Division, Nepal Agric. Research Council; DFID Nepal/Hill Agriculture Research Project

Milchunas, D; Lauenroth, W (1989) 'Quantitative effects of grazing on vegetation and soils over a global range of environments.' *Ecological Monographs* 63(4): 328-366

Nagaland Pollution Control Board (2005) *State of Environment Nagaland 2005*. Kohima (India): Nagaland Dept. of Forests, Ecology, Environment & Wildlife. http://www.teriin.org/div/moe_nagaland.pdf

Nagendra, H; Pareeth, S; Sharma, B; Schweik, CHM; Adhikari, KR (2008) 'Forest fragmentation and re-growth in an institutional mosaic of community, government and private ownership in Nepal.' *Landscape Ecology* 23: 42-54

NEDFi Databank (2008) 'Rubber Plantation in North East India.' *North East Resource Databank*. Guwahati (Assam, India): North Eastern Development Finance Corporation Ltd. http://databank.nedfi.com/content/rubber-plantation-north-east-india

NEDFi Databank (2009) 'Forests of Nagaland.' *North East Resource Databank*. Guwahati (Assam, India): North Eastern Development Finance Corporation Ltd. http://databank.nedfi.com/content/forests-nagaland

Negi, AK; Bhatt, BP; Todaria, NP (1999) 'Local population impacts on the forests of Garhwal Himalaya, India.' *The Environmentalist* 19: 293-303

Pearson, T; Walker, S; Brown, S (2005) *Sourcebook for land use, land-use change and forestry projects*. Washington DC: Winrock International and the World Bank Biocarbon Fund. http://www.winrock.org/Ecosystems/files/Winrock-BioCarbon_Fund_Sourcebook-compressed.pdf

Penman, J; Gytarsky, M; Hiraishi, T; Kruger, D; Pipatti, R; Buendia, L; Miwa, K; Ngara, T; Tanabe, K; Wagner, F. (eds) (2003) *Good practice guidance for land use, land-use change and forestry*. Hayama (Japan): IPCC/IGES. http://www. ipccnggip. iges. or. jp

Peskett, L; Huberman, D; Bowen-Jones, E; Edwards, G; Brown, J (2008) *Making REDD work for the poor*. Gland (Switzerland): IUCN

Prasad, VK; Badarinath, KVS; Tsuruta, H; Sudo, S; Yonemura, S; Cardina, J; Stinner, B; Moore, R; Stinner, D; Hoy, C (2003) 'Implications of land-use changes on carbon dynamics and sequestration – evaluation from forestry datasets, India.' *The Environmentalist* 23: 175-187

Ravindranath, NH; Murthy, IK; Chaturvedi, RK; Andrasko, K; Sathaye, JK (2007) 'Carbon forestry economic mitigation potential in India, by land classification.' *Mitigation and Adaptation Strategies for Global Change* 12: 1027-1050

Renner, SC; Rappole, JH; Leimgruber, P; Kelly, DS; Nay Myo Shwe, Aung, T; Aung, M (2007) 'Land cover in the Northern Forest Complex of Myanmar: new insights for conservation.' *Oryx* 41: 27-37

Ribot, JC; Agrawal, A; Larson, A (2006) 'Recentralizing while decentralizing: How national governments reappropriate forest resources.' *World Development* 34 (11): 1864-1886

Rights and Resources Initiative (2008) *Seeing people through the trees: Scaling up efforts to advance rights and address poverty, conflict and climate change*. Washington DC: RRI

Roy, PS; Joshi, PK (2002) 'Forest cover assessment in north-east India–the potential of temporal wide swath satellite sensor data (IRS-1C WiFS).' *International Journal of Remote Sensing* 23 (22); 4881-4896

Schild, A (2008) ICIMOD's Position on climate change and mountain systems. *Mountain Research and Development* 28 (3/4): 328-331

Schlensinger, WH (1997) *Biogeochemistry: An analysis of global change*. San Diego (CA, USA): Academic Press

