Capability and cost assessment of the major forest nations to measure and monitor their forest carbon

for

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Background

This paper was commissioned by the Office of Climate Change as background work to its report 'Climate Change: Financing Global Forests' (the Eliasch Review). Further information about the report is available from www.occ.gov.uk

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List of Acronyms

CIESEN	Consortium for International Earth Science Information
DANIDA	Danish International Development Assistance
DFID	Department for International Development
EU	European Union
FAO	Food and Agricultural Organisation of the United Nations
FCPF	World Bank led Forest Carbon Partnership Facility
FRA	Forest Resources Assessment (FAO – every 5 years)
GHG	Green House Gas
GIS	Geographic Information Systems
GMES	Global Monitoring for Environment and Security
IPAM	Amazon Institute for Environmental research
IPCC	Intergovernmental Panel on Climate Change
IPCC GPG	IPCC Good Practice for Land Use, Land-Use Change and Forestry
ITTO	International Tropical Timber Organization
MERIS	Medium Resolution Imaging Spectrometer Instrument
MODIS	Moderate Resolution Imaging Spectrodiameter
PRSPS	Poverty Reduction Strategy Papers
REDD	Reducing emissions from deforestation and forest degradation
RS	Remote Sensing
SBSTA	Subsidiary Body for Scientific and Technological Advice
SOFO	Biennial State of the World's Forests (FAO)
UNFCCC	United Nations Framework Convention on Climate Change
UXO	Unexploded ordinance; land mines, *etc*
WB	World Bank
WHRC	Wood's Hole Research Centre

Executive Summary

The aims and objective of this report are to provide an assessment of national capacity and capability in 25 tropical countries for measuring and monitoring forest as a requirement for reporting on REDD under IPCC guidelines.

The approach adopted followed two strands. The first was to assess the capacity and capability of each country using their reporting to IPCC and FAO as an evidence base. This was then triangulated through parallel published sources (particularly material from ITTO), consultation with expert reviewers and contact with country representatives for FAO.

Having determined the capacity and capability on the basis of evidence from reporting and expert opinion, this was then compared with what might be expected given past support for remote sensing and inventory. This was done through personal knowledge, expert opinion, published information and web based information on past donor projects and programmes. In several cases, the apparent capability was much less than might be expected given past donor support for capacity building. The amalgamation of these results was then used to make a subjective assessment of both need for support and the likely response of each of the countries.

The second strand followed was to summarise the extent, condition and changes of the forest resource base from international statistical information complemented by a short overview of the forest ecology, major strategies and constraints using a standard format for each country. The level of accuracy and detail varies between countries and not all details were available for every country but there is at least a clear overview. For the larger countries it proved hard to encapsulate everything within the length limits.

To assess the cost of building capacity for each of the monitoring scenarios laid out in the Terms of Reference, a model was created and each country assessed against this model in terms of current capacity and the gap between this and each of the target scenarios. The evidence used was international reporting to IPCC and FAO by each country.

The tables below summarise the findings for each country and indicate the priority for new support. The overall cost implications are also presented for each country. Table 1 below lists countries in three categories on the basis of their IPCC reporting: no carbon tier reporting, tier 1 reporting or tier 2 reporting. Within each reporting tier, countries are listed alphabetically for Africa, Tropical America and Asia/Pacific.

For each country, a short comment is provided on remote sensing and inventory capacity as well as flagging up key issues from the sector overviews for each country. There is also a note on the subjective assessment of priority for support. This is based on an amalgam of existing capacity and capability, experience from past interventions, likely level of interest and success and opportunity to integrate support into wider sector initiatives. Table 1 provides a succinct overview of the findings from this study.

Table 2 offers a summary of remote sensing and inventory capacity using the scales shown in the grid below. Thereafter, for each country a short comment is provided on relevant past donor support, on accessibility and on the likelihood of enabling institutional support. This is followed a brief assessment of the value of new support being given and the priority for providing support, as shown in Table 1. The key to these priorities is:

0 – Zero, either not required or not likely to be effective

L – Low, support is not likely to result in improved reporting

M – Moderate, support may result in improved reporting if conditions are met

H – High, support is likely to be well used and effective and/or may be included in wider sector support.

Remote Sensing Capacity		Forest Inventory Capacity	
0	No national capacity	0	No forest inventory data available
1	Landcover map available, constructed by external consultants or donor	1	One inventory carried out by external consultants or donor
2	Multiple landcover maps available, used to estimate landcover change, constructed by external consultants or donor	2	Multiple inventories carried out by external consultants or donor
3	Landcover map available, constructed in-house	3	One inventory carried out in-house
4	Multiple landcover maps available, used to estimate landcover change, constructed in-house	4	Multiple inventories carried out in-house
5	Remote sensing data are also used for supplementary data gathering or to support inventory activities		
6	Advanced remote sensing techniques are also used to monitor forestry		

Table 3 summarises the estimated costs of support required for each country to achieve various levels of reporting capability. The initial and recurrent costs are shown separately. The cost information was derived from the application of the standard model as described in detail in the study report.

The costs are indicative but show the levels of funding that would be required to achieve Tier 2 reporting using Approach A and Approach B and also Tier 3 reporting ignoring and including degradation.

Table 1 Summary of carbon tier reporting by country

Country	Comment	Priority for support
No carbon tier reporting		
Cameroon	Good inventory capacity from past support, no RS capacity. Important leader within Congo basin and possible focus of regional initiative. Past interventions have not been successful	Need to maintain engagement and use as regional leader – **moderate**
DR Congo	No RS or Inventory capacity, country in disarray, use regional approach operating at sub-national level. Major governance issues	Opportunity to include support with wider sector development – **high**
Equatorial Guinea	No RS or Inventory capacity, poor response to past support approaches	May be best only at political level, possibly include in any regional approach – **low**
Gabon	No RS or Inventory capacity, wealthy country, mainly urban, difficult access, stable forest in main	Include in regional approaches but not targeted otherwise – **low**
Sierra Leone	No RS or Inventory capacity, major post-conflict difficulties, forest highly degraded, weak institutions	Could be packaged with sector wide intervention – **high**
Peru	Very good RS and inventory capacity, positive approach in forestry sector likely to secure response. Staffing numbers low	Good leading country for Amazon region, deserving of support – **high**
Venezuela	No RS or Inventory capacity, little evidence of political interest in forest and environment sectors	Little value in anything other than political level until responses secured – **zero**
PNG	Some RS and a little Inventory capacity. Very difficult access, responsive institutions	Good response possible and massive forest resource – **high**
Level 1 carbon tier reporting		
Congo Republic	Good RS and inventory capacity, better than neighbouring countries. Large forest area with good potential	Possibly very valuable as a technical leader in region – **high**
Ghana	No RS and largely dormant inventory capacity that could be usefully resuscitated and provide regional focus. Highly degraded forest	Useful to engage provided valid assurances of response can be secured – **moderate**
Liberia	Following demise of Taylor regime, substantial support is being given to forest sector, institutions very weak	Support may be well used if linked with other sector building activities, which might be used to provide what is needed – **moderate**
Bolivia	Very good RS and good inventory capacity. Only limited support is likely to be needed	If specific support requested, it should be provided but otherwise – **low**
Colombia	Good RS but no inventory capacity. Major security and access issues in rainforest region	Unlikely to be particularly responsive – **zero**

Country	Comment	Priority for support
Costa Rica	Very good RS but limited inventory capacity, strong interest and some recent action. Positive institutional and political framework	Only relatively limited support required, likely to be well used – **high**
Guyana	Some RS at Iwokrama and past inventory capacity little used currently. Major political difficulties and governance issues. Competent individuals, forest area largely unoccupied land tenure questions unresolved.	Support should be linked into assurances that it would be used and not allowed to degrade – **moderate**
Cambodia	Very good RS but no inventory capacity. Weak institutions but extensive NGO sector, very degraded forest resource, major governance issues	Good opportunity to engage, likely to achieve some positive response - **high**
China	Plantations and restoration are main activities. More than adequate capacity available for use	Not required
Indonesia	Very good RS and good inventory capacity. Major concern due to continued governance and application failures despite huge levels of support offered	Need care to avoid yet more support being ineffective - **moderate**
Malaysia	High RS and inventory capacity, Sarawak less progressed than other states. No outside support necessary	Not required
Myanmar	Technical RS and inventory capacity both good. Political insecurity is main issue	Unlikely to be useful at present time – **zero**
Thailand	Good RS and inventory capacity but this has degraded in past years. Good expertise available at universities and research institutions. Useful regional leader with high national competence	Some limited support may be useful to start things moving – **low**
Vietnam	No RS but excellent inventory capacity. Likely to respond to national or regional support opportunities	National capability to make progress is quite high but positive response to requests indicated – **moderate**
Level 2 carbon tier reporting		
Brazil	Excellent remote sensing capacity, inventory capacity not used rather than not available. Needs political impetus	Not required
Mexico	Excellent RS and good inventory capacity. Higher level of control now instituted and able to undertake all that is needed without outside support	Not required
India	More than adequate national capacity available for use	Not required

Table 2 Summary of current capacity, capability and related factors

Country	RS Capacity (0 to 6)	Inventory cap (0 to 4)	Past relevant donor support?	Accessibility	Institutional support likely?	Overall comment on value of new support	Priority
Bolivia	4 -	3 -	ITTO 1999 – 2001	Poor, river possible	Yes	Not really required, give positive response to any request	L
Brazil	6 -	2 – good potential but data limited		Poor, river possible	Possibly	Not really necessary if political commitment is made	0
Colombia	4 -	0 -		Poor + security issues	No	Not likely to be much help	0
Costa Rica	4 -	1 – Rapid increase possible	FAO NFA 2005	Good	Yes	Not much required, worthy of support	H
Guyana	0 – some at Iwokrama	1 – basic skills in place, institutional degradation	DFID 1994 to 2002	Difficult over considerable area	Possibly, quite unreliable	Only if solid response to conditionalities, basics already exist	M
Mexico	5 -	3 -	USFS, GTZ, DFID and others 1990s	Fairly good	Yes	Not required	0
Peru	4 -	4 -		Poor, river possible	Yes	If request made, likely to be well used	H
Venezuela	0 -	0 -		Poor, some river access	No	Not likely to be government interest	0
Cambodia	4 -	0 –		Fair in main UXO	Yes, but weak	Could be useful, some good NGOs, weak institutions	H
China	4 -	4 -	ITTO RS in Hainan 1997	Adequate	Yes	Not required	0
India	4 -	4 -	UNDP 1980s, WB and others FRET 1990s	Adequate	Yes	Not required	0
Indonesia	4 -	3 -	DFID 1995 to 2001 TFF 2001	Difficult in a few places	Yes but decentralisation is major issue	May be useful to approach universities to channel support	M

Country	RS Capacity (0 to 6)	Inventory cap (0 to 4)	Past relevant donor support?	Accessibility	Institutional support likely?	Overall comment on value of new support	Priority
Malaysia	5 -	4 -		Sarawak difficult in places	Yes	Not required, Sarawak is most difficult area	0
Myanmar	4 -	4 -	UNDP/FAO 1982 – 85	Security issues	Not at present	Unlikely to be useful at present	0
PNG	2 -	2 – interest exists but limited capacity	Small ITTO input awaited	Very difficult in places, steep, high altitude	Yes	High need, positive approach likely	H
Thailand	3 -	3 – historically present	FAO 1991	Generally OK	Yes	Could regenerate capacity, universities may be access route	L
Vietnam	0 – regional?	4 -	UNDP 1982 – 86	Generally OK	Yes	Especially on RS, good inventory capability	M
Cameroon	0 -	3 -	FAO NFA 2005	Some difficult areas	Yes but weak	Build up through COMIFAC or similar rather than nationally	M
Congo Republic	3 -	3 -	FAO NFA ongoing ITTO RS 2002 - 04	Difficult in east	Yes	Could be useful leader in COMIFAC approach	H
DRC	0 -	0 -		Very difficult over significant area	Very weak	Needs to be a pilot approach initially, huge variation	H
Equatorial Guinea	0 -	0 -	FAO initial study 1990	Not difficult	Not known, seems unlikely	Unlikely to secure positive response politically	L
Gabon	0 -	0 -	ITTO 1998 – 2000	Difficult over large areas	Yes but may be ineffective	Better through COMIFAC, little national response in past	L
Ghana	0 -	1 -	DFID 1985 – 96	No problems	Yes, may not be effective	Focus on enabling present unused expertise	M
Liberia	1 -	1 -	Major donor presence now: USAID, WB	Some problems, UXO?	Yes, weak	Link with massive ongoing sector support	M
Sierra Leone	0 -	0 -	NFAP 1995 – 96	Difficult to some locations, UXO?	Yes, very weak	Link to wider institution building, very weak capacity	H

Table 3 Indicative Costs

Country	Tier 2						Tier 3							
	Approach A				Approach B		Ignore degradation				Include degradation			
	1st year		recurring		recurring		1st year		recurring		1st year		recurring	
	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}
Bolivia	813	0.0138	114	0.0019	386	0.0066	813	0.0138	304	0.0052	906	0.0154	334	0.0057
Brazil	5,807	0.0122	306	0.0006	1,960	0.0041	5,807	0.0122	2016	0.0042	6,640	0.0139	2,286	0.0048
Colombia	1,051	0.0173	173	0.0028	537	0.0089	1,051	0.0173	401	0.0066	1,161	0.0191	437	0.0072
Costa Rica	491	0.2051	103	0.0433	347	0.1453	491	0.2051	167	0.0696	521	0.2177	177	0.0738
Guyana	767	0.0508	183	0.0121	625	0.0413	767	0.0508	247	0.0163	797	0.0528	257	0.0170
Mexico	251	0.0039	120	0.0019	251	0.0039	334	0.0052	203	0.0032	346	0.0054	215	0.0033
Peru	1,436	0.0209	247	0.0036	837	0.0122	1,436	0.0209	513	0.0075	1,565	0.0228	555	0.0081
Venezuela	1,147	0.0241	186	0.0039	720	0.0151	1,147	0.0241	376	0.0079	1,240	0.0260	406	0.0085
Total America	11,763		1432		5,663		11,846		4227		13,176		4,667	
Cambodia	462	0.0442	75	0.0072	319	0.0305	462	0.0442	138	0.0132	492	0.0471	148	0.0142
China	0	0	0	0	0	0	0	0	0	0	0	0	0	0
India	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indonesia	1,500	0.0170	168	0.0019	645	0.0073	1,500	0.0170	548	0.0062	1,685	0.0190	608	0.0069
Malaysia	227	0.0109	0	0	56	0.0027	227	0.0109	76	0.0036	264	0.0126	88	0.0042
Myanmar	486	0.0151	99	0.0031	343	0.0106	486	0.0151	163	0.0051	516	0.0160	172	0.0053
PNG	897	0.0305	162	0.0055	640	0.0217	897	0.0305	276	0.0094	952	0.0323	294	0.0100
Thailand	767	0.0529	183	0.0126	625	0.0430	767	0.0529	247	0.0170	797	0.0549	257	0.0177
Viet Nam	629	0.0486	141	0.0109	582	0.0450	629	0.0486	204	0.0158	850	0.0657	214	0.0165
Total Asia/Pacific	4,968		828		3210		4,968		1652		5,556		1781	

Country	Tier 2						Tier 3							
	Approach A				Approach B		Ignore degradation				Include degradation			
	1st year		recurring		recurring		1st year		recurring		1st year		recurring	
	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}	£000	£ ha^{-1}
Cameroon	544	0.0256	150	0.0071	544	0.0256	580	0.0273	186	0.0088	632	0.0297	238	0.0112
Congo	385	0.0171	109	0.0049	313	0.0139	385	0.0171	205	0.0091	431	0.0192	219	0.0098
DR Congo	2,251	0.0169	325	0.0024	1,097	0.0082	2,251	0.0169	839	0.0063	2,501	0.0187	919	0.0069
Eq. Guinea	711	0.4362	128	0.0783	569	0.3485	712	0.4362	191	0.1169	742	0.4545	201	0.1230
Gabon	872	0.0401	193	0.0089	657	0.0302	873	0.0401	289	0.0132	917	0.0421	303	0.0139
Ghana	821	0.1488	127	0.0231	596	0.1081	821	0.1488	217	0.0394	851	0.1543	232	0.0421
Liberia	713	0.2263	130	0.0411	571	0.1809	714	0.2263	193	0.0611	744	0.2358	203	0.0642
S. Leone	713	0.2589	129	0.0468	570	0.2070	713	0.2589	192	0.0697	743	0.2698	202	0.0733
Total Africa	0		0		0		0		0		0		0	
Overall Total	!B23 Is Not In Table		!D23 Is Not In Table		!F23 Is Not In Table		!H23 Is Not In Table		!J23 Is Not In Table		!L23 Is Not In Table		!N23 Is Not In Table	

Capability and cost assessment of the major forest nations to measure and monitor their forest carbon

1 Introduction

This report has been prepared by LTS International for the Office of Climate Change in accordance with the Terms of Reference attached as Annex 1.

In undertaking the work, time constraints meant that reliance had to be placed on published sources of information. The main sources used were the quinquenniel Forest Resources Assessments for 2000 and 2005 and ITTO Publications. The main documents consulted are listed in Annex 2.

The terms of reference asked for separate reports for each of the 25 countries on measuring capabilities (Task 1) and monitoring capacity (Task 2) for IPCC Tiers 2 and 3. These two reports have been combined into a single one for each country together with consolidated reports on findings and costs. At the same time a short overview of each country has been provided to highlight the background on forest composition, degradation and loss rates and give indications of relevant strategic level changes. One of the major ones is forest restoration, the second is whether there is scope for community engagement in part of the work required.

Assessment of capacity or capability was done through analysis of the reporting delivered from each country in key forestry and IPCC statistical reports. Although not analysed in detail, responses to ITTO questionnaires on the status of tropical forest management were also considered. In nearly every case, these proved wanting and were far below what was necessary to compile even a broad national overview.

The tables of statistical information and associated graphs are presented in Annex 3. The methodology adopted for making the assessments is described in detail in Section 2 and the general findings in Section 3. The request for satellite data cost estimates (Task 3) is provided as a separate Section 4 in this report while Section 5 summarises the various remote sensing techniques that might be employed. Annex 3 provides details of the reference scenario for the methodology.

Thereafter in Section 6, the country profiles are presented in the order given in the Terms of Reference with an introductory summary. References are attached as Annex 5.

We looked at a range of Country Assistance Strategies from WB, DFID, EU, DANIDA and national reports and development strategies including PRSPs and IPCC reports as well as National Forestry Programmes in the central FAO electronic repository. While climate change was regularly mentioned as an important issue, we were unable to find anything of significance relating to capacity for measuring and reporting.

As noted in the table in the Executive Summary, some of the countries reviewed had benefited from support to develop forest inventory expertise but this has not been carried forward into evidence of capacity to deliver forest inventory information in international reporting. This suggests that an approach along traditional lines with capacity building and provision of equipment might well not result in sustainably enhanced capability. The reason for the failure of earlier interventions should be carefully evaluated.

It is interesting to note that countries with the weakest capacity and capability are predominantly in Africa. Furthermore, there appears to be a correlation between countries with weak capacity and significant log exports.

While in some circumstances, there are valid economic and development reasons that make log exports appropriate, in many instances such exports reflect a lack of control in the field and low investment in concessions and associated infrastructure.