Shrestha, BM; Sitaula, BK; Singh, BR; Bajracharya, RM (2004) 'Soil organic carbon stocks in soil aggregates under different land use systems in Nepal.' *Nutrient Cycling in Agroecosystems* 70: 201-213

Shrestha, RK; Ladha JK; Gami SK; (2006) 'Total and organic soil carbon in cropping systems of Nepal.' *Nutrient Cycling in Agroecosystems* 75: 257-269

Singh, J; Dhillon, SS (1984) *Agricultural geography*. New Delhi: McGraw Hill

Sitaula, BK; Sankhayan, PL; Bajracharya, RM; Singh, BR (2005) 'A systems analysis of soil and forest degradation in a mid-hill watershed of Nepal using a bio-economic model.' *Land Degradation & Development* 16: 435-446

Smith, P; Martino D; Cai Z; Gwary D; Janzen H; Kumar P; McCarl B; Ogle S; O'Mara F; Rice Ch; Scholes B; Sirotenko O; Howden M; McAllister T; Pan G; Romanenkov V; Schneider U; Towprayoon S; Wattenbach M; Smith J (2008) 'Greenhouse gas mitigation in agriculture.' *Philosophical Transactions of The Royal Society* 363: 789-813

Tennigkeit, T; Wilkes A (2008) *An assessment of the potential for carbon finance in rangelands,* ICRAF Working Paper No. 68. Nairobi: ICRAF

Tennigkeit, T; Kahrl, F; Wolke, J; Newcombe, K (2009) *Agricultural carbon sequestration in sub-saharan Africa: Economics and institutions*. Washington DC: World Bank

Than, Than Thwe (2004) *Regionalised population forecast for the Union of Myanmar*. Stuttgart: Institut für Raumordnung und Entwicklungsplanung der Universität Stuttgart

Tiwari, PC (1999) 'Land-use changes in Himalaya and their impact on the plains ecosystem: need for sustainable land use.' *Land Use Policy* 17: 101-111

UNEP (2001) *Nepal: State of the environment 2001*. Bangkok: UNEP

UNEP/GRID (2009) *The vicious cycle of depletion UNEP/GRID-Arendal Maps and Graphics Library*. Arendal (Norway): UNEP/GRID-Arendal. http://maps.grida.no/go/graphic/the-vicious-cycle-of-depletion

Upadhyay, TP; Sankhayan, PL; Solberg, B (2005) 'A review of carbon sequestration dynamics in the Himalayan region as a function of land-use change and forest/soil degradation with special reference to Nepal.' *Agriculture, Ecosystems and Environment* 105: 449-465

Upadhyay, TP; Solber,g B; Sankhayan, PL (2006) 'Use of models to analyse land-use changes, forest/soil degradation and carbon sequestration with special reference to Himalayan region: A review and analysis.' *Forest Policy and Economics* 9: 349-371

VCS (2008) *Guidance for agriculture, forestry and other land use projects (VCS 2007.1, 2008)*. Washington, D.C.: Voluntary Carbon Standard Association. www.v-c-s.org

Wang, GX; Qian, J; Cheng, G; Lai, Y (2002) 'Soil organic carbon pool of grassland soils on the Qinghai-Tibetan Plateau and its global implication.' *Science of the Total Environment* 291: 207–217

WBGU (2009) *Solving the climate dilemma: The budget approach*. Berlin: Wissenschaftl. Beirat der Bundesregierung Globale Umweltveränderungen

White, R; Murray, S; Rohweder, M (2000) 'Grassland ecosystems.' In *Pilot analysis of global ecosystem*. Washington DC: World Resources Institute

Wilkes, A (2008) *Towards mainstreaming climate change in grassland management policies and practices on the Tibetan Plateau*, ICRAF Working Paper No. 67. Nairobi: ICRAF