The report has been produced under severe time constraint and gives only a broad picture of each of the 25 countries considered. There is considerable variation within most of these countries and more detailed study of potential target partners will be essential before making investment in capacity building and capability enhancement. In particular, those countries which had earlier capacity building that appears to have been lost would merit detailed investigation as to why this happened.

2 Methodology

2.1 Assessing national capacity

National capacity for environmental monitoring is reflected in the information contained in reports to a range of international conventions.

2.1.1 FAO Forest Resources Assessment

In the forestry sector, the most important international reporting mechanism is the FAO Forest Resources Assessment (FRA). This report is issued every 5 years, and draws on information provided in national reports produced by each country. All the countries in the target list have reported for the last FRA, in 2005. We have abstracted these reports and scored each country for evidence of remote sensing capacity, forest inventory capacity, and the IPCC Tier used for calculating carbon stocks.

We have also canvassed opinion from the FAO FRA 2010 National Correspondent for each country, although at the time of writing, we have received only one reply (Papua New Guinea – their scores agreed with ours).

Table 4 National capacity scoring system for FAO FRA 2005 reports and questionnaires sent to FAO FRA 2010 National Correspondents

REMOTE SENSING CAPACITY	
0	No national capacity.
1	Landcover map available, constructed by external consultants or donor.
2	Multiple landcover maps available, used to estimate landcover change, constructed by external consultants or donor.
3	Landcover map available, constructed in-house.
4	Multiple landcover maps available, used to estimate landcover change, constructed in-house.
5	Remote sensing data are also used for supplementary data gathering or to support inventory activities.
6	Advanced remote sensing techniques are also used to monitor forestry.
FOREST INVENTORY CAPACITY	
0	No forest inventory data available.
1	One inventory carried out by external consultants or donor.
2	Multiple inventories carried out by external consultants or donor.
3	One inventory carried out in-house.
4	Multiple inventories carried out in-house.
USE OF IPCC TIER DATA TO ESTIMATE CARBON STOCKS	
0	No carbon stocks data.
1	Tier 1
2	Tier 2
3	Tier 3

2.1.2 *UNFCCC National Communications*

In the carbon accounting sector, the most important reporting mechanism is the UNFCCC National Communications. All but 3 of the target countries have reported under this mechanism.

2.1.3 *Other sources*

Other sources include ITTO Diagnostic Missions (available for 13 of the target countries), European Union Country and Regional Strategy Papers, and communications to the UNFCCC SBSTA related to reducing emissions from deforestation in developing countries. We have also canvassed opinion from our network of contacts.

2.2 Costing the capability gaps

2.2.1 *Institutional capacity*

Methods for monitoring carbon stocks in tropical forestry range from the relatively straightforward to the cutting edges of earth observation science. Even the simplest methods, however, require a high degree of organisational capacity. Forest monitoring demands the coordinated efforts of a large number of individuals, across a broad range of professions. To be effective, monitoring must be sustained over many years.

Even should funding become available, in some cases institutional capacity is lacking and is unlikely to improve in the medium term. We have tried to identify alternative approaches in these situations, such as participatory forest monitoring and contracting-out.

2.2.2 *Approach to cost estimation*

Annex 4 presents a reference scenario for forest monitoring. This represents the case of a medium-sized country with no existing forest inventory capacity and no remote sensing capacity. Cost estimates are presented for implementing a national forest inventory to a range of levels (IPCC Tier 2 and Tier 3 levels of accuracy, using either approach A or approach B to stratification, with or without including monitoring for degradation). Estimates are also provided for establishing the required remote sensing capability.

The reference scenario also lays out considerations for adjusting cost estimates based on the size of the country, the complexity of the forestry within a country, and the level of existing capacity.

Each country is then assessed against this scenario, providing cost estimates for implementing a monitoring system capable of reporting to the minimum standards required within a REDD framework. Where significant capacity exists, estimates are provided for improving the quality of reporting to allow more accurate, and therefore less conservative reporting.

We do not provide estimates for raising countries with no existing capacity to the highest levels of remote sensing capability, as this would be unrealistic. Achieving even the minimum standards will represent a level of institutional capacity far in excess of any comparable systems in some of the countries included in this study. Instead, we present a decision tree (Figure 1 below) which may be used to identify the next logical improvement to apply to any existing monitoring system. We use this tool to provide cost estimates for improving existing capacity in the individual country assessments.

A corollary of this is that we have provided no estimates for implementing operational LiDAR systems. Very few of the target countries have advanced capacity in remote sensing. Where capacity exists, we have provided cost estimates for enhancing that capacity to the next level. However, in no case do we see highly advanced techniques such as LiDAR as being an appropriate technology. The clear deficit across almost all of the target countries is not capacity in remote sensing, but capacity in ground inventory. Without a decent ground-based data collection system, attempts to apply state-of-the-art remote sensing techniques would be a complete waste of money and a missed opportunity.

2.3 Summary of the reference scenario

The reference scenario is presented in detail in Annex 4. Here we summarise its key features. See also Figure 1 below.

2.3.1 Remote sensing capacity

A team of 3 is the smallest unit that can be considered sustainable. This means that apart from data costs, the estimates are static for all sizes of country. Smaller countries should consider the possibility of establishing shared regional capacity, as most non-data costs are largely independent of the geographical extent of the monitored area.

In the first year, international consultants are hired to establish the capacity. National staff are recruited and trained, and operate the facility from the second year.

- First year: £520,000 + £60,000 data costs
- Annual recurring: £126,000 + £60,000 data costs

The alternative approach for countries lacking institutional capacity is to contract this component out to a technology supplier.

2.3.2 Forest inventory capacity

Table 5 Forest inventory reference scenario costs

Tier 2, approach A	£567,500 one-off cost
Tier 2, approach B	£140,000 recurring annually
Tier 3, approach A	£567,500 in first year £190,000 recurring annually
Tier 3, approach A, including degradation	£660,000 in first year £220,000 recurring annually
Participatory	£605,000 in first year £590,000 recurring annually

For larger countries, these costs would increase in proportion to the increase in forest area.

For smaller countries, costs would fall in proportion to the decreased forest area, down to a minimum of about 1/3. This assumes that the number of strata would also be reducing at the same rate. It seems very unlikely that any country would have fewer than 2 strata, requiring 100 survey points and setting the minimum cost.

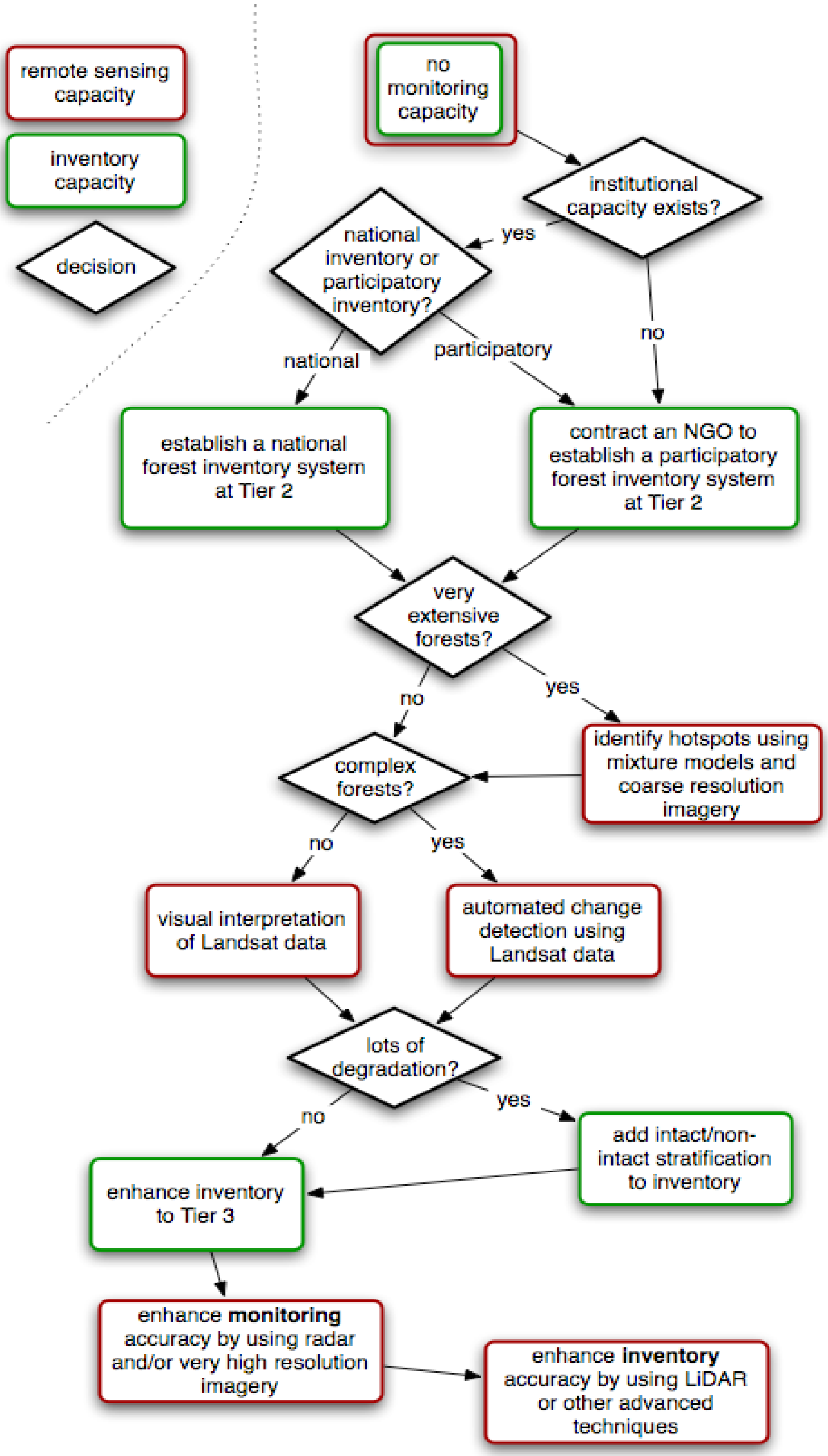

Figure 1 Decision tree for assessing current national capacity and identifying next steps in capacity building

2.3.3 Baseline modelling capacity

Annex 4 discusses different approaches to determining an emissions baseline. The baseline is used to assess whether a country has succeeded in reducing its forest carbon emissions, and in quantifying the reduction. There are two broad approaches – a historical baseline, and a modelled baseline.

Current IPCC guidelines provide no recommendations as to how countries should establish the baseline (see Annex 4).

Using a historical baseline is simpler, more transparent, and favours countries that were actively deforesting during the baseline period. On the other hand, countries that have not lost forests are likely to prefer a modelling approach, which takes into account likely future increases in deforestation and rewards reductions against the projected rather than the historical rate.

Annex 4 provides a cost estimate for carrying out the modelling exercise. The cost is fixed for all countries that choose to follow this approach – the cost of constructing the model is independent of forest extent.

The individual country assessments assign a baseline approach (historical or modelled) based on past deforestation rates. Countries with a low rate of deforestation, or positive reforestation, should use the modelling approach. This assumes that a modelling approach will be accepted by the IPCC.

Annex 4 estimates the cost of constructing a baseline model as **£37,500** if international experts are used, and **£17,500** if national experts are used. We assume international experts for this exercise.

2.4 Participatory forest monitoring

Recent work to develop community participation in sustainable forestry has demonstrated how the judicious use of technology (field GIS systems) and effective approaches to training and stakeholder involvement, can build operational forest monitoring and sustainable management systems delivered by local communities (Murdiyarso & Skutsch 2006; McCall & Minang 2005).

If such an approach could be tied to the delivery of financial benefits back down to the community, and could be developed at a national level, significant REDD benefits could be realised without the necessity of institutional effort on the behalf of governments. This would be an attractive proposition in countries where institutional capacity or motivation for organising complex national programmes is lacking.

Annex 4 estimates the cost of setting up a participatory forest inventory. Annual costs are significantly greater than for a national forest inventory, partly due to ongoing coordination, training and quality control costs, but also because communities must be rewarded for their participation.

- **Setup costs: £605,000**
- **Recurring annual costs: £590,000**

The individual country assessments examine whether a participatory approach would be beneficial. However, given that no country has set up a nationwide participatory forest inventory system, and therefore there is no prior practise to guide us, we have not included participatory monitoring in our cost calculations as these estimates are more speculative than other components. They are also highly dependent on the level of reward paid to participating communities.

2.5 Natural disturbance, reforestation, and other country-specific considerations

The situation in every country is somewhat unique. The forest monitoring system described in the REDD sourcebook (Brown *et al* 2007) addresses this through the stratification scheme decided upon by each country. This identifies each important class of forest change and ensures sufficient sample blocks are located in each stratum.

In the case of countries in the hurricane region, like Mexico and Costa Rica, periodic natural disturbance of coastal forests is important. Carbon emissions from forests damaged by hurricanes are likely to be different from other types of forest change, and therefore "hurricane impacted forests" would be one of the sample strata specified in the stratification. There is no specific extra cost associated with monitoring natural disturbance, as it is already incorporated in the stratification approach.

The monitoring system described in the sourcebook is designed to measure gross changes, not net changes, in forest area. That is, emissions from conversion of class A to class B in one part of the forest, and from class B to class A in another part, are calculated independently and then summed. In a forest undergoing change in both directions, a net system would miss a substantial proportion of the emissions. This emphasises that the system is a forest monitoring system, not a deforestation monitoring system. Reforestation, just like deforestation, is identified by the remote sensing capacity. Carbon emissions (or, more likely, carbon uptake) are then assessed via the stratification. Again, there is no specific extra cost associated with monitoring reforestation as opposed to deforestation.

2.6 Indicative costs from other sources

The **reference scenario** (Tier 3, excluding degradation) presented in Annex 4 costs **£1,147,500** in the first year and **£376,000** annually thereafter.

The **World Bank Forest Carbon Partnership Facility** (FCPF) is investing £50 million to help 20 countries in its Readiness Mechanism (**£2.5 million** per country). The Readiness Mechanism will provide support for specifying a baseline and setting up a monitoring system, as well as writing an action plan for implementing REDD at a national level (World Bank 2008).

Herold & Johns (2007) estimate the costs for setting up a monitoring system at between £25**0,000 to £1 million**, based on experiences from Brazil and India, and on national case studies. They do not provide a breakdown of this estimate.

The **IPCC** (Watson et al. 2000) estimates vegetation carbon inventories at national scale to cost £0.025 – £0.30 ha^{-1}. This would price our reference scenario (50 Mha) at **£125,000 - £15 million** (in 2000 prices).

A recent national forest survey carried out by **Cameroon**, in association with the **FAO**, cost **£500,000** (MINEF/FAO 2006). This of course does not include the remote sensing component of a REDD monitoring service.

The **GMES Service Element "Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting"** provides a REDD forest monitoring service which has been used by Indonesia in a pilot study. Dr. Thomas Häusler (Project Manager, GMES Service Element Forest Monitoring) has kindly provided us with a general indication of costs at national scale. For our reference scenario, this service would cost in the region of £100,000 to £475,000 per annum for ground sampling, £200,000 to £400,000 per annum for analysis of remote sensing data, and £60,000 to £120,000 for data costs. The combined estimate is **£360,000 to £995,000 per annum.**

3 Overview of country analyses

3.1 Current capacity for remote sensing and forest inventory

As described in the methodology (section 2), a simple scoring scheme was devised to compare the remote sensing and forest inventory capacity of each country (Figure 2). The figure suggests that many countries have significant capacity in remote sensing. On the other hand, capacity in forest inventory is generally low, and very few countries have the capacity to estimate carbon stocks at better than IPCC Tier 1 levels of accuracy.

The most striking lack of capacity is among the African forested countries. At the other end of the scale, India and China already have sufficient inventory and remote sensing capacity (if each invests a small amount of effort in developing Tier 2 or 3 factors). Malaysia already has sufficient remote sensing capacity, while Mexico and perhaps Cameroon have sufficient capacity (at Tier 2) in forest inventory - Mexico, through recent investments in forest monitoring, and Cameroon through collaboration with the FAO.

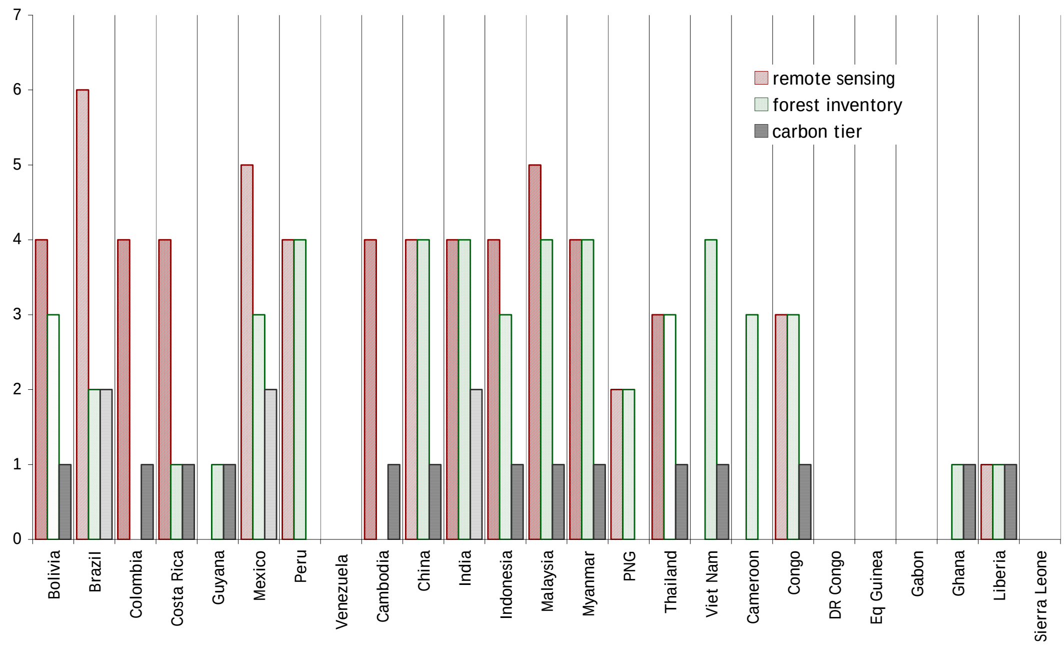

Figure 2 Capability assessment scores. Remote sensing scale: 0 – 6. Forest inventory scale: 0 – 4. Carbon tier: 0 – 3.

3.2 Estimated costs

Cost estimates depend on existing capacity and the extent of a country's forests. Estimates are based on a reference scenario described in detail in Annex 4, and summarised in section 2. These estimates do not represent the full cost of implementing forest monitoring systems, but the cost of bridging the gap between existing and required forest monitoring capacity.

Table 6 presents cost estimates for the individual components of forest monitoring capacity. Table 7 combines these to produce gross and per hectare costs of establishing each monitoring system.

Table 6 Component cost estimates for implementing annual forest monitoring systems.

Country	Forest Area (000 ha)	Baseline model	Remote sensing costs			Inventory costs					
						Tier 2		Tier 3			
						Approach A (one-off)	Approach B (recurring)	Ignore degradation		Include degradation	
			1st year	recurring	data			1st year	recurring	1st year	recurring
Bolivia	58,740	0	174	42	72	568	140	568	190	660	220
Brazil	477,698	0	520	126	180	5,108	1,260	5,108	1,710	5,940	1,980
Colombia	60,728	37.5	260	63	72	681	168	681	228	792	264
Costa Rica	2,391	37.5	260	63	3	190	47	190	63	220	73
Guyana	15,104	37.5	520	126	20	190	47	190	63	220	74
Mexico	64,238	0	173	42	78	0	0	83	83	95	95
Peru	68,742	37.5	520	126	84	795	196	795	266	924	308
Venezuela	47,713	0	520	126	60	568	140	568	190	660	220
Cambodia	10,447	0	260	63	12	190	47	190	63	220	73
China	197,290	0	0	0	0	0	0	0	0	0	0
India	67,701	0	0	0	0	0	0	0	0	0	0
Indonesia	88,495	0	260	63	105	1,135	280	1,135	380	1,320	440
Malaysia	20,890	0	0	0	0	227	56	227	76	264	88
Myanmar	32,222	0	260	63	36	190	47	190	64	220	73
PNG	29,437	0	520	126	36	341	84	341	114	396	132
Thailand	14,520	37.5	520	126	20	190	47	190	63	220	73
Viet Nam	12,931	0	520	126	15	94	47	94	63	315	73
Cameroon	21,245	0	520	126	24	0	0	36	36	88	88
Congo	22,471	37.5	175	42	30	142	70	142	95	188	110
DR Congo	133,610	37.5	520	126	162	1,532	378	1,532	513	1,782	594
Eq. Guinea	1,632	0	520	126	2	190	47	190	63	220	73
Gabon	21,775	37.5	520	126	30	285	70	285	95	330	110
Ghana	5,517	0	520	126	1	300	75	300	90	330	105
Liberia	3,154	0	520	126	4	190	47	190	63	220	73
S. Leone	2,754	0	520	126	3	190	47	190	63	220	73

Table 7 Cost estimates (total and per hectare) for implementing annual forest monitoring systems

Country	Tier 2						Tier 3							
	Approach A				Approach B		Ignore degradation				Include degradation			
	1st year		recurring		recurring		1st year		recurring		1st year		recurring	
	£000	£ ha-1	£000	£ ha-1	£000	£ ha-1	£000	£ ha-1	£000	£ ha-1	£000	£ ha-1	£000	£ ha-1
Bolivia	813.5	0.0138	114	0.0019	386	0.0066	813.5	0.0138	304	0.0052	906	0.0154	334	0.0057
Brazil	5807.5	0.0122	306	0.0006	1960	0.0041	5807.5	0.0122	2016	0.0042	6640	0.0139	2286	0.0048
Colombia	1050.5	0.0173	172.5	0.0028	537.5	0.0089	1050.5	0.0173	400.5	0.0066	1161.5	0.0191	436.5	0.0072
Costa Rica	490.5	0.2051	103.5	0.0433	347.5	0.1453	490.5	0.2051	166.5	0.0696	520.5	0.2177	176.5	0.0738
Guyana	767.5	0.0508	183.5	0.0121	624.5	0.0413	767.5	0.0508	246.5	0.0163	797.5	0.0528	257.5	0.0170
Mexico	251	0.0039	120	0.0019	251	0.0039	334	0.0052	203	0.0032	346	0.0054	215	0.0033
Peru	1436	0.0209	247.5	0.0036	837.5	0.0122	1436	0.0209	513.5	0.0075	1565.5	0.0228	555.5	0.0081
Venezuela	1147.5	0.0241	186	0.0039	720	0.0151	1147.5	0.0241	376	0.0079	1240	0.0260	406	0.0085
Cambodia	462	0.0442	75	0.0072	319	0.0305	462	0.0442	138	0.0132	492	0.0471	148	0.0142
China	0	0	0	0	0	0	0	0	0	0	0	0	0	0
India	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indonesia	1500	0.0170	168	0.0019	645	0.0073	1500	0.0170	548	0.0062	1685	0.0190	608	0.0069
Malaysia	227	0.0109	0	0	56	0.0027	227	0.0109	76	0.0036	264	0.0126	88	0.0042
Myanmar	486	0.0151	99	0.0031	343	0.0106	486	0.0151	163	0.0051	516	0.0160	172	0.0053
PNG	896.5	0.0305	162	0.0055	640	0.0217	896.5	0.0305	276	0.0094	952	0.0323	294	0.0100
Thailand	767.5	0.0529	183.5	0.0126	624.5	0.0430	767.5	0.0529	246.5	0.0170	797.5	0.0549	256.5	0.0177
Viet Nam	629	0.0486	141	0.0109	582	0.0450	629	0.0486	204	0.0158	850	0.0657	214	0.0165
Cameroon	544	0.0256	150	0.0071	544	0.0256	580	0.0273	186	0.0088	632	0.0297	238	0.0112
Congo	384.5	0.0171	109.5	0.0049	312.5	0.0139	384.5	0.0171	204.5	0.0091	430.5	0.0192	219.5	0.0098
DR Congo	2251.5	0.0169	325.5	0.0024	1097.5	0.0082	2251.5	0.0169	838.5	0.0063	2501.5	0.0187	919.5	0.0069
Eq. Guinea	711.8	0.4362	127.8	0.0783	568.8	0.3485	711.8	0.4362	190.8	0.1169	741.8	0.4545	200.8	0.1230
Gabon	872.5	0.0401	193.5	0.0089	657.5	0.0302	872.5	0.0401	288.5	0.0132	917.5	0.0421	303.5	0.0139
Ghana	821.2	0.1488	127.2	0.0231	596.2	0.1081	821.2	0.1488	217.2	0.0394	851.2	0.1543	232.2	0.0421
Liberia	713.6	0.2263	129.6	0.0411	570.6	0.1809	713.6	0.2263	192.6	0.0611	743.6	0.2358	202.6	0.0642
S. Leone	713	0.2589	129	0.0468	570	0.2070	713	0.2589	192	0.0697	743	0.2698	202	0.0733

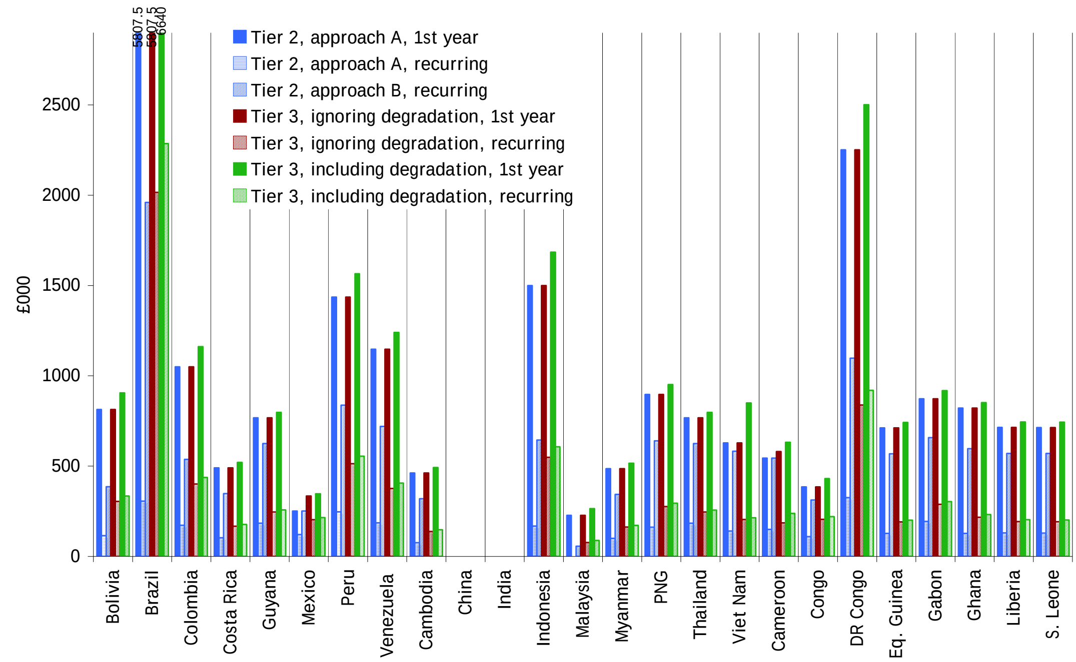

Figure 3 **Cost assessments of capability gaps for implementing forest monitoring approaches**

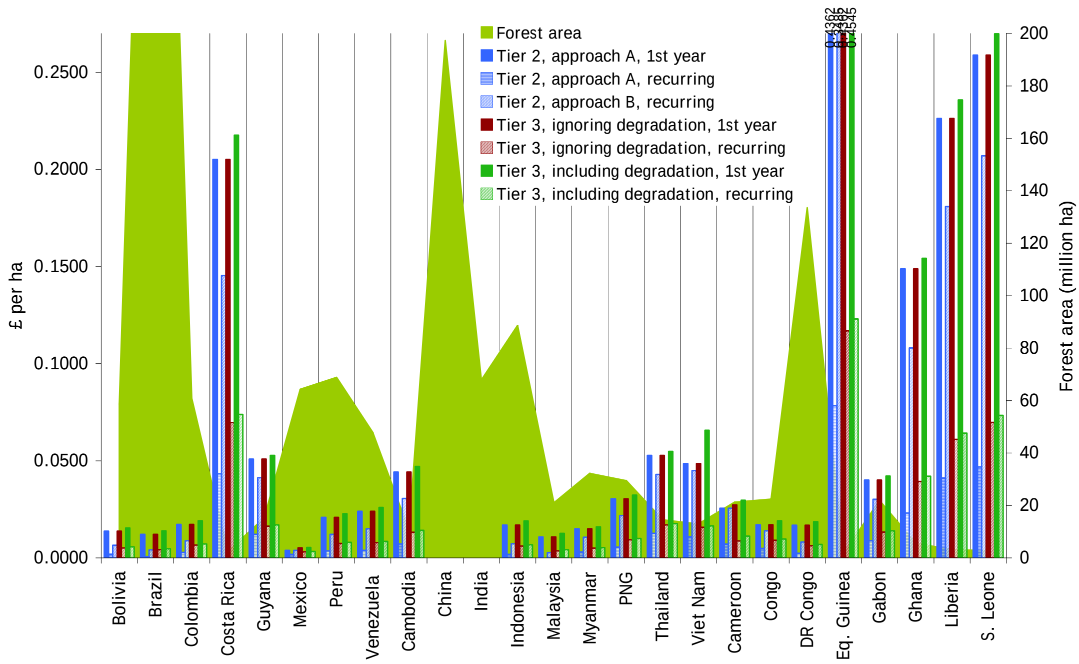

Figure 4 **Cost per hectare for implementing forest monitoring approaches. Secondary plot illustrates forest area of each country.**

3.3 Opportunities for regional cooperation

Figure 4 illustrates the very high costs per hectare to implement forest monitoring systems in countries with small forest areas – Costa Rica (2.4 Mha), Equatorial Guinea (1.6 Mha), Ghana (5.5 Mha), Liberia (3.2 Mha) and Sierra Leone (2.8 Mha). For these countries, the cost of establishing capacity is independent of forest area because minimum technical requirements must be satisfied. For instance, to establish statistical validity, the forest inventory must sample a minimum number of locations. Similarly, a minimum level of manpower must be established for a viable remote sensing capacity.

Small countries could partner with other countries to establish regional rather than national capacity, especially in remote sensing which provides the main opportunity for cost savings. A shared regional capacity could cost little more than the cost of national capacity for one country, apart from increased data costs. Other advantages would include standardisation of methodologies for carbon accounting and reporting, facilitating a regional rather than national integration with carbon markets, and perhaps reducing transaction costs.

Costa Rica is rather isolated from other countries considered in this report, but could certainly benefit from a regional capacity developed among other small Central American nations.

In Central Africa, there is already an established partnership among the Central African nations (COMIFAC – Commission for the Forests of Central Africa), which includes Cameroon, Congo, DR Congo, Equatorial Guinea and Gabon. By establishing a shared regional remote sensing capacity, these nations could save around £1,215,000 in the first year, and £294,000 per annum thereafter. This assumes the regional capacity would cost twice the reference scenario to establish. Further savings would be gained by including other COMIFAC nations not considered in this report.

The small West African nations would benefit from a partnership among themselves (Liberia, Sierra Leone and Ghana) and other neighbouring countries. Savings from a shared remote sensing capacity would be in the order of £1,040,000 in the first year and £152,000 in subsequent years. This assumes the regional capacity for these countries would cost the same as the reference scenario.

Table 8 Available savings from regional cooperation. Note that achievable savings are likely to be significantly higher, because other regional partners not considered in this report could also take part.

Region	Countries	1st year savings	Recurring savings
West Africa	Liberia Sierra Leone Ghana	> £1,040,000	> £152,000
Central Africa	Cameroon Congo DR Congo Equatorial Guinea Gabon	> £1,215,000	> £294,000
Central America	Costa Rica	Depends on partners	

3.4 Opportunities for participatory forest inventory

For a number of countries, we have recommended consideration of a participatory community approach to forest inventory.

This approach would be considerably more expensive in the long run than establishing a national forest inventory capacity. Annex 4 estimates that a participatory scheme would cost £605,000 in the first year, and £590,000 in subsequent years. This compares to £660,000 in the first year and £220,000 in subsequent years for a Tier 3 capacity including degradation.

However, as discussed in Annex 4 and in the individual country assessments, a participatory approach may have distinct advantages, and in some cases, may be the only realistic approach.

Although participatory inventory does not itself involve community forest management, it would provide a powerful infrastructure for parallel work to establish community forest management projects.

In some countries, lack of institutional capacity or motivation means that the likelihood of a sustainable national inventory capacity being established successfully is small. In these cases an NGO-led participatory scheme may be an attractive alternative.

The set of circumstances favouring a participatory approach is rather restrictive. Communities need to be rewarded for their work, but the level of available rewards is likely to be rather low, so a participatory approach is only feasible in the poorest nations. On the other hand, a basic level of education is necessary, which precludes the least developed nations. Poor security, official antipathy towards NGOs, and inaccessibility of some regions makes it impossible for NGOs to build the required extended network of projects in some countries.

Table 9 summarises the opportunities for participatory inventory. The assessments are necessarily preliminary and subjective. Furthermore, although the number of community forest management projects is steadily growing, these are rather different from the concept of a national participatory forest inventory. There is no prior practice to draw upon. Therefore although we have indicated below and in the country assessments where participatory inventory may be an attractive option, we have based all cost assessments on traditional national forest inventory capacity.

For some countries, the settlement pattern and accessibility are such that although participatory inventory may not be useful over a large areas, there may be some locations where it might be used. The following observations should be considered when using Table 9.

- Bolivia and Peru both have community managed areas and in these localities, participatory approaches may be feasible. There may also be such opportunities in parts of Mexico such as Yucatan, where communities are organised into Ejidos;
- In Guyana, there are communities at the edges of the forest, along major rivers and in the south west that could be engaged although the participatory approaches would not be feasible in the large unoccupied areas;
- PNG while mainly unsuitable has some areas with heavier settlement and possible access through communities supported by local NGOs;
- Costa Rica and Vietnam have rapidly expanding private forests and there may be a possible approach through forest owners' groups. In Vietnam, it is mainly planted forests but in Costa Rica, there are significant areas of secondary forest on private pasture land that has been abandoned;
- Both Liberia and Sierra Leone may have difficulty finding suitable people in some communities, meaning either more substantial training or a mix of approaches.

Table 9 Opportunities for participatory forest inventory

Country	Indicators	Opportunity
Bolivia	Institutions are engaged in developing forest inventory.	No
Brazil	GDP per capita relatively high. Large forest regions are inaccessible, sparsely populated, with very poorly educated communities.	No
Colombia	GDP per capita relatively high. Poor security.	No
Costa Rica	GDP per capita relatively high.	No
Guyana	Forests are sparsely populated.	No
Mexico	GDP per capita relatively high. National forest inventory well established.	No
Peru	GDP per capita relatively high. Institutions are engaged in developing forest inventory.	No
Venezuela	GDP per capita relatively high.	No
Cambodia	**Many NGOs operating successfully. Low per capita GDP. Well educated population.**	**Yes**
China	National forest inventory well established.	No
India	National forest inventory well established.	No
Indonesia	**Existing national forest inventory capacity, though fragmented and declining.**	**Maybe in some regions**
Malaysia	GDP per capita relatively high. National forest inventory well established in some regions.	No
Myanmar	Difficult for NGOs to operate. Otherwise, Myanmar would be a good candidate – low GDP, relatively well educated population.	No
Papua New Guinea	Low GDP per capita. Inaccessible forests with poorly educated communities.	No
Thailand	GDP per capita relatively high.	No
Viet Nam	Institutions are engaged in developing forest inventory.	No
Cameroon	**Low institutional capacity for sustaining inventory. Open to NGOs.**	**Yes**
Congo	Some capacity for forest inventory. Important areas are inaccessible with very poorly educated forest communities.	No
DR Congo	**Low institutional capacity for sustaining inventory. However, important areas are inaccessible with very poorly educated forest communities.**	**Maybe**
Eq Guinea	Poor security.	No
Gabon	GDP per capita relatively high. Inaccessible forests.	No
Ghana	**NGOs can operate effectively. Well educated population.**	**Yes**
Liberia	**NGOs can operate effectively. Sparsely populated forests may restrict potential.**	**Yes**
Sierra Leone	**NGOs can operate effectively. Sparsely populated forests may restrict potential.**	**Yes**

4 Summary of data costs

This section summarises basic characteristics and data acquisition costs for a selection of the most useful satellite and airborne systems (Table 11).

Section 2 uses these costs to calculate data costs for a reference national monitoring system. These estimates are repeated here in Table 10 for reference, and are used in the individual country assessments to estimate data costs.

Figure 5 illustrates the spatial coverage offered by individual scenes from different satellites.