Willey, Z; Chameides, B (eds) (2007) *Harnessing farms and forests in the low-carbon economy: How to create, measure, and verify GHG offsets*, The Nicholas Institute for Environmental Policy Solutions. London: Duke University Press

World Resources Institute (2009) *Climate analysis indicators tool (CAIT) Version 6.0*. Washington DC: WRI

Zomer R J; Trabucco A; Bossio DA; Verchot LV (2008a) 'Climate change mitigation: A spatial analysis of global land suitability for clean development mechanism afforestation and reforestation.' *Agriculture, Ecosystems and Environment* 126: 67-80

Zomer R J; Trabucco A; Verchot LV; Muys B (2008b) 'Land area eligible for afforestation and reforestation within the Clean Development Mechanism: A global analysis of the impact of forest definition.' *Mitigation and Adaptation Strategies for Global Change* 13: 219-239

Acronyms and abbreviations

AEZ	agro-ecological zone
AFD	avoided forest degradation
AFOLU	agriculture, forestry and other land uses
ALM	agricultural land management
APD	avoided planned deforestation
ARR	afforestation, reforestation and revegetation
AUD	avoided unplanned deforestation
CDM	Clean Development Mechanism
CFM	community forest management
COP	Conference of the Parties
FAO	Food and Agriculture Organization
FLEGT	Forest Law Enforcement, Governance and Trade
FSI	Forest Survey of India
GG	good governance
GHG	greenhouse gas
HKH	Hindu Kush-Himalayas(n)
ICIMOD	International Centre for Integrated Mountain Development
IFM	improved forest management
IPCC	Intergovernmental Panel on Climate Change
LUC	land use change
LULUCF	land use, land-use change and forestry
MDF	medium dense forest
MRV	monitoring reporting and verification
NFP	national forest programme
OF	open forest
REDD	reduced emissions from deforestation and degradation
SALM	sustainable agricultural land management
SOC	soil organic carbon
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Voluntary Carbon Standard
VDF	very dense forest
WBGU	Wissenschaftl. Beirat der Bundesregierung Globale Umweltveränderungen
WRI	World Resources Institute

Annexes

Annex 1: AFOLU carbon mitigation activities by land-use type

Land Use Type	Carbon finance category (VCS terminology)	Carbon mitigation activities/practices
Forest Land	REDD http://www.v-c-s.org/afl.html http://www.v-c-s.org/methodology_rmm.html http://wbcarbonfinance.org/Router.cfm?Page=DocLib&CatalogID=45001	Avoided planned deforestation Avoided unplanned deforestation Avoided unplanned forest degradation
Forest Land	AR/R http://www.v-c-s.org/afl.html	Afforestation/reforestation
Wasteland/ Degraded Land	AR/R http://www.v-c-s.org/afl.html	Revegetation/afforestation
Forest Land	IFM http://www.v-c-s.org/afl.html http://www.v-c-s.org/methodology_eghger.html	Conversion from conventional logging to reduced impact logging Conversion from logged forests to protected forests Extending the rotation age of evenly-aged forests Conversion of low-productive to high-productive forests
Cropland	ALM http://www.v-c-s.org/afl.html	Agronomy: improved crop varieties, extending crop rotations, use of cover crops, multiple cropping (intercropping, rotational cropping) Nutrient management: fertiliser use efficiency, manure management, compost as organic fertiliser Tillage, residue management: conservation tillage, mulching, composting integrated livestock and manure management Water management: terracing, water harvesting, irrigation structures Agroforestry: great variety of agro-silvicultural systems, planting of trees as windbreaks, boundaries, hedges, and counter line tree planting
Pasture Land	Rangeland http://www.v-c-s.org/afl.html	Grazing management: stocking rate management, rotational, planned or adaptive grazing, enclosure from livestock grazing Vegetation cultivation: cultivation of grasslands and legumes, management of vegetation community structure Fire management: reduced fire frequencies, litter management and management of timing of burns
Wetland	Wetland	Avoided cultivation Stopping drainage Restoration