Table 10 Indicative annual budgets for the reference forest monitoring project described in annex 4

Category	Expenditure	Coverage
Very high resolution e.g. Quickbird	£7,000	Sample
Moderate resolution e.g. Landsat	£60,000	Wall-to-wall
Coarse resolution e.g. MODIS, MERIS	Free	Wall-to-wall
Radar e.g. ERS-1	£160,000	Wall-to-wall
LiDAR	£30,000	Sample

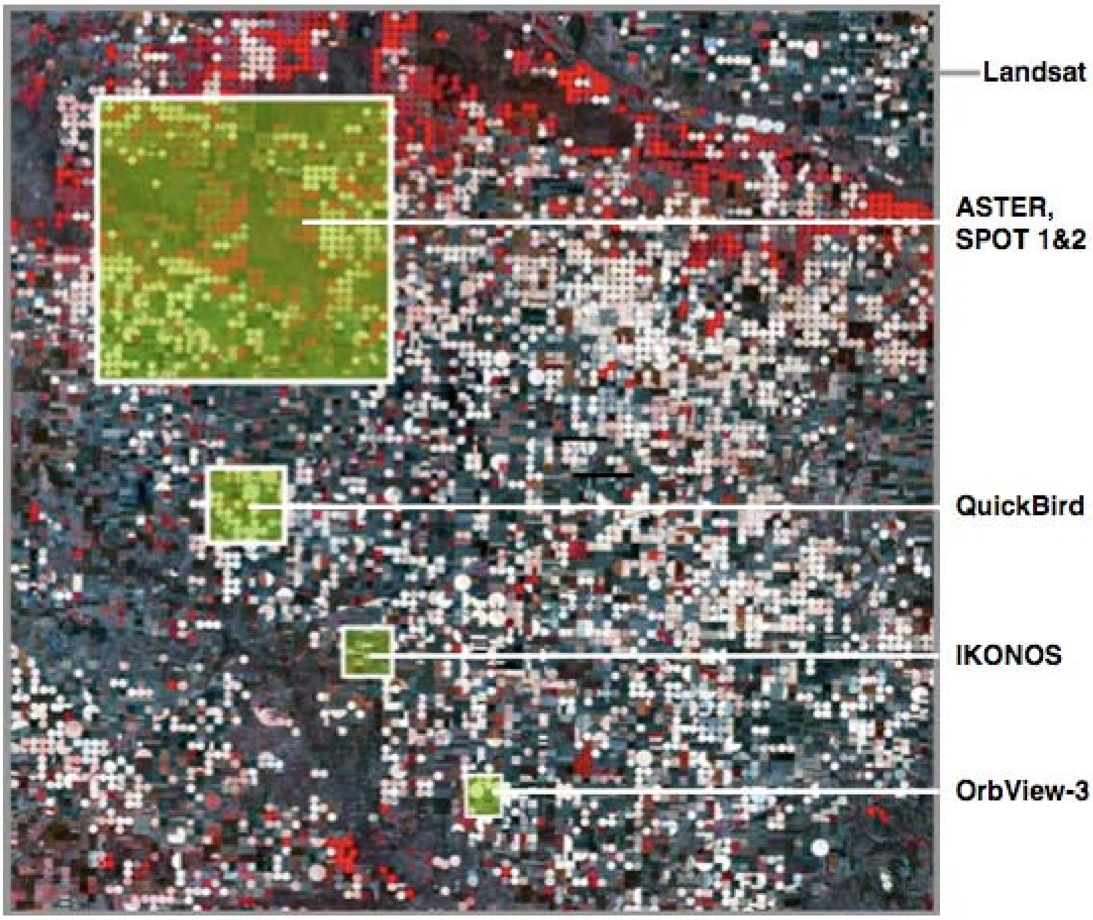

Figure 5 Coverage of different sensors, relative to a Landsat scene, 185x185km. Source: Stoney 2008.

Table 11 Key sensors for forest monitoring

Satellite/sensor	Operator	Spatial resolution	Characteristics and uses	Repeat cycle	Pricing	
					Notes	£ per km^2
Very high resolution						
Quickbird-2	DigitalGlobe	0.61m pan 2.44m MS	MS 4 bands Ground-truthing	1-3.5 days	$64km^2$ minimum purchase for new data. $25km^2$ minimum purchase for archival data.	£11.25
IKONOS-2	Space Imaging	1m pan 4m MS	MS 4 bands Ground-truthing	1-3 days	Archived: £3.50 km^{-2}, minimum purchase 49 km^2 New: £7.50 km^{-2}, minimum purchase 100 km^2	£7.50

Satellite/sensor	Operator	Spatial resolution	Characteristics and uses	Repeat cycle	Pricing	
					Notes	£ per km^2
Multispectral moderate resolution						
Landsat 4 & 5 TM	NASA/NOAA/ USGS	30m MS 120m thermal IR	MS 7 bands Landcover mapping and change detection down to about 0.05ha.	16 days	Free archives for 1990, 2000, and 2005 (available soon). £300 per scene for new data.	0.01
Landsat 7 ETM+	NASA/NOAA/U SGS	15m pan 30m MS 60m TIR	MS 8 bands Landcover mapping and change detection down to about 0.05ha. Data quality badly compromised since SLC failure in June 2003.	16 days	Free archives for 1990, 2000, and 2005 (available soon). £300 per scene for new data.	0.01
Terra ASTER	MITI/NASA	15m VNIR 30m SWIR 90m TIR	MS 15 bands Landcover mapping and change detection down to about 0.05ha. Possible replacement for Landsat 7 data.	16 days	Data acquired on request. Raw data free (requires pre-processing), otherwise £30 per scene.	0.01
SPOT MSS	CNES	10m pan 20m MS	MS 4 bands Landcover mapping and change detection down to about 0.05ha. Possible replacement for Landsat 7 data.	3-26 days	Data acquired on request. £950– £2,150 per scene.	0.26 - 0.60

Satellite/sensor	Operator	Spatial resolution	Characteristics and uses	Repeat cycle	Pricing	
					Notes	£ per km^2
Multispectral low resolution						
SPOT-Vegetation	CNES	1.1km	MS 4 bands Regional/global landcover mapping. Hotspot detection, especially for >20ha.	3-26 days	Free	0
Envisat-1 MERIS	ESA	300m	MS 15 bands Regional/global landcover mapping. Hotspot detection, especially for >20ha.	35 days	Free	0
Terra/Aqua MODIS		250, 500 or 1,000m	Regional/global landcover mapping. Hotspot detection.	Up to daily	Free	0
Radar						
PALSAR ALOS	JAXA	10m	Landcover mapping and change detection down to about 0.05ha. Cloud-free imagery.	3-46 days	Unclear. Launched recently (2006), data are now reaching the research community.	
ERS-2	ESA	30m	Landcover mapping and change detection down to about 0.05ha. Cloud-free imagery.	35 days	£800 per scene.	0.08
Airborne 3D imaging						
LiDAR		< 1m	Forest volume for biomass estimation.	n/a	£2,000 per hour	Very high

Sources: Leroux 2004, Stoney 2008, Kellndorfer et al 2007.

Table 12 Remote sensing acronyms

ALOS	Advanced Land Observing Satellite
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
CNES	Centre National d'Etudes Spatiales
ESA	European Space Agency
ETM+	Enhanced Thematic Mapper (Landsat 7 sensor)
JAXA	Japan Aerospace Exploration Agency
LiDAR	Light detection and ranging
MERIS	Medium Resolution Imaging Spectrometer
MODIS	Moderate Resolution Imaging Spectroradiometer
MS	Multispectral – data recorded in multiple wavebands
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
PALSAR	Phased-array L-band SAR
pan	Panchromatic – a single band image combining data from multiple bands
Radar	Radio Detection and Ranging
SAR	Synthetic Aperture Radar
SPOT	Satellite Probatoire d'Observation de la Terre
SWIR	Short-wave infra-red
TIR	Thermal infra-red
TM	Thematic Mapper (Landsat 4 & 5 sensor)
USGS	United States Geological Service
VNIR	Very-near infra-red

5 Systems for forest monitoring

This section provides a summary of the main classes of satellite imagery useful for forest monitoring. The value of each class is explained and the situations where it would be useful are described. An indication of costs is provided for a monitoring system of the same scale as the reference system laid out in annex 4. These costs form the basis of data cost estimates provided in the individual country assessments.

5.1 Very high resolution imagery

Very high resolution imagery are impractical in terms of cost, processing and management effort, to use for wall-to-wall national coverage. These data sources are used for ground-truthing. In general, ground-truthing refers to using higher resolution data to verify the interpretation of lower resolution imagery – the high resolution data need not really be "ground" data. IKONOS and Quickbird data would be used by a forest monitoring project to validate the classes identified in a land-cover map, or to validate locations identified as having undergone changes in land-cover class.

Use of such data can reduce costs associated with ground survey, especially in countries where many sample locations are hard to access.

5.1.1 Indicative project expenditure

High resolution data are used as part of a sampling procedure, much as described for the carbon inventory survey. In the reference scenario, 300 blocks of 10 x 10km are sampled by medium resolution imagery. The high resolution imagery would sub-sample these blocks at the same 3% intensity:

3% of 30,000km^2 x £7.50 km^{-2} = £6,750 annually

5.2 Moderate resolution data

This includes the Landsat satellites. National coverages of data at 30m resolution can be purchased at reasonable cost, and can be processed and managed efficiently. Historical archives of Landsat data are available free of cost, and can be used to establish baselines. Areas of change can be identified down to about 0.05ha.

Landsat was the workhorse of land-cover monitoring, until the failure of Landsat 7 in 2003 (the sensor continues to operate, but the data it collects are badly degraded). NASA has undertaken to launch a replacement mission, but this is not scheduled until 2010. Until then, this leaves projects needing to identify replacement products. The most likely candidates are Landsat 5, Terra ASTER and SPOT MSS. For the latter two satellites, projects must negotiate acquisition requests with the satellite operators.

5.2.1 Indicative project expenditure

For a moderately large country (e.g. Indonesia, 1.8 million km^2), annual purchase of full coverage Landsat imagery would cost: 241 tiles x £300 = £72,300.

For comparison, the cost of IKONOS coverage would be: 1.8 million km^2 x £7.50 = £13.5 million. Quite apart from the huge cost, very high resolution imagery are impractical to use at national scales because of the huge data processing load. As described above, this type of data are most valuable for verifying analyses carried out using moderate resolution imagery.

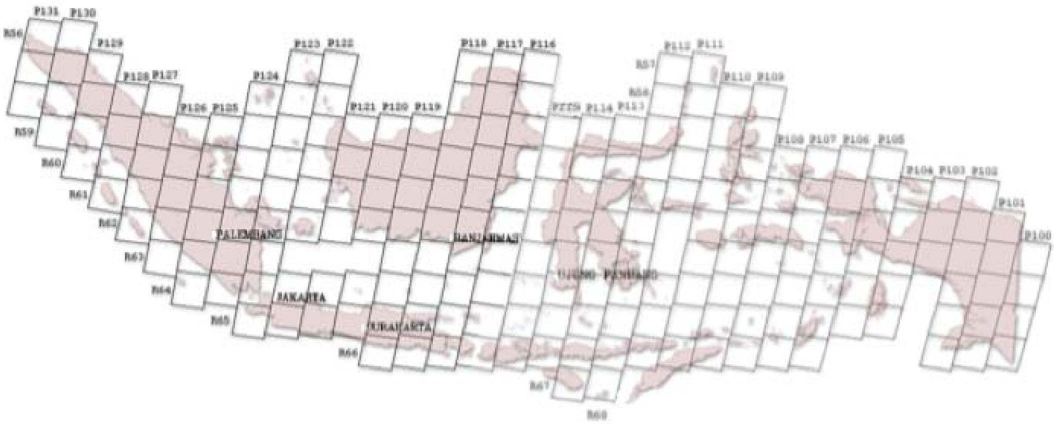

Figure 6 Landsat tiles for national coverage of Indonesia (Murdiyarso 2007).

5.3 Coarse resolution data

MODIS, MERIS and SPOT-Vegetation data are available cheaply or for free, and repeat coverage of the same location on an up to daily basis. Although the low resolution prevents these data from being used directly to measure deforestation, they can be used to identify areas where change is occurring. Higher resolution imagery can then be obtained and analysed to measure the extent over which change has occurred. Implementing this as an intermediate analysis step can, especially for very large countries, reduce the amount of work done. Projects can focus their high resolution analyses on regions identified by the coarse resolution data.

5.3.1 Indicative project expenditure

These data are available free of charge.

5.4 Radar data

Until recently, radar data have rarely been used in operational systems. This situation is rapidly changing (Kellndorfer et al 2007, 2008), and it can be expected that in the next 2 to 5 years, radar data will be used in many places.

Radar data have significant advantages, particularly in the tropics where the ability of radar to penetrate sometimes near-constant cloud cover is extremely valuable. Radar is an active sensor – the sensor itself illuminates the target. This means the satellite can collect data day and night.

Radar can potentially be used to measure vegetation height. From this, volumes can be calculated and radar can be used to survey vegetation volumes, from which biomass can be inferred, and ultimately carbon. This type of application is still in the proof of concept stage (Moss et al 2008), and is unlikely to become operational in the next 3 to 5 years.

5.4.1 *Indicative project expenditure*

ERS-2 scenes are of similar dimensions to Landsat. National coverage for a country about the size of Indonesia would require about 200 scenes x £800 per scene = £160,000

5.5 LiDAR

LiDAR sensors shine a laser on the ground surface, and measure how long it takes for the beam to be reflected back. When shone on vegetation, the beam is partly reflected from the top of the vegetation, and partly from the ground surface. Both of these reflections can be measured, generating first and second returns. The difference between these can be used to measure the height of the vegetation, from which volumes, biomass, and ultimately carbon stocks can be calculated (Omasa et al 2007, Lefsky et al 2001, Gonzalez et al 2005).

NASA planned to place a LiDAR sensor on board a satellite in the late 1990s, but the mission was cancelled. A LiDAR sensor was carried on board the ICESat platform, and proof-of-concept research has shown that forest biomass can be surveyed using this instrument (Lefsky et al 2005).

LiDAR sensors can also be flown on aircraft. However, LiDAR is a very advanced technique, and would only be achievable by the most advanced monitoring organisations. The current limitation of systems to aircraft platforms restricts the achievable coverage to small areas – sampling rather than wall-to-wall coverage.

5.5.1 *Indicative project expenditure*

The primary costs of using LiDAR are associated with the need to use aircraft, costing in the region of £2,000 per hour. If the aircraft flew for 30 hours, allowing flights to take place over 3 days (and therefore 3 different regions) the cost would be £60,000.

6 Country Summaries

Country	GDP per capita (2006)	Forest ha per cap	% Rural population	Community approaches feasible?	National Reporting Capacity?	National Remote Sensing Capacity	National Inventory Capacity	Forest loss rate pa (% 2005)	Forest Degradation	Restoration Capability	Restoration Potential
Bolivia	Moderate	Very High	Moderate	Yes	Basic	Very good	Good	Medium	Moderate	Little or none	Feasible
Brazil	High	High	Low	Maybe	Good	Excellent	Some?	Medium	Moderate	Good	Mixed
Colombia	Fair	Medium	Low	Maybe	Basic	Very good	None	Low	Moderate	Some	Feasible
Costa Rica	High	Medium	Moderate	Yes	Basic	Very good	Limited	Low	Little or none	Good	Feasible
Guyana	Moderate	Very High	High	Maybe	Basic	Limited?	Limited?	Low	Little or none	Some	Challenging
Mexico	High	Medium	Low	Yes	Good	Excellent	Good	Low	Moderate	Good	Challenging
Peru	Fair	High	Moderate	Yes	None	Very good	Excellent	Low	Little or none	Good	Feasible
Venezuela	High	High	Low	Unlikely	None	Non existent	None	Medium	Severe	Little or none	Challenging
Cambodia	Very Low	Medium	Very High	Yes	Basic	Very good	None	Extreme	Severe	Good	Feasible
China	Moderate	Low	High	Yes	Basic	Very good	Excellent	Positive	Moderate	Good	Feasible
India	Low	Low	Very High	Yes	Good	Very good	Excellent	Low	Severe	Good	Feasible
Indonesia	Moderate	Low	High	Maybe	Basic	Very good	Good	Extreme	Severe	Some	Feasible
Malaysia	High	Medium	Moderate	Unlikely	Basic	Excellent	Excellent	Medium	Moderate (east)	Some	Feasible
Myanmar	Very Low	Medium	Very High	Unlikely	Basic	Very good	Excellent	High	Severe	Little or none	Feasible
PNG	Moderate	Very High	Very High	Maybe	None	Limited	Some	Medium	Severe	Little or none	Feasible
Thailand	Fair	Low	Very High	Yes	Basic	Good?	Good	Low	Severe	Some	Feasible
Vietnam	Low	Low	Very High	Unlikely	Basic	Non existent	Excellent	High	Severe	Good	Feasible
Cameroon	Moderate	Medium	Moderate	Maybe	None	Non existent?	Good	High	Moderate	Little or none	Challenging
Congo Republic	Fair	Very High	Moderate	Maybe	Basic	Good	Good	Low	Little or none	Good	Feasible
DRC	Very Low	High	Very High	Maybe	None	Non existent	None	Low	Severe	Little or none	Challenging
Equatorial Guinea	High	High	High	Unlikely	None	Non existent	None	High	Moderate	Some	Feasible
Gabon	High	Very High	Low	Unlikely	None	Non existent	None	Low	Little or none	Good	Feasible
Ghana	Low	Low	High	Yes	Basic	Non existent	Limited?	Extreme	Severe	Good	Feasible
Liberia	Very Low	Medium	High	Unlikely	None	Non existent	Limited	High	Severe	Little or none	Challenging
Sierra Leone	Very Low	Medium	High	Unlikely	None	Non existent	None	Medium	Severe	Little or none	Challenging

Key to categories

GDP per capita (2006)	Forest ha per cap	% Rural population	Community approaches feasible?	National Reporting Capacity?	National Remote Sensing Capacity	National Inventory Capacity	Forest loss rate pa (% 2005)	Forest Degradation	Restoration Capability	Restoration Potential
>3500=High	>5= Very High	>65=Very High	Yes	Excellent- R.S Tier 3	Excellent (5 or 6)	Excellent (4)	>2=Extreme	Extreme	Good	Feasible
1750-3500 =Fair	1.5-5=High	50-65=High	Maybe	Good- R.S Tier 2	Very Good (4)	Good (3)	1-2%=High	Severe	Some	Challenging
700-1750 =Moderate	0.5-1.5 =Medium	25-50 =Moderate	Unlikely	Basic-R.S Tier 1	Good (3)	Some (2)	0.5-1% =Medium	Modest	Little or none	
350-700=Low	<0.5= Low	<25=Low		None	Limited (2)	Limited (1)	<0.5%=Low (Inc 0 or +)	Little or none		
<350=Very Low					Non Existent (0 or 1)	None (1)				

Note a query (?) after a rating shows where the results of the analysis carried out are not fully consistent with known or historical information

The category limits have been set subjectively to try and secure country groupings that seem to be logical

Information sources below

Table 13 Information Sources

Information	Source
GDP per capita 2006	FAO State of World's Forests 2007
Forest area per cap	FAO State of World's Forests 2007, FRA 2005
% Rural Population	FAO State of World's Forests 2007
Community approaches feasible?	Subjective – based on rural population, to what extent these are settled as opposed to forest dwelling, legal opportunity for community forestry, reported evidence of community level actions
National Reporting Capacity	Analysis of national reports to IPCC and related reporting
National Remote Sensing capacity	Evidence of use of remote sensing in national reports to FAO and IPCC, comments added from other sources and knowledge where known
National Inventory capacity	Evidence of use of remote sensing in national reports to FAO and IPCC, comments added from other sources and knowledge where known, including inventory related donor projects
Forest loss rate pa - (% 2005)	FRA 2005, FRA 2000 where no later data
Forest degradation	Variety of sources, ITTO, FAO and other information plus expert knowledge of reviewers
Restoration capability	Range of information sources - ITTO, Darwin, national reports, expert reviewers – relating to ongoing forest restoration work
Restoration potential	Subjective assessment based on forest type, forest ecology, soils and other similar factors plus level of degradation plus ITTO and reviewers' comments

Bolivia

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Bolivia has extensive tropical forest resources including significant areas of primary forest. Forest loss and degradation are relatively low and the forest resource is in good condition overall while progress with sustainable management is remarkable;
- Community rights including extensive forest land are enshrined in forest law but use is mainly extractive;
- Protected areas occupy a high proportion of the land but their control and management is often weak. Illegal cutting of prime species remains an issue;
- The need for restoration is slight other than in a few localities and natural regeneration techniques may be possible in most cases.

Table 14 Basic Statistics

GDP per cap (2006) US$	1101	Forest, ha per cap	6.54	Tropical % *of which*	100
HDI (2005)	0.70	Average volume m^3/ha	114	Rainforest %	32
Land Area 000ha	108,438	Annual change forest %	- 0.5	Moist forest %	18
Population 000s (2004)	8,986	Ann plantation change %	0	Dry forest %	40
Pop density / km^2	8.3	Primary %	50	Mountain forest %	10
% rural population	36.1	Modified natural %	50	Other %	
Forest area 000ha (2005)	58,740	Semi-natural %		Sub-tropical %	
Forest Cover %	54.2	Plantation %		Sub-tropical % *of which*	
Closed forest 000ha (2000)	47,999			Humid %	
Closed forest %	44.3			Dry %	
Protected areas %	31			Mountain %	
				Other %	

Bolivia has a substantial tropical forest in the east of the country, which is part of Amazonia. There is also significant forest on the slopes of the Andes up to around 3,500 metres elevation. The Amazon forest has a low to moderate natural disturbance rates and includes moist as well as semi-deciduous forest, with different species. Mahogany (*Swietenia macrophylla*) and Cedro (*Cedrela odorata*) have been major timber species.

Loss of forest cover has been greater in the more heavily settled Andean region although creaming of valuable species and land conversion has occurred in the Amazon zone. The overall rate of forest cover loss generally been less than 0.5% although degradation also needs to be considered.

The population density and the proportion of rural dwellers are both relatively low. Bolivia has made progress with sound policy and legislation aimed at sustainable management although application has not been problem free. Bolivia leads South America in certified natural forest.

There are good possibilities for community management as the forest law recognises community rights and allows community-managed production forest although non-timber products are generally more important in these than timber. Despite the good intent of the policy and legislation, there has not yet been fully effective implementation. Problems remain in respect of the absence of a clear land tenure system, illegal logging of prime species and cultivation of narcotics.

There are extensive protected areas but the quality of their control and management is not clear. Despite localised forest loss, overall pressure is quite low.

There appears to be little requirement for active forest restoration within the lower lying tropical forest area apart from some abandoned farming clearances. In the main, any restoration should be possible with natural means. Plantation experience is mainly at higher elevations including the treeless Altiplano.

Forest inventory

National capacity

- Bolivia scores 3 for the availability of forest inventory data in FRA 2005. Forest inventory statistics were based on a national forest inventory carried out in 1999;
- Carbon stocks were estimated in the FAO FRA 2005 using Tier 1 default factors;
- Bolivia did not report GHG emissions from forestry in their National Communication to the UNFCCC in 2000;
- There was an ITTO Diagnostic Mission to Bolivia in 1996 which resulted in major policy revision, some of the results of which have seen more recent progress;
- Bolivia has indicated interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **some national capacity** for forest inventory in Bolivia.

Capability gap

- Bolivia has a forested area of 58.7 Mha, about 20% more than the reference scenario;
- There is some inventory capacity;
- Investment required to achieve inventory capacity is estimated as 100% of the reference scenarios. We discount the 20% extra forest cover area with the fact that there is some existing capacity.

Table 15 Estimated costs to achieve capacity

Tier 2, approach A	£567,500 one-off cost
Tier 2, approach B	£140,000 recurring annually
Tier 3, approach A	£567,500 in first year £190,000 recurring annually
Tier 3, approach A, including degradation	£660,000 in first year £220,000 recurring annually

Remote sensing

National capacity

- Bolivia scores highly (4) for remote sensing capacity, having constructed land-cover maps based on Landsat imagery and also having performed deforestation measurements using Landsat imagery;
- The Noel Kempff Climate Action Project has been underway in Bolivia since 1997. The project implements REDD and uses state-of-the-art monitoring technology to verify reductions (Foster et al. 2002, Brown 2003). However, despite the close involvement of the Bolivian government, this is a project-level activity, and the degree of technology transfer to the host nation seems limited;
- There appears to be **significant national capacity** for remote sensing forest monitoring in Bolivia.

Capability gap

- The forested land area of Bolivia is about 120% of the reference scenario, requiring about 240 Landsat scenes. Annual data purchase costs (Landsat) would be about £72,000;
- Given the sustained track record Bolivia has of using remote sensing to monitor land-cover, we estimate the costs of establishing an annual monitoring capability at 33% of the reference scenario. This would allow for the recruitment and training of one additional analyst, to support the increased frequency of analyses required for annual monitoring;
- Cost estimates:
  - ⇒ First year: £174,000 + £72,000 data costs
  - ⇒ Annual recurring: £42,000 + £72,000 data costs
- With extensive forestry and significant experience in analysing Landsat-type imagery to identify areas undergoing change, Bolivia should investigate the advantages of using coarse resolution imagery and mixture models to refine its forest monitoring programme. The data are freely available, and the analytical methods straightforward. Both Brazil and Mexico have significant operational experience which could be drawn upon in a south-south partnership. Costs would be low, primarily being the time of an analyst, and training requirements. These costs would be offset by the increased efficiency resulting from the ability to focus analytical resources on locations undergoing change.

Brazil

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Huge forest area with losses and conversion activities attracting international attention. Atlantic forest nearly all lost and unlikely to be redeemable;
- Much forest production from plantations, these gave rise to conflict on social and environmental grounds, criticisms reduced but not fully addressed;
- Important forest dwelling communities in Amazon, which is largely privately owned;
- Complex regulations on forest protection, conservation and use are not well implemented due to poor access, low personnel numbers as well as undue complexity exacerbates poor control;
- Some progress with certification of natural and planted forests;
- Protected areas difficult to ascertain due to wide range of mechanisms depending on land cover type;
- Restoration potential will depend on location and substrate, some areas may be almost impossible to restore. Most community forest areas are for extractive rather than productive use.

Table 16 Basic Statistics

GDP per cap (2006) US$	5,460	Forest, ha per cap	2.67	Tropical % *of which*	98
HDI (2005)	0.80	Average volume m³/ha	131	Rainforest %	75
Land Area 000ha	845,942	Annual change forest %	- 0.6	Moist forest %	14
Population 000s (2004)	178,718	Ann. change plantation %	0	Dry forest %	8
Pop density / km²	21.1	Primary %	87.1	Mountain forest %	1
% rural population	16.4	Modified natural %	11.8	Other %	
Forest area 000ha (2005)	477,698	Semi-natural %		Sub-tropical % *of which*	2
Forest Cover %	57.2	Plantation %	1.1	Humid %	2
Closed forest 000ha (2000)	564,581			Dry %	
Closed forest %	66.7			Mountain %	
Protected areas %	17			Other %	

Brazil is a massive country with a huge forest resource. It is important to recall that low percentage figures may still refer to large areas! The main tropical forest resource is the Amazon forest; the coastal Atlantic forest is largely destroyed. The Amazon forest, mainly privately owned, has low natural disturbance but increasing human impact from clearance for small-scale and, particularly, large-scale agriculture has led to some increase in fire as well as forest loss.

The population is largely urban but there is a significant rural population including forest dwelling communities with high forest dependency. A major plantation resource provides much industrial wood, part is located in the tropical regions including Amazonia. Many of these plantations were subjected to intense criticism mainly on social but to a lesser extent on environmental grounds.

The policy and legislative framework is complex. Although regulations exist that should provide effective conservation and limit forest loss, difficulties of access and low personnel numbers for the size of the area involved have led to poor control over much of the area.

Exploitation of natural forest was historically focused on prime species only and had a return cycle of 50 years. This potentially sustainable approach may be compromised by the reduction of the return cycle to 25 years and the increasing range of species cut, leading to much larger canopy opening and possible ecological changes.

Protected Areas include a range of types from strict reserves through extractive reserves to the protected portion of privately owned land. It is not easy to determine the precise area but the level of control is less than optimal.

Forest restoration could be useful in some areas although the potential depends on the substrate. Laterite areas are likely to be very resistant to any but the most expensive and intensive interventions. There has been major international interest in the Atlantic forest but the potential for extensive restoration given the changes of land use that have occurred seems minimal.

Technical capacity – general situation

Brazil accounts for about one third of global tropical forests.

The PRODES program (Project for Gross Deforestation Assessment in the Brazilian Legal Amazonia) monitors land cover using satellite and other remote sensing data, allowing the annual estimation of gross rates of deforestation.

PRODES has developed sophisticated land use change predictive models, and near-real-time deforestation monitoring using coarse resolution (MODIS) imagery is in place (Dutschke & Wolf, 2007; UNFCCC 2006c).

Brazil is involved in south-south technology transfer, building capacity in neighbouring countries to implement monitoring systems using similar approaches (WHRC/IPAM 2007).

On the other hand, forest inventory data are scant and out of date. In the early 1970s, the forests of the Brazilian Amazon were inventoried under the RADAMBRASIL project but this inventory has not been updated since (UNFCCC 2006a).

Forest inventory

<u>National capacity</u>

- Brazil scores poorly (2) for the availability of forest inventory data in FRA 2005. Reporting relied on a compilation of data from various local projects and study sites. There has been no national forest inventory since the early 1970s;
- Carbon stocks were estimated using Tier 2 factors in the FAO FRA 2005. These were obtained from various academic studies conducted at multiple sites throughout the Amazon;
- Brazil estimated GPG emissions from forestry in its National Communication to the UNFCCC in 2004;
- Three Brazilian states (Acre, Amazonas and Mato Grosso) have indicated interest in participating in the World Bank FCPF initiative. Brazil has submitted views on REDD to the UNFCCC 2005 (although not discussing existing monitoring capacity specifically);
- There is little use made of national capacity for forest inventory in Brazil.

Capability gap

- Brazil has a forested area of 477.7 Mha, more than 9 times the reference scenario;
- There is little inventory capacity;
- Tier 2 factors are available for at least some strata;
- We estimate the cost of establishing a national forest inventory in Brazil as 9 times the reference scenario. Although some economies of scale could be expected (for instance, the number of strata would increase more slowly than the total forest area), there are also significant extra costs associated with the inaccessibility of large areas.

Table 17 Estimated costs to achieve capacity

Tier 2, approach A	£5,107,500 one-off cost
Tier 2, approach B	£1,260,000 recurring annually
Tier 3, approach A	£5,107,500 in first year £1,710,000 recurring annually
Tier 3, approach A, including degradation	£5,940,000 in first year £1,980,000 recurring annually

Remote sensing

National capacity

- Brazil scores very highly (6) for remote sensing capacity. Within the legal Amazon zone, the PRODES project applies a range of sophisticated remote sensing and modelling techniques to monitor deforestation, including near-real-time monitoring using coarse resolution satellite data;
- Outside of the Amazon region however, national monitoring is much less intensive. FRA 2005 reporting for these areas relied on information from a number of independent research and conservation projects;
- There is **very good national capacity** for remote sensing forest monitoring in Brazil. However, most activity is focussed on the Amazon region, with much less forest monitoring taking place outside of the Amazon zone.

Capability gap

- The forested land area of Brazil is 9 times the reference scenario, requiring about 1800 Landsat scenes. Annual data purchase costs (Landsat) would be £540,000. Brazil also has access to its own satellites, carrying instruments comparable to those on board Landsat;
- Brazil has an operational remote sensing monitoring system, providing accurate measurements of annual deforestation in the Amazon region;

- Amazonian forests represent about 70% of the forests of Brazil, with some 140 Mha (roughly 3 times the reference scenario) of Brazilian forests outside the Amazon basin;
- Because of the very large extent of Brazil's forests, we estimate the cost of extending the annual monitoring system to the rest of the country to be 100% the reference scenario, plus annual data costs:
  - ⇒ First year: £520,000 + £180,000 data costs
  - ⇒ Annual recurring: £126,000 + £180,000 data costs

Colombia

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Colombia has substantial forest resources with the large area in the Amazon – Orinoco basin largely untouched. That area is sparsely inhabited and has difficult access although there are forest dwelling, forest dependent communities. The forests of the Pacific coast and lower Andes have been heavily over-exploited;
- Forest loss and forest degradation are focused rather than widespread but significant areas are effectively out of bounds due to insurgency;
- There is a wide gulf between the enabling policy and legislation and its application. There is little effective control at field level. Decentralisation may be in part to blame and institutions are generally short of resources and guidance;
- There are extensive plantations in the Andean foothills and on the Pacific coast for industrial wood which include trials of indigenous species;
- The status of the extensive protected areas is difficult to ascertain although most appear to be relatively intact;
- There is scope for forest restoration, especially on the Pacific coast and in the foothills and community engagement may be possible in this.

Table 18 Basic Statistics

GDP per cap (2006) US$	2,874	Forest, ha per cap	1.34	Tropical % *of which*	100
HDI (2005)	0.79	Average volume m³/ha	108	Rainforest %	84
Land Area 000ha	103,870	Annual change forest %	- 0.1	Moist forest %	3
Population 000s (2004)	45,300	Ann. change plantation %	0.02	Dry forest %	2
Pop density / km²	43.6	Primary %	87.4	Mountain forest %	11
% rural population	23.1	Modified natural %	12.1	Other %	
Forest area 000ha (2005)	60,728	Semi-natural %		Sub-tropical % *of which*	
Forest Cover %	58.5	Plantation %	0.5	Humid %	
Closed forest 000ha (2000)	51,437			Dry %	
Closed forest %	49.5			Mountain %	
Protected areas %	24			Other %	

Colombia has a substantial wet and moist tropical forest resource the major part of which lies in the Amazon – Orinoco basin with a smaller block on the Pacific coast. The relatively flat topography and high rainfall mean that there is significant swamp forest. The lower slopes of the Andes are also forested and most of the forest loss is in this area and the Pacific coast forests rather than in the more extensive Amazon block.

The country is strongly decentralised administratively. Forest legislation grants rights to indigenous and local communities and roughly half of the forest is so allocated. There is armed insurgency and strong influence from the narcotics trade in the forest area, which consequently has restricted use.

There is a large gap between the intention and scope of the policy and legislation, generally well intentioned towards sound and sustainable forest management, and the reality on the ground. There are no guidelines or prescriptions in place relating to forest harvesting and regeneration and most exploited areas have been heavily abused.

There are extensive protected areas under various categories but the level of control is not readily apparent. Areas affected by insurgency, especially the closed rainforests, are particularly problematic.

The present plantation resource is predominantly at middle to higher elevations, where it is often associated with coffee growers, but there are also plantations for industrial wood. There are plans to increase the plantation resource, reportedly to 1.5 million ha, but it is not yet clear where this would be.

Restoration opportunities exist on the Pacific side and in the Andean foothills, watershed protection is identified as an important function of reforestation. It is not clear to what extent natural regeneration may be feasible, as degraded areas have been heavily exploited leading to secondary forests. The existence of community forests in this area may open up possibilities for community engagement.

There appears to be a mismatch between the policy and legislative framework and its application with most institutions under-resourced. The level of decentralisation and the small role of federal government agencies makes national level inventory and related tasks difficult. Despite relatively good training and education opportunities, the limited numbers of staff on the ground do not seem to be fully effective.

Forest inventory

<u>National capacity</u>

- Colombia scores 0 for the availability of forest inventory data in FRA 2005. No data were available for table T5 in the report (stand volumes);
- Carbon stocks were estimated in the FAO FRA 2005 using Tier 1 default factors;
- Colombia did not report GHG emissions from forestry in their National Communication to the UNFCCC in 2001;
- There has not been an ITTO Diagnostic Mission to Colombia;
- Colombia has indicated interest in participating in the World Bank FCPF initiative;
- Colombia has submitted views on REDD to the UNFCCC SBSTA. Colombia has started assessing its existing capacity and its institutional, technical and financial needs for supporting a REDD monitoring system, and is establishing pilot activities;
- There is **no national capacity** for forest inventory in Colombia.

<u>Capability gap</u>

- Colombia has a forested area of 60.7 Mha, about 20% larger than the reference scenario;
- There is no inventory capacity;
- Investment required to achieve inventory capacity is estimated as 120% of the reference scenarios.

Table 19 Estimated costs to achieve capacity

Tier 2, approach A	£681,000 one-off cost
Tier 2, approach B	£168,000 recurring annually
Tier 3, approach A	£681,000 in first year £228,000 recurring annually
Tier 3, approach A, including degradation	£792,000 in first year £264,000 recurring annually

Remote sensing

National capacity

- Colombia scores highly (4) for remote sensing capacity, having constructed three land-cover maps based on Landsat imagery since the mid 1980s (1986, 1994 and 2001). Although the images were classified by visual interpretation rather than automated methods, these exercises have furnished Colombian forest agencies with a useful technical base in remote sensing;
- There appears to be **significant national capacity** for remote sensing forest monitoring in Colombia.

Capability gap

- The forested land area of Colombia is about 120% of the reference scenario, requiring about 240 Landsat scenes. Annual data purchase costs (Landsat) would be about £72,000;
- Given the sustained track record Colombia has of using remote sensing to monitor land-cover, we estimate the costs of establishing an annual monitoring capability at 50% of the reference scenario;
- Cost estimates:
  - ⇒ First year: £260,000 + £72,000 data costs
  - ⇒ Annual recurring: £63,000 + £72,000 data costs
- We do not provide estimates for advanced capabilities (LiDAR, radar etc). Although Colombia has experience of analysing satellite imagery, the lack of any national inventory capacity is a more critical limiting factor. There can be no benefits from advanced remote sensing techniques until high quality ground survey data are available.

Baseline modelling capacity

- Colombia has a low rate of deforestation (-0.1%), and therefore would benefit from a modelling approach to establishing a forest emissions baseline;
- Modelling capacity: £37,500.

Costa Rica

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Historical major loss of forest, primarily through land conversion for agriculture and pasture;
- Currently strong incentives to protect forest for high value ecotourism;
- Land use changes have returned land to secondary forest and plantations to meet national timber demand;
- Country has been active in securing pilot carbon funding for conservation;
- Good remote sensing capacity but very limited inventory capacity.

Table 20 Basic Statistics

GDP per cap (2006) US$	5,034	Forest, ha per cap	0.59	Tropical % *of which*	100
HDI (2005)	0.85	Average volume m³/ha	211	Rainforest %	61
Land Area 000ha	5,106	Annual change forest %	0.1	Moist forest %	24
Population 000s (2004)	4,061	Ann. change plantation %	0.01	Dry forest %	2
Pop density / km²	79.5	Primary %	7.5	Mountain forest %	13
% rural population	38.8	Modified natural %	55.2	Other %	
Forest area 000ha (2005)	2,391	Semi-natural %	37.1	Sub-tropical % *of which*	
Forest Cover %	46.8	Plantation %	0.2	Humid %	
Closed forest 000ha (2000)	2,058			Dry %	
Closed forest %	40.3			Mountain %	
Protected areas %	36			Other %	

Costa Rica was a heavily forested country but suffered extensive land clearance for agriculture and pasture. Market changes have returned some of this land back to natural forest and made it available for plantations.

The country has moved strongly towards a conservation focus in its remaining natural forest and is prominent in international debate on forest conservation. There is continuing pressure for land conversion in some areas depending on product prices.

There is good knowledge of plantations and sound research information is available to underpin this if required. In regional terms, Costa Rica scores quite well for governance.