Annex 2: Major agro-ecological regions in the HKH region

Agro-ecological region (AER)	Geographical area ('000 ha) (LGP days)	Distribution	Soil characteristics	Rainfall mm (PET mm) [mean temp. °C]	Classified in major climatic zone (IPCC GPG)	Major land uses, crops grown	Remarks
Cold arid with shallow skeletal soils	15,200 (60)	North-western Himalayas, Ladakh, Gilgit, Lahul & Spiti	Shallow, sandy, skeletal and calcareous, low to medium organic matter content	150-300 (700-800) [9-11°C]	Cold temperate dry	Vegetables, millets, wheat, fodder, pulses, barley, apples, apricots; grazing	Low crop productivity (400-700 kg/ha) nutrient imbalances for normal crop production PNV: sparse forest vegetation
Warm sub-humid to humid with inclusion of perhumid with brown forest and podzolic soils	21,200 (180-210)	Western Himalayas, Jammu and Kashmir, Himachal Pradesh, north-west Uttar Pradesh	Shallow to deep, high organic matter, fine loamy	1000-2000 increasing trend W to E (800-1300) [12-20°C]	Warm temperate wet	Rainfed farming, wheat, maize, rice, millets; terraced uplands, paddy, horticulture	Deforestation and excessive slopes favour soil erosion; soil degradation PNV: moist temperate, subtropical pine, and sub-alpine forests
Warm perhumid eco-region with brown and red hill soil	10,600 (>210)	Eastern Himalayas, Assam, Arunachal Pradesh Sikkim states, northern hills of West Bengal	Shallow to moderately shallow, loamy, brown forest soils, deep, organic matter rich	1600-2600 (1000-1100) [13-25°C]	Warm temperate wet	Jhum cultivation (3-4 yr intervals)with mixed cropping on steep slopes (rainfed); millets, potatoes on upland terraces; paddy in valleys; rice, wheat, maize, vegetables, hill terraces for tea	Steep sloping conditions result in severe erosion; deforestation for shifting cultivation (+ heavy rainfall) leads to severe soil degradation* PNV: subtropical pine forest and temperate wet evergreen forests, subalpine forests
Warm perhumid eco-region with red and lateritic soils	10,600 (270-300)	NE hills, Nagaland, Meghalaya, Manipur, Mizoram and E Tripura	Shallow to very deep, loamy red and yellow soils	2000-3000 (1400-1600) [16-24°C]	Tropical wet	Jhum cultivation with rice as the main crop; millets, maize, potatoes, hill terraces for tea.	Deforestation and shifting cultivation result in severe soil erosion and degradation, small to marginal land holdings PNV: wet evergreen and tropical moist deciduous forests
Northern dry mountains		NWFP	Valley soils are deep and clayey	300 [-10 - 10°C]	Cold temperate dry	Maize, wheat, rice, sugar	Mostly used for grazing NWFP: 6.1 million ha rangelands
Wet mountains		NWFP	Silt loams, silty clays	1700 [0-15°C]	Cold temperate wet	Small area under rainfed maize wheat cultivation	Most of the area under forest
Western dry mountains		Southern NWFP, N Balochistan	Soils in the valleys deep and loamy	300 [10-25°C]	Warm temperate dry	Maize-wheat, grain, fruit crops	Grazing areas
Dry Western plateau		Balochistan		400-500 [13-25°C]	Warm temperate dry	Fruit crops, vegetables, wheat	Mainly used for grazing 27.4 million ha rangelands
Barani (rainfed) lands		NW Punjab		500-900 [10-20°C]	Warm temperate wet	Wheat, millet, oilseed, pulses	

LGP = length of growing period; PET = potential evapotranspiration; PNV = potential natural vegetation

Annex 2 cont...