Forest inventory

National capacity

- Costa Rica has a low score (1) for the availability of forest inventory data in FRA 2005. Forest inventory statistics were based on a pilot forest inventory project carried out by the FAO in 2001. The project did not gather national-level data;
- Carbon stocks were estimated in the FAO FRA 2005 using Tier 1 default factors;

- Costa Rica did report GHG emissions from forestry in their National Communication to the UNFCCC in 2000;
- Costa Rica is not a member of ITTO;
- Costa Rica has indicated interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **little or no national capacity** for forest inventory in Costa Rica.

Capability gap

- Costa Rica has a forested area of 2.4 Mha, about 5% of the reference scenario;
- There is no inventory capacity;
- Investment required to achieve inventory capacity is estimated as 33% of the reference scenarios;
- As explained in Annex 4, cost savings from reduced extent of forestry are small or zero below about 1/3 the forest area reference scenario;
- Costa Rica should investigate the option of forming a regional forest inventory capability, to share costs.

Table 21 Estimated costs to achieve capacity

Tier 2, approach A	£190,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£190,000 in first year £63,000 recurring annually
Tier 3, approach A, including degradation	£220,000 in first year £73,000 recurring annually

Remote sensing

National capacity

- Costa Rica scores highly (4) for remote sensing capacity, having constructed three land-cover maps based on aerial and Landsat imagery since the early 1990s (1992, 2000 and 2004). Although the images were classified by visual interpretation rather than automated methods, these exercises have furnished Costa Rican forest agencies with a useful technical base in remote sensing;
- There appears to be **significant national capacity** for remote sensing forest monitoring in Costa Rica.

Capability gap

- The forested land area of Costa Rica is about 5% of the reference scenario, requiring about 10 Landsat scenes. Annual data purchase costs (Landsat) would be about £3,000;
- Given the sustained track record Costa Rica has of using remote sensing to monitor land-cover, we estimate the costs of establishing an annual monitoring capability at 50% of the reference scenario;
- Cost estimates:
  - ⇒ First year: £260,000 + £3,000 data costs
  - ⇒ Annual recurring: £63,000 + £3,000 data costs
- As explained in Annex 4, there are no cost savings available because of the small area to cover. The smallest sustainable team requires 3 analysts, and the range of analyses are no different from a larger country;
- Costa Rica should investigate the possibility of forming a regional remote sensing capacity, to share costs;
- We do not provide estimates for advanced capabilities (LiDAR, radar etc). Although Costa Rica has experience of analysing satellite imagery, the lack of any national inventory capacity is a more critical limiting factor. There can be no benefits from advanced remote sensing techniques until high quality ground survey data are available.

Baseline modelling capacity

- Costa Rica's forests are increasing slightly (+0.1%), and therefore would benefit from a modelling approach to establishing a forest emissions baseline;
- Modelling capacity: £37,500.

Guyana

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Guyana has an extensive lowland tropical forest resource of low productivity and great ecological fragility with substantial areas still in good condition and largely inaccessible;
- Despite innovative policy and legislation and considerable past donor support, implementation on the ground is weak with critically short staff levels;
- Political upheavals and conflict have damaged the economy and pervade all aspects of life in the country. There are serious unresolved Amerindian land rights issues;
- Small-scale and usually illegal gold mining is a major source of forest loss and degradation;
- There is limited scope for forest restoration, which could engage communities in some areas but much of the forest area is unoccupied.

Table 22 Basic Statistics [1]

GDP per cap (2006) US$	1,219	Forest, ha per cap	19.56	Tropical % *of which*	100
HDI (2005)	0.75	Average volume m^3/ha	145	Rainforest %	73
Land Area 000ha	19,685	Annual change forest %	0.0	Moist forest %	23
Population 000s (2004)	772	Ann change plantation %	0.0	Dry forest %	
Pop density / km^2	3.9	Primary %	61.7	Mountain forest %	4
% rural population	62	Modified natural %	38.3	Other %	
Forest area 000ha (2005)	15,104	Semi-natural %	0.0	Sub-tropical % *of which*	
Forest Cover %	76.7	Plantation %	0.0	Humid %	
Closed forest 000ha (2000)	16,916			Dry %	
Closed forest %	85.9			Mountain %	
Protected areas %	1			Other %	

Guyana lies on the Caribbean coast of South America and is very heavily forested. The bulk of the country is relatively flat with mountains to the west and savanna clad hills in the southwest. Guyana is best known as the supplier of Greenheart (*Chlorocardium rodiei*).

The forest has low productivity and is vulnerable to overcutting, especially on the white sands which are of very low inherent fertility and almost impossible to restore. Iwokrama International Rainforest Centre occupies 360,000 ha of forest, half dedicated to demonstrating sustainable management the remainder to conservation.

The population is concentrated along the coast and the major river estuaries with the forest zone largely unoccupied. Outstanding tenure issues relating to Amerindian rights remain unresolved and contentious.

[1] The figure for the rural population is misleading as the majority live on the coastal strip. The forest area is largely unoccupied

Although the accessible areas with useful timber species have been largely logged over and a substantial area degraded, a large and relatively pristine forest resource remains. Abandoned bauxite mine land, however, remains unrestored. Extensive small-scale gold mining is a major factor in forest disturbance through altered drainage patterns.

The forest policy and associated legislation are well formulated and include guidelines appropriate for sound management; staff shortages and political uncertainties have restricted their application. Standards of field management vary but there is evidence of illegal harvesting and corruption in concession allocation. The standard forest management method is polycyclic felling on a 60-year return cycle, the length reflecting the poor productivity and difficulties of regeneration. Although up to 20 m^3/ha can be cut, the actual average figure is less than 10 m^3.

Guyana has been in political disarray at some scale since independence in 1966 and there is underlying ethnic conflict pervading most elements of politics and the economy. There has been a massive loss of skilled people from the country and increasing problems with the narcotics trade.

As in the state forest area, the level of field control in protected areas is low and increased accessibility has exacerbated this. There is a major conservation concession as well as the Iwokrama area, both of which are better protected than other localities.

There is limited scope for forest restoration, given the challenges of the site types although the possibility for some work in community managed areas exists. Unresolved land tenure issues may preclude effective action.

Overall forest-based activities in Guyana are prejudiced and limited by inadequate public-sector staffing levels and poor practices in much of the associated industry.

Forest inventory

National capacity

- Guyana scores 1 for the availability of forest inventory data in FRA 2005. Reporting relies on the report of an ITTO Diagnostic Mission, and a study in Iwokrama;
- Carbon stocks in the FAO FRA 2005 report were estimated using IPCC Tier 1 factors;
- Guyana did not include forestry GHG estimates in its National Communication to the UNFCCC in 2002;
- Guyana has indicated its interest in participating in the World Bank FCPF initiative;
- Guyana has not submitted views on REDD to the UNFCCC SBSTA;
- There is **little or no national capacity** for forest inventory in Guyana although the basics are in place; this is mainly due to staffing problems.

Capability gap

- Guyana has a forested area of 15.1 Mha, about 1/3 the size of the reference scenario;
- There is little existing forest inventory capacity despite earlier DFID support;
- Estimated costs are 1/3 the reference scenario.

Table 23 Estimated costs to achieve capacity

Tier 2, approach A	£190,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£190,000 in first year £63,000 recurring annually
Tier 3, approach A, including degradation	£220,000 in first year £74,000 recurring annually

Remote sensing

National capacity

- Guyana showed no evidence of using remote sensing in FRA 2005;
- There appears to be **no national capacity** for remote sensing forest monitoring in Guyana although capacity does exist within Iwokrama.

Capability gap

- The forested land area of Guyana is about 1/3 that of the reference scenario. Annual data purchase costs (Landsat) would be about £20,000;
- Cost estimates:
  - ⇒ First year: £520,000 + £20,000 data costs;
  - ⇒ Annual recurring: £126,000 + £20,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*).

Baseline modelling capacity

- Guyana's forest area is stable, and therefore Guyana would benefit from a modelling approach to establishing a forest emissions baseline;
- Modelling capacity: £37,500.

Mexico

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- The main tropical forests in Mexico have high natural disturbance and are ecologically robust. Illegal clearance and over exploitation have nevertheless resulted in extensive forest loss and degradation;
- The latest policy and legislative framework provides a sound basis for forward movement and there is an active programme of forest restoration. This may need to be developed around planted trees in much of the tropical region;
- There is a high level of technical forestry competence in Mexico.

Table 24 Basic Statistics

GDP per cap (2006) US$	7,875	Forest, ha per cap	0.62	Tropical % *of which*	70
HDI (2005)	0.83	Average volume m³/ha	52	Rainforest %	9
Land Area 000ha	190,869	Annual change forest %	- 0.4	Moist forest %	32
Population 000s (2004)	103,795	Ann change plantation %	0.0	Dry forest %	11
Pop density / km²	54.4	Primary %	51.1	Mountain forest %	18
% rural population	24.2	Modified natural %	47.2	Other %	
Forest area 000ha (2005)	64,238	Semi-natural %		Sub-tropical % *of which*	30
Forest Cover %	33.7	Plantation %	1.6	Humid %	
Closed forest 000ha (2000)	33,613			Dry %	
Closed forest %	17.6			Mountain %	20
Protected areas %	4			Other %	10

Mexico' main tropical forests lie in the Yucatan peninsular and along the coast of the Gulf of Mexico and the Pacific. The forest is hurricane forest subjected to regular major disturbance and associated fire. There has also been resettlement and illegal settlement, land clearing and ranching all of which has reduced forest cover, degraded remaining forest and increased the frequency of fire.

Most settlement in the tropical forest region is concentrated into communities (ejidos) with communal forest rights and there is high forest dependency in many of these for timber and other products. The Yucatan peninsular is limestone and there are major problems with access to fresh water, such that standard techniques such as raising nursery stock may prove difficult.

The tropical forests of Mexico have perhaps been more neglected than those in some other regions. Despite past forest losses, forest loss appears to be reducing under increased control and there is an active programme of restoration of degraded areas. In parts of the tropical belt, the natural forest is so degraded that artificial restoration approaches will be essential.

There is a high level of technical forestry competence in Mexico and recent legislation and political support appear to be reversing years of decline. There remain some challenges particularly in respect of forest related matters in impoverished communities.

Technical capacity – general situation

Mexico has a relatively advanced economy and supports a sophisticated education sector. This is reflected in the advanced technical capacity of its lead forestry organisation, CONAFOR (Comisión Nacional Forestal). CONAFOR was set up in 2001 with a broad mandate to manage Mexican forest resources, and was supported by a large increase in the budget devoted to forestry (FAO 2005).

CONAFOR maintains the national inventory of forests and soils, INFyS (Inventario Nacional Forestal y de Suelos). Annual monitoring is carried out using satellite data (MODIS) to generate maps of deforestation, reforestation, and degradation, and to identify hotspots for more detailed analysis.

CONAFOR collaborates with a number of national and international organisations, including the US Forest Service and the Canadian Forest Service, ensuring they have direct access to high quality technical assistance when required.

CONAFOR has established a standard methodology and baselines for forest monitoring using moderate resolution satellite imagery (MODIS).

Land-cover change is monitored annually using satellite imagery and a standardised methodology. For specific analyses, CONAFOR can also draw on other national datasets. For instance, to provide reporting against 1990, 2000, and 2005 baselines for the 2005 Global FRA, CONAFOR chose to use national vegetation cover maps produced by INEGI (Instituto Nacional de Estadística Geografía e Informática) in 1993 and 2002 using a combination of field work, photo interpretation, and satellite imagery. Additionally, CONAFOR builds models of future land-use changes based on a wide range of data, which it uses to inform policy (FAO 2005).

Forest inventories are carried out every 5 years, starting from 2004 (FAO 2005). No data prior to this date are available (FAO 2005). A high degree of expertise for carrying out field-based measurement of forest carbon exists within Mexico (*e.g.* Návar *et al*. 2005).

Forest inventory

National capacity

- Mexico scores average (3) for the availability of forest inventory data in FRA 2005. However, a new national forest inventory, operating on a 5 year cycle, was established in 2004, and it seems likely that this inventory will support Tier 2 (at least) carbon estimation and will provide accurate forest stocks data;
- Carbon stocks were estimated using Tier 1 factors in the FAO FRA 2005;
- Mexico has not estimated GPG emissions from forestry in its National Communications to the UNFCCC in 1997, 2001 and 2006;
- Mexico has indicated interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **good national capacity** for forest inventory in Mexico.

Capability gap

- Mexico has a forested area of 64.2 Mha, roughly 130% of the reference scenario;
- There is good inventory capacity, and Tier 2 factors are likely to be available;

- CONAFOR reports a very large increase in investment in national forest monitoring, starting in 2004. The first results from this programme will not be available until 2009;
- We assess that Mexico is currently fully capable of monitoring her forests at Tier 2 level of detail;
- Lacking further information (until the first inventory is completed in 2009), we provide estimates for achieving Tier 3 given a starting point of Tier 2.

Table 25 Estimated costs to achieve capacity

Tier 2, approach A	Capacity exists.
Tier 2, approach B	n/a
Tier 3, approach A	£83,000 recurring annually
Tier 3, approach A, including degradation	£95,000 recurring annually

Remote sensing

National capacity

- Mexico scores highly (5) for remote sensing capacity. Land-cover maps have been generated on multiple dates, based on satellite imagery, aerial photos, and ground truthing exercises. There is also an advanced system of hotspot identification using coarse resolution imagery, which identifies locations undergoing rapid change;
- There appears to be **good national capacity** for remote sensing forest monitoring in Mexico.

Capability gap

- The forested land area of Mexico is 130% of the reference scenario, requiring about 260 Landsat scenes. Annual data purchase costs (Landsat) would be £78,000;
- Although Mexico has significant capability in remote sensing, and has implemented a coarse resolution monitoring system, fine resolution monitoring (*i.e.* Landsat) on an annual basis has not been implemented;
- We estimate the cost of establishing an annual monitoring system to be 1/3 the reference scenario, plus annual data costs:
  - ⇒ First year: £173,000 + £78,000 data costs;
  - ⇒ Annual recurring: £42,000 + £78,000 data costs.

Baseline modelling capacity

- Mexico has a low rate of deforestation (-0.4%), and therefore would benefit from a modelling approach to establishing a forest emissions baseline;
- Substantial capacity for land-use and economic modelling already exists within Mexico;
- There is no capacity gap for baseline modelling.

Peru

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Peru has a very extensive tropical rainforest resource in the Amazon region and much of this is not under severe threat apart from where prime species occur. Settlement into the region and expansion around existing towns are the major causes of forest loss;
- There has long been shifting agriculture on the flood banks of major rivers and these areas are dominated by secondary forests;
- The relatively new, forest policy and associated legislative framework are forward looking and, if effectively implemented, would be a major achievement. The principal constraint is the lack of trained personnel to oversee control at field level;
- There are extensive protected areas of various categories which are relatively secure;
- Community forests have been imaginatively incorporated into the sector strategy including allowing timber production in parallel with other uses;
- Forest restoration plans have been developed and could engage communities.

Table 26 Basic Statistics

GDP per cap (2006) US$	3,264	Forest, ha per cap	2.50	Tropical % *of which*	100
HDI (2005)	0.77	Average volume m³/ha	158	Rainforest %	86
Land Area 000ha	128,000	Annual change forest %	- 0.1%	Moist forest %	
Population 000s (2004)	27,547	Ann. change plantation %	0.01	Dry forest %	
Pop density / km²	21.5	Primary %	88.8	Mountain forest %	14
% rural population	25.8	Modified natural %	10.1	Other %	
Forest area 000ha (2005)	68,742	Semi-natural %		Sub-tropical % *of which*	
Forest Cover %	53.7	Plantation %	1.1	Humid %	
Closed forest 000ha (2000)	64,204			Dry %	
Closed forest %	50.2			Mountain %	
Protected areas %	10			Other %	

Peru straddles the Andes from the Pacific to the Amazon basin and consequently exhibits considerable forest diversity. The Amazon area remains a considerable resource in relatively good condition. There are extensive floodplain forests that have been cleared repeatedly for shifting agriculture and carry secondary forests. The plantation resource is mainly exotic *Eucalyptus globulus* and in the highlands.

The natural disturbance level in the Amazon block is low to moderate and human activity is the main influence. Clearing tends to be along rivers and/or around existing settlements leaving large areas that are very stable. There are significant forest dwelling communities with high forest dependency but community management of timber producing forests is also allowed under the legislation.

The latest policy and legislation, dating from 2000, are forward looking and appropriate with a strong focus on sustainable management. The forest management system is polycyclic felling with a 40-year return cycle and felling intensity limits. There is illegal cutting of high value species and delivering effective control on the ground remains a challenge. Certified forest is presently of limited extent but there are indications of considerable expansion of this area

Protected areas, including two transboundary reserves, are extensive. There are also protected parts within production areas and conservation concessions that allow extractive use but not production. The integrity of the protected areas is not under significant threat although there is pressure on prime timber species where they occur. There are also pressures on community lands.

Settlement into the Amazon region is at a high level and a forest restoration plan has been developed with preliminary research on planting indigenous species undertaken. It would appear that a mix of natural and artificial regeneration systems is envisaged. There would be scope for community engagement where it is community land.

The lack of adequate human capacity and the difficulties of access are the main issues that require to be addressed if progress is to be made.

Forest inventory

National capacity

- Peru scores highly (4) for the availability of forest inventory data in FRA 2005. Forest inventory statistics were based on regionally assembled statistics gathered throughout the 1990s and 2000s. However, statistics are only available on commercial stocks;
- Because inventory data are limited to commercially valuable stocks, carbon stocks were not estimated in the FAO FRA 2005;
- Peru did not report GHG emissions from forestry in their National Communication to the UNFCCC in 2001;
- There was an ITTO Diagnostic Mission to Peru in 2003;
- Peru has indicated interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **some national capacity** for forest inventory in Peru. However, this is based on local and regional collection of data, and is limited to commercially valuable species.

Capability gap

- Peru has a forested area of 68.7 Mha, roughly 40% more than the reference scenario;
- There is some inventory capacity, but of limited utility for carbon accounting;
- Investment required to achieve inventory capacity is estimated as 140% of the reference scenarios. We do not discount for existing inventory capacity on the basis that this has no utility for estimating carbon fluxes.

Table 27 Estimated costs to achieve capacity

Tier 2, approach A	£794,500 one-off cost
Tier 2, approach B	£196,000 recurring annually
Tier 3, approach A	£794,500 in first year £266,000 recurring annually
Tier 3, approach A, including degradation	£924,000 in first year £308,000 recurring annually

Remote sensing

National capacity

- Peru scores highly (4) for remote sensing capacity, having constructed land-cover maps based on Landsat imagery and also having performed deforestation measurements using Landsat imagery. However, the more recent analyses (2000) were carried out using printed satellite images rather than computer-based methods;
- There appears to be **little national capacity** for remote sensing forest monitoring in Peru.

Capability gap

- The forested land area of Peru is 140% of the reference scenario, requiring about 280 Landsat scenes. Annual data purchase costs (Landsat) would be £84,000;
- We estimate the costs of establishing an annual monitoring capability at 100% of the reference scenario. The methods employed in previous satellite image analyses do not represent capacity for annual forest monitoring for REDD;
- Cost estimates:
  - ⇒ First year: £520,000 + £84,000 data costs;
  - ⇒ Annual recurring: £126,000 + £84,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*).

Baseline modelling capacity

- Peru has a low rate of deforestation (-0.1%), and therefore would benefit from a modelling approach to establishing a forest emissions baseline;
- Modelling capacity: £37,500.