Agro-ecological region AER)	Geographical area ('000 ha) (LGP days)	Distribution	Soil characteristics	Rainfall (PET mm) [ean Temp. °C]	Classified in major climatic zone (IPCC GPG)	Major land uses, crops grown	Remarks
North eastern mountains	5,234	Wakhan, Badakhshan		300-800 [10 - –1°C]	Polar wet	0.2% rain fed agricultural land; wheat, barley, rice	Mostly barren, rocky land
Central mountains	11,452			300-400 [1-7°C]	Cold temperate dry	12% agricultural land, more rainfed; wheat, maize, barley	Mostly barren, rocky land
Eastern mountains and foothills	5,082			500 [0-24°C]	Warm temperate dry	12% agricultural land, more irrigated; wheat, rice, maize	
Southern mountains and foothills	6,439			400 [8-15°C]	Warm temperate dry	12% agricultural land, more irrigated; wheat, maize, barley	
Northern mountains and foothills	9,030			300 [8-15°C]	Warm temperate dry	30% agricultural land, mostly rainfed	
High Himal	3,350	>2,500m	Rocky soils	1000–2500; varies from east to west [–10-0°C]	Polar/boreal wet	less agricultural importance; grazing	
High mountains	2,899	2,000 – 2,500m	Rocky soils	1000-2500; varies from east to west [–5-10°C]	Polar/boreal wet	Mainly remote forest areas, mountain animal grazing	
Middle mountains	4,350	The Mahabharat range >2000m	Soils extremely variable	1000-2500 varies from east to west [10-20°C]	Warm temperate wet	Intensively cultivated, 60% of the population; paddy, wheat, maize, finger millet	Subtropical dense forest with grazing
Hill zone	1,886	300-1,800 m; Siwaliks	Valleys are very fertile (alluvial deposition)	1000–2500 varies from east to west [10-20°C]	Warm temperate wet	Mainly highly degraded forest areas	Soils unable to retain high precipitation, flash flood hazards;
Terai zone	2,142	66-300 m	Alluvial soils are fertile	1000-2500 varies from east to west [>20°C]	Tropical moist	Intensively cultivated; rice; forests degraded	Less grazing land and forest
Alpine	Whole northern region	>3,500m		<650 [–1-12°C]	Polar/boreal wet		
Cool temperate	Bumthang, Ha, Gasa	2,500-3,500m		650-850 [1-22°C]	Cold temperate dry	Farming dependent on livestock, fruit crops, potatoes, buckwheat, wheat, barley	
Warm temperate	Paro, Thimphu, Trashigang, Lhuntse, Trashi Yangtse	1,800-2,500m		650-850 [1-26°C]	Warm temperate dry	Farming dependent on livestock, fruit crops, potatoes, buckwheat, wheat, barley	

Annex 2 cont...

Agro-ecological region (AER)	Geographical area ('000 ha) (LGP days)	Distribution	Soil characteristics	Rainfall (PET mm) [mean Temp. °C]	Classified In major climatic zone (IPCC GPG)	Major land uses, crops grown	Remarks
Dry sub-tropical	Punakha, Wangdue, Trongsa Trashigang, Mongar	1,200-1,800m		850-1200 [3-29°C]	Warm temperate dry	Farming dependent on livestock, fruit crops, potatoes, buckwheat, wheat, barley	
Humid sub-tropical	Samtse, Trashigang, Zhemgang, Tsirang, Sarpang, Chhukha	600-1,200m		1200-1500 [5-33°C]	Tropical moist	Rice, maize,	
Wet sub-tropical	Samtse, Sarpang, Samdrup Jongkhar	150-600m		2500-5500 [12-35°C]	Tropical wet	Rice, maize	
Northern and eastern hills	1,817	Chittagong hills, 300-900m	Brown hill soils, organic matter content and fertility low	2000-3000 [19-27°C]	Tropical wet	Rice dominated, wheat, tea plantations	
Western mountains ranges and Chin hills	3,601	Chin state; 2100-3000m	Cambisols	>2500	Tropical wet	>85% forest cover; shifting cultivation, Jowar millet main crop, maize, rice in lower regions	Deciduous forest
Shan Plateau and horthern hill region	24,484	Shan, Kachin state	Acrisols	1000-2500	Tropical moist	75-90% forest cover, less agricultural importance	Tropical mountain/evergreen forests
Qinghai-Tibet zone	249,520 (of which HKH represents 66%)	Tibet, Qinghai, Gansu, Sichuan, Yunnan		100-500, in eastern parts up to 1000 [-6.5-10°C]	Polar/boreal wet	Rangeland/pasture most dominating (58m ha alpine meadow grassland, 37m ha of alpine steppe), forest, silvopastoral systems in southern parts (Yunnan, Sichuan)	