Venezuela

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Venezuela, which was originally well covered in forest has lost most of its once extensive semi-deciduous forest to land conversion and the evergreen forest north of the Orinoco is in very poor condition. The forest to the south of the river is less degraded;
- Despite the large nominal protected area, this figure masks underlying conflict over land rights and loss of traditional forest use to settlers;
- The country places heavy reliance on its substantial pine plantation resource while there seems to be little interest in the natural forestry sector and very limited capacity for control or assessment;
- There appears to be little scope for and less concern for forest restoration.

Table 28 Basic Statistics

GDP per cap (2006) US$	6,633	Forest, ha per cap	1.83	Tropical % *of which*	100
HDI (2005)	0.79	Average volume m^3/ha	134	Rainforest %	51
Land Area 000ha	88,205	Annual change forest %	- 0.6	Moist forest %	19
Population 000s (2004)	26,127	Ann. change plantation %	0.0	Dry forest %	9
Pop density / km^2	29.6	Primary %	n.a.	Mountain forest %	18
% rural population	12.1	Modified natural %	n.a.	Other %	3
Forest area 000ha (2005)	47,713	Semi-natural %	n.a.	Sub-tropical % *of which*	
Forest Cover %	54.1	Plantation %	n.a.	Humid %	
Closed forest 000ha (2000)	49,926			Dry %	
Closed forest %	56.6			Mountain %	
Protected areas %	66			Other %	

Venezuela has a large area of semi-deciduous and evergreen forest in the Amazon – Orinoco basin, which is heavily degraded north of the Orinoco. There is an outlying Andean massif and a narrow coastal strip along the Caribbean Sea. It is reported that the semi-deciduous forest has been the most severely affected by cutting and subsequent conversion. There is extensive small-scale mining for gold and diamonds, which is presumably similarly destructive to that in Guyana.

A large proportion of the forest now falls within protected areas but these are often only on paper and there are considerable land tenure disputes with Amerindian communities living in the areas defined. Although low in number these communities are heavily forest dependent and there is conflict with settlers.

Venezuela has created a large plantation resource, 863,000 ha, mainly of *Pinus caribaea*. One sixth of this has been certified. No natural forest is certified and only a small proportion is regarded as being sustainably managed.

There are major weaknesses in legislation and institutional overlaps and the reality of control on the ground is weak. Lack of access appears to be the main protector of the extensive forests south of the Orinoco.

There appears to be relatively little interest in the forest resource at the political level nor any opportunities for restoration in the near future. The lack of control of settlement and conversion is a major constraint

Forest inventory

National capacity

- Venezuela scores 0 for the availability of forest inventory data in FRA 2005. No data were available to estimate forest stocks;
- Carbon stocks were not estimated in the FAO FRA 2005 report;
- Venezuela did not report GHG emissions from forestry in their National Communication to the UNFCCC in 2005;
- There has not been an ITTO Diagnostic Mission to Venezuela;
- Venezuela has not indicated interest in participating in the World Bank FCPF initiative, and has not submitted views on REDD to the UNFCCC SBSTA;
- There is **little or no national capacity** for forest inventory in Venezuela.

Capability gap

- Venezuela has a forested area of 47.7 Mha, very close to the size of the reference scenario;
- There is little or no existing forest inventory capacity;
- Estimated costs are the same as the reference scenario.

Table 29 Estimated costs to achieve capacity

Tier 2, approach A	£567,500 one-off cost
Tier 2, approach B	£140,000 recurring annually
Tier 3, approach A	£567,500 in first year £190,000 recurring annually
Tier 3, approach A, including degradation	£660,000 in first year £220,000 recurring annually

Remote sensing

National capacity

- Venezuela showed no evidence of using remote sensing in FRA 2005;
- There appears to be **no national capacity** for remote sensing forest monitoring in Venezuela.

Capability gap

- The forested land area of Venezuela is about the same as that of the reference scenario, requiring about 200 Landsat scenes. Annual data purchase costs (Landsat) would be about £60,000;
- Cost estimates:
  - ⇒ First year: £520,000 + £60,000 data costs;
  - ⇒ Annual recurring: £126,000 + £60,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*).

Cambodia

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Cambodia had an extensive forest cover of diverse moist and dry tropical forest but clearance and uncontrolled cutting has severely degraded this but not to extinction;
- Forest cover loss continues at a high rate despite a ban on commercial logging and there is high forest dependency;
- The level of control of illegal activities is generally poor;
- There are important centres of biodiversity, particularly in the north east;
- Fire and agricultural expansion are increasing problems;
- There is urgent need for forest restoration, the potential for natural restoration is constrained by the degraded forest base but there is scope for artificial systems;
- Community engagement is legally possible and could be an effective approach.

Table 30 Basic Statistics

GDP per cap (2006) US$	453	Forest, ha per cap	0.77	Tropical % *of which*	100
HDI (2005)	0.60	Average volume m³/ha	40	Rainforest %	7
Land Area 000ha	17,652	Annual change forest %	- 2.1	Moist forest %	16
Population 000s (2004)	13,630	Annual plantation %	-0.02	Dry forest %	77
Pop density / km²	77.2	Primary %	3.1	Mountain forest %	
% rural population	80.8	Modified natural %	96.4	Sub-tropical %	
Forest area 000ha (2005)	10,447	Semi-natural %			
Forest Cover %	59.2	Plantation %	0.6		
Closed forest 000ha (2000)	5,500				
Closed forest %	31.2				
Protected areas %	24%				

Cambodia is dominated by the heavily settled flood plain of the Mekong and its tributary, the Tonle Sap. There are hills to south-west and a more substantial massif to the north east. The climate is monsoonal. The closed forests include both most and dry types, those of the mountains of the north-east having particularly high biodiversity values.

Forest-cover loss and degradation from returning refugees and uncontrolled logging during the 1990s was catastrophic and the current rate of loss remains high despite a ban on commercial logging since 2002. The average standing volume figure reflects the substantial areas that were effectively clear-felled. Practically no undisturbed forest remains while fire and conversion to continue to cause losses as does illegal logging.

The population is predominantly rural and high levels of poverty result in heavy forest dependency for timber and non-timber products, included traded products such as damar and rattans.

The forest is amenable to management through application of a polycyclic felling system but the breakdown in control has resulted in extensive secondary forests and degraded areas with islands of less degraded forest. Forest restoration is a high priority.

Natural regenerative capacity is generally high although the depleted resource base will result in relatively poor quality regrowth. There is considerable experience of plantations with a wide range of species, including teak and exotics.

The policy and legislation are conducive to community management and there is a fairly strong history of community co-operation. Technical support remains limited although the country has a strong international voluntary sector active in environmental and community development.

National capacity for inventory and related measurements exists but is relatively limited.

Forest inventory

National capacity

- Cambodia scores 0 for the availability of forest inventory data in FRA 2005. The only information available was an old FAO report with estimates of growing stock ha^{-1};
- Carbon stocks were estimated in the FAO FRA 2005 using Tier 1 default factors;
- Cambodia did not report GHG emissions from forestry in their National Communication to the UNFCCC in 2002;
- There was an ITTO Diagnostic Mission to Cambodia in 2004. Although levels of conceptual training have improved, there are few opportunities for staff to gain practical field experience. Without significant external support, the forest authority does not have and is unable to develop the capacity to manage Cambodia's forests;
- Cambodia has not indicated interest in participating in the World Bank FCPF initiative, and has not submitted views on REDD to the UNFCCC SBSTA;
- There is **no national capacity** for forest inventory in Cambodia.

Capability gap

- Cambodia has a forested area of 10.4 Mha, about 20% the size of the reference scenario;
- There is no inventory capacity;
- Investment required to achieve inventory capacity is estimated as 33% of the reference scenarios.

Table 31 Estimated costs to achieve capacity

Tier 2, approach A	£190,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£190,000 in first year £63,000 recurring annually
Tier 3, approach A, including degradation	£220,000 in first year £73,000 recurring annually

Participatory forest inventory

- Cambodia has a low per capita GDP, but a relatively well-educated population;
- The NGO sector is able to operate effectively within the country;
- There is a large rural population;
- Cambodia's forests are accessible;
- A participatory forest inventory approach may be feasible.

Remote sensing

National capacity

- Cambodia scores highly (4) for remote sensing capacity, having constructed three land-cover maps based on Landsat imagery since the early 1990s. The first two exercises lacked ground-truth data, because of wars, but the third map, constructed in 2002, was verified with adequate ground truthing;
- There appears to be **significant national capacity** for remote sensing forest monitoring in Cambodia.

Capability gap

- The forested land area of Cambodia is about 20% of the reference scenario, requiring about 40 Landsat scenes. Annual data purchase costs (Landsat) would be about £12,000;
- Given the sustained track record Cambodia has of using remote sensing to monitor land-cover, we estimate the costs of establishing an annual monitoring capability at 50% of the reference scenario;
- Cost estimates:
  - ⇒ First year: £260,000 + £12,000 data costs;
  - ⇒ Annual recurring: £63,000 + £12,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar etc). Although Cambodia has experience of analysing satellite imagery, the lack of any national inventory capacity is a more critical limiting factor. There can be no benefits from advanced remote sensing techniques until high quality ground survey data are available.

China

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- China has a diverse forest resource based increasingly on plantations and restored natural forest. There is tropical forest only in Hainan, which is nominally fully protected. Wet sub-tropical forest occurs in Yunnan and adjacent provinces;
- In terms of measuring and monitoring for climate change reporting, the normal systems if management control for restoration and plantations can be readily adapted to provide the necessary information.

Table 32 Basic Statistics

GDP per cap (2006) US$	2,055	Forest, ha per cap	0.15	Tropical % *of which*	4
HDI (2005)	0.78	Average volume m³/ha	52	Rainforest %	
Land Area 000ha	932,742	Annual change forest %	2.1	Moist forest %	1
Population 000s (2004)	1,326,544	Ann. change plantation %	0.75	Dry forest %	
Pop density / km²	142.2	Primary %	5.9	Mountain forest %	3
% rural population	60.4	Modified natural %	58.0	Other %	
Forest area 000ha (2005)	197,290	Semi-natural %	20.3	Sub-tropical % *of which*	58
Forest Cover %	21.2	Plantation %	15.9	Humid %	36
Closed forest 000ha (2000)	110,172			Dry %	
Closed forest %	11.8			Mountain %	22
Protected areas %	3			Other %	
				Temperate and boreal	38

Forest inventory

National capacity

- China scores highly (4) for the availability of forest inventory data in FRA 2005. China's National Forest Inventory (NFI) has established a network of 415,000 permanent sample plots, each one being re-surveyed every 5 years, with more than 50 variables recorded;
- Carbon stocks were estimated using Tier 1 factors in the FAO FRA 2005. Standing volumes are estimated using Tier 3 factors, but biomass and carbon conversions are still at Tier 1;
- China included GPG emissions from forestry in its National Communication to the UNFCCC in 2004;
- There has not been an ITTO Diagnostic Mission to China;
- China has not indicated interest in participating in the World Bank FCPF initiative, and has not submitted views on REDD to the UNFCCC;

- There is **excellent national capacity** for forest inventory in China.

Capability gap

- We assess that there is no capability gap for forest inventory in China. Extending the existing framework to include measurement of Tier 3 factors for biomass and carbon conversions would be almost trivial compared to the current level of investment in the NFI.

Remote sensing

National capacity

- China scores highly (5) for remote sensing capacity. Remote sensing and other related technologies including GPS and GIS are used extensively in the NFI;
- There is **very good national capacity** for remote sensing forest monitoring in China.

Capability gap

- We assess that there is no capability gap for remote sensing in China.
-

India

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Diverse forest ecosystems from Himalaya to closed wet and moist tropical forests in north east and south west. Predominant forest type is dry;
- Very extensive plantation resource under public and private ownership. This expands relatively slowly;
- Significant degradation continues in many areas and field level control is often weak;
- There is high forest dependency in many closed forests;
- Protected areas are often poorly managed and subject to destructive influences;
- Community based approaches are well-established in India but complex structures and land ownership disputes hinder progress. There are significant numbers of landless families which creates additional challenges;
- India has good capacity and capability in remote sensing and inventory.

Table 33 Basic Statistics

GDP per cap (2006) US$	784	Forest, ha per cap	0.06	Tropical % *of which*	95
HDI (2005)	0.62	Average volume m^3/ha	43	Rainforest %	13
Land Area 000ha	297,319	Annual change forest %	0.0	Moist forest %	11
Population 000s (2004)	1,079,721	Ann. change plantation %	0.12	Dry forest %	55
Pop density / km^2	363.2	Primary %	0.0	Mountain forest %	7
% rural population	71.5	Modified natural %	48.7	Other %	9
Forest area 000ha (2005)	67,701	Semi-natural %	46.6	Sub-tropical % *of which*	5
Forest Cover %	22.8	Plantation %	4.8	Humid %	
Closed forest 000ha (2000)	38,223			Dry %	
Closed forest %	12.9			Mountain %	5
Protected areas %	13			Other %	
				Temperate and boreal	

Forest inventory

National capacity

- India scores highly (4) for the availability of forest inventory data in FRA 2005. The Forest Survey of India (FSI) produces a State of Forest Report (SFR) every 2 or 3 years;
- The SFR usually does not contain information on growing stock, except for 1984 and 1994. This data is also being collected for the next SFR;

- Carbon stocks were estimated using Tier 2 factors;
- India did not include GPG emissions from forestry in its National Communication to the UNFCCC in 2004;
- There was an ITTO Diagnostic Mission to India in 2006. Although operational budgets for reforestation were found to be limited, the general level of training of foresters at all levels was found to be high;
- India has not indicated interest in participating in the World Bank FCPF initiative;
- India has submitted information on REDD to the UNFCCC SBSTA. The remote sensing based SFRs for 2001 and 2003 show that India's forests have stabilised and are now increasing in extent. Carbon models predict that forest carbon stocks will increase from 8.79 GtC in 2005 to 9.75 GtC in 2030. The precision of the SFRs is increasing, with forest mapping at 1:50,000 scale, 200 forest types classified, and canopy density split into 3 classes (10-40%, 40-70%, and >70%). Future SFRs will be able to measure carbon stocks using Tier 3 factors;
- There is **excellent national capacity** for forest inventory in India.

<u>Capability gap</u>

- We assess that there is no capability gap for forest inventory in India. Extending the existing framework to include measurement of Tier 3 factors for biomass and carbon conversions would be straightforward.

Remote sensing

<u>National capacity</u>

- India scores highly (4) for remote sensing capacity. The SFR has used remotely sensed imagery since 1987;
- There is **very good national capacity** for remote sensing forest monitoring in India.

<u>Capability gap</u>

- We assess that there is no capability gap for remote sensing in India.

Baseline modelling capacity

- India's forest area is stable, and therefore India would benefit from a modelling approach to establishing a forest emissions baseline;
- Substantial capacity for land-use and economic modelling already exists within India;
- There is no capacity gap for baseline modelling.

Indonesia

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Very diverse country extensive tropical forest cover subject to severe degradation and largely uncontrolled conversion, massive illegal logging problem, flawed decentralisation processes have exacerbated problems;
- Despite the huge size of the forest resource, peat, swamp and lowland tropical forest are under particular threat;
- Control of forest and protected areas generally weak despite large personnel numbers and good education and training;
- Great variation in forest dependency but this remains high in many places;
- Forest restoration through natural processes possible in some instances in concert with artificial and mixed approaches;
- Community based approaches may be possible provided control against outside influences can be achieved: this requires better established land and tree tenure rights;
- Potentially high capability for all REDD measurement and monitoring subject to genuine political support.

Table 34 Basic Statistics

GDP per cap (2006) US$	1,592	Forest, ha per cap	0.41	Tropical % *of which*	
HDI (2005)	0.73	Average volume m^3/ha	79	Rainforest %	88
Land Area 000ha	181,157	Annual change forest %	- 2.1	Moist forest %	2
Population 000s (2004)	217,588	Annual plantation %	0.09	Dry forest %	
Pop density / km^2	120.1	Primary %	55.0	Mountain forest %	9
% rural population	53.3	Modified natural %		Other %	1
Forest area 000ha (2005)	88,495	Semi-natural %	41.1	Sub-tropical %	
Forest Cover %	48.8	Plantation %	3.8		
Closed forest 000ha (2000)	100,382				
Closed forest %	55.4				
Protected areas %	16				

Indonesia is a massive archipelago the main islands being Sumatra, Java, Kalimantan, Sulawesi and Papua, each of which is geologically and ecologically distinct. The last two lie east of Wallace's line; this separates the Indo-malayan flora to the west from the Australasian flora to the east.

Overall population density is high but settlement relates to underlying productivity. There are substantial areas of low population while Java has almost 1000 people per km^2. Forest dependency also varies but there are very significant forest dwelling communities as well as rural farmers, many of whom were relocated under the transmigration scheme.

There is considerable discrepancy amongst the various figures quoted for forest cover and a high rate of loss from settlement and conversion, with the rate of oil palm expansion being of particular concern. The category “tropical rainforest” includes a wide range of sub-types, mixed hills forest accounting for two thirds. Of particular importance are swamp and peat forests and mangroves as well as lowland tropical forest. Peat forest conversion has massive carbon impact from the peat as well as the forest while lowland tropical forest is being lost at an alarming rate as it covers the most desirable land for conversion and settlement. Some 8% of the forest is classed as suitable for conversion.

Natural levels of disturbance are moderate to high with earthquakes and high wind being common. Fire has been a notable problem since the 1990s, often associated with land conversion and/or poor logging practices.

Field control in both forests and protected areas is weak in most cases. Decentralisation has not assisted in this with considerable conflict between national and local government. Despite this, there are some well-managed concessions that have been certified but others are disastrous and illegal logging is reported to exceed legal production.

Indonesia has been and continues to be the focus of massive external support for the forest sector in the widest sense, including governance and climate change related actions from a host of bilateral donors and multilateral agencies. There is substantial support for trade-related Voluntary Partnership Agreements.

Silviculture and forest management has been considerably behind that of adjacent Malaysia and even where guidance was given observance was poor. The current regime concentrates on natural regeneration supplemented by enrichment planting. Natural forest logging is due to cease by 2014, to be replaced by plantations. It seems unlikely this ambitious target will be achieved.

Forest restoration through natural processes is possible in many areas but there is also useful plantation experience. Although many plantations have been badly executed as large blocks of exotic monoculture there are examples of better practice that could be harnessed.

The institutional, policy and legislative landscapes are complex, in a state of flux and still not fully resolved. There is scope for engaging with communities in at least some localities to undertake forest restoration and management.

The power and influence of those involved in illegal logging and other destructive practices is considerable and will act as a major constraint on any initiatives. A huge gulf remains between paper strategies and implementation. Expansion of oil palm and pulpwood plantations are particularly significant issues.

Technical capacity - general situation

The highly centralised “New Order” government of Indonesia prior to the economic and political crises of the late 1990s managed forests ineffectively (Nugroho 2006). However, there was at that time a significant infrastructure in place for forest monitoring, including relatively advanced use of remote sensing capabilities, alongside significant field survey efforts and an effective reporting process for transferring local and regional data to the MoF (Ministry of Forestry) (Nugroho 2006).