Annex 3: ALM practices in the HKH region

Most promising agricultural practices for GHG mitigation in the HKH region

	Afghanistan	Bangladesh	Bhutan	India	Myanmar	Nepal	Pakistan
Reducing emissions	Reduced tillage, improved fertiliser management	Reduced burning of biomass in shifting cultivation		Improved fertiliser management	Reduced burning of biomass in shifting cultivation	Reduced burning of biomass in shifting cultivation	Reduced tillage, improved fertiliser management
Increasing C stocks	Agroforestry, retention of crop residues, reduced tillage	Agroforestry	Agroforestry	Agroforestry, retention of crop residues	Agroforestry	Agroforestry, retention of crop residues	Agroforestry, retention of crop residues, reduced tillage
Improving rice production practises	Irrigation and nutrient management		Irrigation and nutrient management	Irrigation and nutrient management		Irrigation and nutrient management	
Increasing N fertiliser use efficiency	Green manure, retention of crop residues, mixed cropping systems, optimised tillage		Mixed cropping systems	Green manure, retention of crop residues, mixed cropping systems		Mixed cropping systems	Green manure, retention of crop residues, mixed cropping systems, optimized tillage
Decreasing forest conversion		Longer rotations in shifting cultivation		Longer rotations in shifting cultivation	Longer rotations in shifting cultivation	Longer rotations in shifting cultivation	

Acknowledgements

This report is the outcome of a collaborative effort between the International Centre for Integrated Mountain Development (ICIMOD) and Unique Forestry Consultants (Germany). The report authors include Mr Matthias Seebauer, Dr Jochen Statz, and Dr Timm Tennigkeit of Unique Forestry Consultants, with direction, input, editing and review by Dr Robert Zomer and Dr Eklabya Sharma of ICIMOD's Environmental Change and Ecosystem Services (ECES) Programme.

ICIMOD gratefully acknowledges the following colleagues who have contributed, reviewed, and/or provided input to the content of this paper: Dr Madhav Karki, Dr Karma Phuntsho, Dr Bhaskar Karky, Dr Krishna Prasad Oli, and Dr Andreas Schild.

ICIMOD is most grateful to the German Government and GTZ for financial support provided towards the preparation, editing and dissemination of the report.

Production team

Robert Zomer (Coordinator)
A Beatrice Murray (Senior editor)
Dharma R. Maharjan (Layout and design)
Asha Kaji Thaku (Editorial assistant)

Printed by Hill Side Press (P) Ltd., Kathmandu, Nepal

Publication details

Published by International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal

ISBN 978 92 9115 132 5 (Printed)
978 92 9115 133 2 (Electronic)

LCCN 2009-341527

This publication is available in electronic form at www.books.icimod.org.

Citation: ICIMOD (2009) Potential for carbon finance in the land use sector of the Hindu Kush-Himalayan region. Kathmandu: ICIMOD

About ICIMOD

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush-Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Khumaltar, Lalitpur, Nepal
Tel +977-1-5003222 **Fax** +977-1-5003299
Email info@icimod.org **Web** www.icimod.org

For further information contact
Dr Robert Zomer
email rzomer@icimod.org

ISBN 978 92 9115 132 5 (printed)

LCCN 2009-341527