Political restructuring since the fall of Suharto (principally, a massive process of devolving powers to the regions) has led to the collapse of the former monitoring infrastructure (Nugroho 2006, FWI/GFW 2002). Conflicts among stakeholders have multiplied due to weak governance, unclear tenure, and contradictory laws. Most practical decision-making with regards to forestry is now taken at a district level, where monitoring capabilities have essentially disappeared and policy is driven by the need to raise funds. Recent forest inventory data do not exist (Setiadi 2007). Decisions are based on poor-quality, out of date information, assessed by staff with little and declining technical capability (Nugroho 2006).

Most remote sensing and GIS international collaboration projects were terminated in 2000 following the economic crises of the late 1990s. The NGO sector now has access to more up-to-date technology and data than MoF. For instance, MoF relies on software license purchases as part of collaboration projects with international bodies which ended some years ago. Compare this situation with NGOs such as FWI, which produced its "State of Indonesian Forests" (FWI/GFW 2002) using up-to-date software, integrating the MoF geodatabase with its own remote sensing data. NGOs have sufficient funds to obtain access to MoF's geodatabase, but MoF gains little from such exchanges (Nugroho 2006) and lacks the institutional motivation to develop these relationships.

Technical capacity does still exist within Indonesia, including aging but serviceable hardware and software (Nugroho 2006), but institutional structures are not capable of coordinating the effective use of such resources, either from the top down (using technical capacity to inform decision making), or from the bottom up (coordinating reporting of local data to a national information system). MoF uses daily NOAA-AVHRR low-resolution imagery to monitor hot spots (fires), and also produces land-cover maps derived from visual interpretation of Landsat ETM imagery (Nugroho 2006). However, the decay of former technical capacity has led to a situation where willingness to adopt new technologies is low, and human resource development has not kept pace with changing needs (ADB 2003, Nugroho 2006).

The best recent national-level data on forest extent were compiled by Forest Watch Indonesia in their "State of the Forests" report (FWI/GFW 2002), which provides accurate satellite-based assessments of forest cover and change at a national level. GFW planned to establish a monitoring facility capable of tracking deforestation on an annual basis, but there is no evidence that they were successful in this initiative.

A range of project-level carbon inventories have been carried out by NGOs, but there have been no national initiatives. MASLI (Indonesian Natural Resources Accounting and Environment Society) contracted GMES (Global Monitoring for Environment and Security) to carry out GHG inventories for five pilot areas within the country (GMES 2006, Setiadi 2007). The intention was that this project should serve as a pilot for scaling up to national coverage, and also as a vehicle for technology transfer. CGIAR has also carried out landscape-level carbon assessments (Dewi et al 2007; van Noordwijk et al 2007). WWF have assessed forest loss in the Riau region of Sumatra with the aim of establishing a REDD process (Uryu et al, 2008).

It seems therefore that the NGO sector is the primary driver of REDD actions in Indonesia, and that national-level information (particularly inventories) is severely lacking.

Forest inventory

National capacity

- Indonesia scores 3 for the availability of forest inventory data in FRA 2005. Forest inventory statistics were based on a national forest inventory carried out between 1990 – 1994, with updates applied in 1996 – 2000;
- Carbon stocks were estimated in the FAO FRA 2005 using Tier 1 default factors;
- Indonesia did not report GHG emissions from forestry in their National Communication to the UNFCCC in 1999;
- There was an ITTO Diagnostic Mission to Indonesia in 2001. Local governments do not have the skills or experience to manage or monitor forestry. There is a lack of technical capacity throughout the forestry sector;

- Indonesia has indicated interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **some national capacity** for forest inventory in Indonesia, but as described above, existing capacity has become severely degraded and is continuing to deteriorate.

Capability gap

- Indonesia has a forested area of 88.5 Mha, about 75% larger than the reference scenario;
- Historically there was significant inventory capacity, but this is largely defunct at national level;
- Investment required to achieve inventory capacity is estimated as 200% of the reference scenarios. This reflects the extent of forestry, and also the extra level of complexity because Indonesia is an archipelago consisting of 1000s of islands.

Table 35 Estimated costs to achieve capacity

Tier 2, approach A	£1,135,000 one-off cost
Tier 2, approach B	£280,000 recurring annually
Tier 3, approach A	£1,135,000 in first year £380,000 recurring annually
Tier 3, approach A, including degradation	£1,320,000 in first year £440,000 recurring annually

Participatory forest inventory

- Indonesia has a low per capita GDP, but a relatively well-educated population;
- The NGO sector is able to operate effectively within the country;
- There is a large rural population;
- Indonesia's forests are generally accessible;
- A central forest inventory capacity does exist, but is weak and declining. Integration between central institutions (such as a national forest inventory) and regional capacity is difficult;
- A participatory forest inventory approach may be feasible in some regions.

Remote sensing

National capacity

- Indonesia scores highly (4) for remote sensing capacity, having constructed land-cover maps based on Landsat imagery and also having performed deforestation measurements using Landsat imagery. However, as discussed above, this capacity has been severely degraded in recent years;

- There appears to be **some national capacity** for remote sensing forest monitoring in Indonesia.

Capability gap

- The forested land area of Indonesia is about 175% of the reference scenario, requiring about 350 Landsat scenes. Annual data purchase costs (Landsat) would be about £105,000;
- Given the track record Indonesia has of using remote sensing to monitor land-cover, we estimate the costs of establishing an annual monitoring capability at 50% of the reference scenario. In theory, significant technical capacity should be available, although this has become dispersed and degraded.;
- Cost estimates:
  - ⇒ First year: £260,000 + £105,000 data costs;
  - ⇒ Annual recurring: £63,000 + £105,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar etc).

Malaysia

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Malaysia is generally regarded as one of, if not the, leading country for demonstration of sustainable forest management of natural tropical forests although Sarawak is less advanced than Sabah or, particularly, the Peninsular States;
- Institutions are generally well resourced and effective;
- Protected areas and forests are generally well managed including recent initiatives such as Heart of Borneo;
- Some past issues with environmental damage and ongoing friction with forest dwellers in Sarawak;
- Controversy relating particularly to oil palm plantation development remains;
- Community based approaches probably of little applicability;
- Adequate national capacity and capability for all IPCC measurement and monitoring.

Table 36 Basic Statistics

GDP per cap (2006) US$	5704	Forest, ha per cap	0.83	Tropical % *of which*	100
HDI (2005)	0.81	Average volume m³/ha	119	Rainforest %	94
Land Area 000ha	32,855	Annual change forest %	- 0.7	Moist forest %	
Population 000s (2004)	25,209	Annual plantation %	- 0.08	Dry forest %	
Pop density / km²	76.7	Primary %	18.3	Mountain forest %	6
% rural population	35.6	Modified natural %		Sub-tropical %	
Forest area 000ha (2005)	20,890	Semi-natural %	74.2		
Forest Cover %	63.6	Plantation %	7.5		
Closed forest 000ha (2000)	19,148				
Closed forest %	58.3				
Protected areas %	9				

Malaysia is comprised of the Peninsular States, Sarawak and Sabah; there are considerable differences between them. In terms of forest cover, the Penisular States have 45%, Sabah 60% and Sarawak 75%. There are very extensive rubber, oil palm and coconut plantations in addition. The predominant natural vegetation is closed tropical moist forest with extensive peat swamps in Sarawak and substantial mangrove areas, notably in Sabah, which also has the bulk of the mountainous area.

The natural forest disturbance level is low to moderate with Dipterocarpaceae predominating. The regeneration ecology of these species has led to the development of the moncyclic Malayan Uniform System of silviculture for the lowland areas and the polycyclic Selective Management System in the hill forests.

The Peninsular states are probably world leaders in the certification of tropical natural forests and have a high standard of management. The situation is Sarawak is less positive while Sabah is intermediate between the two but rapidly reaching the standards of the

Peninsular States. There is heavy forest dependency in Sarawak, including forest dwelling peoples and some in Sabah.

Overall Malaysia is regarded as having effective control of its forests and well-resourced control structure, although the situation in Sarawak is less clear-cut than in other states. ITTO note that the Matang mangrove area has been sustainably managed for more than a century. There is good control of Protected Areas and the contribution to the Heart of Borneo initiative especially from Sabah indicates high level commitment to conservation.

There are issues with forest loss from conversion and also with the differing levels of progress across the whole country but overall, Malaysia is at the forefront of effective tropical forest management. There is recognition of community rights but with the exception of forest dwelling communities, there seems to be little role for "community" forests.

Malaysia has very extensive rubber plantations and was a world leader in utilising rubber wood for processing. There is also good plantation expertise although some of the older industrial wood plantations were badly implemented in environmental and social terms.

The institutional capabilities and capacity are of a high order and there appears to be little need for external support to provide measurement and monitoring of forest carbon.

Forest restoration is possibly a desirable intervention in parts of Sarawak but elsewhere unlikely to be appropriate. The conversion of forest to oil palm and other crops remains potentially contentious although standards observed are generally much higher than in Indonesia.

Forest inventory

National capacity

- Malaysia scores highly (4) for the availability of forest inventory data in FRA 2005. Forest inventories are carried out in peninsular Malaysia on a regular basis. However, inventory data for the remaining regions (Sarawak and Sabah) are sparse and out-dated;
- Carbon stocks were estimated using Tier 1 factors in the FAO FRA 2005;
- Malaysia did not report GHG emissions from forestry in their National Communication to the UNFCCC in 2000;
- There has not been an ITTO Diagnostic Mission to Malaysia;
- Malaysia has indicated interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **some national capacity** for forest inventory in Malaysia. However, there is great regional variation in the availability and quality, and therefore capacity, to carry out inventories.

Capability gap

- Malaysia has a forested area of 20.9 Mha, roughly 40% of the reference scenario;
- There is some inventory capacity, but of limited coverage and variable quality;
- Investment required to achieve inventory capacity is estimated as 40% of the reference scenarios. Capacity for inventory in peninsular Malaysia is good, but

elsewhere is poor, therefore we discount for forested area but not for existing capacity.

Table 37 Estimated costs to achieve capacity

Tier 2, approach A	£227,000 one-off cost
Tier 2, approach B	£56,000 recurring annually
Tier 3, approach A	£227,000 in first year £76,000 recurring annually
Tier 3, approach A, including degradation	£264,000 in first year £88,000 recurring annually

Remote sensing

National capacity

- Malaysia scores highly (5) for remote sensing capacity, having an advanced facility in the Malaysian Remote Sensing Agency. This facility is capable of performing state-of-the-art analyses, using a broad range of satellite data sources;
- There is **very good national capacity** for remote sensing forest monitoring in Malaysia.

Capability gap

- We assess that there is no capability gap for remote sensing in Malaysia.

Myanmar

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Ecological potential for wide diversity of natural forest types from evergreen to dry;
- Highly disturbed in recent years, catastrophic loss of forest cover and severe degradation of growing stock;
- Overly centralised and corrupt administration with severely eroded skills base and lack of resources for effective control leading to widespread illegal cutting of prime species;
- Heavy forest dependency but community led approaches unlikely to be effective at present;
- Considerable potential for restoration through a mix of natural and artificial means although some of the wetter ecotypes will prove very challenging;
- Little current capability for measuring and monitoring IPCC information.

Table 38 Basic Statistics

GDP per cap (2006) US$	281	Forest, ha per cap	0.65	Tropical % *of which*	99
HDI (2005)	0.58	Average volume m³/ha	33	Rainforest %	35
Land Area 000ha	65,755	Annual change forest %	- 1.4	Moist forest %	36
Population 000s (2004)	49,910	Annual plantation %	0.09	Dry forest %	4
Pop density / km²	75.9	Primary %	0	Mountain forest %	24
% rural population	70	Modified natural %	97.4	Sub-tropical %, *of which*	1
Forest area 000ha (2005)	32,222	Semi-natural %		Humid	
Forest Cover %	49.0	Plantation %	2.6	Dry	
Closed forest 000ha (2000)	25,177			Mountain	1
Closed forest %	38.3			Other	
Protected areas %	5				

Myanmar has the relatively flat Irrawaday valley as its central part with hills to the west and the broken and mountainous Shan States to the east rising to the Himalaya in the north. Monsoon rainfall is variable but there is a distinct dry season in most localities. In addition to extensive evergreen forest, Myanmar is notable for its extensive deciduous teak forests and there are patches of dry forest.

The natural disturbance level is moderate, with steep slopes, heavy rainfall and fire all influencing forest ecology but the main recent impacts have been human in origin. The high rate of deforestation combined with massive degradation has led to substantial area losses but more especially to loss of growing stock.

Despite the practice of advanced and effective forestry in the past, concentration of authority within the central ruling cabal, the suppression of outside influence and the exclusion of internal political freedom have all interacted to effectively negate what was an effective system of forest management.

The population is largely rural and extreme poverty has resulted in high forest dependency for much of the population, formally and informally. There is some recognition of the need for livelihood improvement but only government approved voluntary organisations are allowed to operate.

The teak forests were amongst the first in the tropics to be brought under sustainable management and the system then instituted appears to have been very effective although it has now broken down. Illegal logging, mainly selective cutting of prime species - especially in border areas - and a lack of effective management and control at field level have reduced the production potential and created a huge need for restoration.

The dryer forest zones, including the teak zone, may be redeemable through a mix of silvicultural operations on assisted natural regeneration and there are good possibilities for various plantation approaches. The wetter evergreen forests are likely to be more difficult. Secondary forests of lower value species will predominate in the moist and transition zones.

Any restoration programme will need to take account of heavy demand for domestic forest produce. The extent to which communities could be engaged effectively in such work is not known but given the political turmoil it seems unlikely it would be appropriate in the short term.

The extent of formal Protected Areas is small and it seems unlikely that there is effective protection. Myanmar is a part of the Indo-Burma biodiversity hotspot.

Forest inventory

National capacity

- Myanmar scores highly (4) for the availability of forest inventory data in FRA 2005. Forest inventories are carried out on a 5 year cycle, with modern sampling techniques and use of GIS databases;
- Carbon stocks were estimated using Tier 1 factors in the FAO FRA 2005;
- Myanmar has not submitted a National Communication to the UNFCCC;
- There has not been an ITTO Diagnostic Mission to Myanmar;
- Myanmar has not indicated interest in participating in the World Bank FCPF initiative, and has not submitted views on REDD to the UNFCCC;
- There is **good national capacity** for forest inventory in Myanmar. However, there are no data to support Tier 2 estimation, and apparently little institutional interest for engaging with international carbon emissions agendas.

Capability gap

- Myanmar has a forested area of 32.2 Mha, roughly 60% of the reference scenario;
- There is good inventory capacity, but Tier 2 factors are not available;
- Investment required to achieve inventory capacity at Tiers 2 & 3 is estimated as 33% of the reference scenarios. Good capacity for data collecting already exists, but the range of data needs to be enhanced to deliver Tier 2 and 3 standards.

Table 39 Estimated costs to achieve capacity

Tier 2, approach A	£190,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£190,000 in first year £64,000 recurring annually
Tier 3, approach A, including degradation	£220,000 in first year £73,000 recurring annually

Remote sensing

National capacity

- Myanmar scores highly (4) for remote sensing capacity, having used aerial and satellite data for forest appraisal since 1957. Techniques have included visual interpretation, automatic classification, and verification of some areas using high resolution (IKONOS) imagery;
- There appears to be **good national capacity** for remote sensing forest monitoring in Myanmar.

Capability gap

- The forested land area of Myanmar is 60% of the reference scenario, requiring about 120 Landsat scenes. Annual data purchase costs (Landsat) would be £36,000;
- We estimate the costs of establishing an annual monitoring capability at 50% of the reference scenario. This would allow Myanmar to carry out annual analyses, and would support additional use of high resolution imagery to perform verification (ground truthing) throughout all the forest cover regions;
- Cost estimates:
  - ⇒ First year: £260,000 + £36,000 data costs;
  - ⇒ Annual recurring: £63,000 + £36,000 data costs.

Papua New Guinea (PNG)

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- PNG has extensive cover of highly species diverse closed wet and moist tropical forest;
- Forest tenure is vested in local communities although their direct engagement with commercial forest use is limited;
- While overall population pressure is low, there is severe localised forest loss for agriculture and extensive degradation from overcutting in concessions;
- Access is restricted and capacity for field control and monitoring of standards is poor;
- There is long term potential for more community engagement in management and control but this requires massive skills building. Local civil society is comprehensive, generally competent and effective;
- Restoration of degraded lands through planting and natural processes is possible but plantation skills are lacking in attention to wider considerations.

Table 40 Basic Statistics

GDP per cap (2006) US$	989	Forest, ha per cap	5.23	Tropical % *of which*	100
HDI (2005)	0.53	Average volume m^3/ha	34	Rainforest %	80
Land Area 000ha	45,286	Annual change forest %	- 0.5	Moist forest %	4
Population 000s (2004)	5,625	Annual plantation %	0.01	Dry forest %	5
Pop density / km^2	12.4	Primary %	85.7	Mountain forest %	11
% rural population	86.8	Modified natural %	14.0	Other	
Forest area 000ha (2005)	29,437	Semi-natural %		Sub-tropical %	
Forest Cover %	65.0	Plantation %	0.3		
Closed forest 000ha (2000)	30,150				
Closed forest %	66.6				
Protected areas %	9				

PNG is comprised of the eastern half of the island of New Guinea plus the large islands of new Britain, New Ireland and Bougainville and numerous small islands. The climate is perhumid. The main block is mountainous and has very restricted access. Forest cover is high and predominantly closed forest of moderate natural disturbance due to steep slopes, high winds, heavy rain and earthquakes. There are extensive coastal mangrove areas.

Forest ownership is unusual and 97% is vested with local community landowners (“clans”). This has given rise to many of the policy and legislative challenges faced. It requires complex processes prior to utilisation, especially to ensure the maintenance of high field standards and avoid corrupt practices. While some progress has been made with these aspects there is much further to go. The theoretical system is sound but application remains weak, with lack of available skills for inventory for example a significant constraint.

The main silvicultural system has been one of cutting trees over the diameter limit within a short time period but, combined with lack of control, this has lead to considerable degradation. There is also pressure for land conversion for subsistence and commercial agriculture. The return cycle was extended to 35 years in 1992 and, combined with more sophisticated cutting rules, this has improved matter but capacity for field control continues to limit effective implementation.

Although there is community ownership, engagement is limited due to lack of appropriate skills and communities are little more than sleeping partners, even in terms of employment, as most people lack the necessary skills. There is longer term potential for more community engagement but this cannot be captured without major inputs in skills-building.

The difficult access caused by topography and lack of infrastructure and the high spiritual values ascribed to forest by many creates interesting opportunity for payments for non-destructive uses. Prices received for exported log in many cases suggest that there may not even be full cost recovery let alone profit on any but the most accessible material.

Protected Areas are ill-defined and there is little information on the quality of their management. The complex land tenure system makes what is regarded as normal processes of land use classification problematic.

Education and training are of a high standard but the low numbers of trained personnel and difficult access mean that basic inventory and monitoring is difficult and there is a huge capacity building requirement.

PNG has an extensive, active and effective national civil society. This may provide an entry point for capacity building, especially in local communities, as an alternative to a government centred approach.

Forest inventory

National capacity

- Papua New Guinea scores poorly (2) for the availability of forest inventory data in FRA 2005. Multiple national forest inventories have been undertaken, but they were performed by external consultants. A Forest Inventory Mapping System was developed by the consultants and is in use by the PNG Forest Authority;
- Carbon stocks were not estimated in the FAO FRA 2005. The report stated that the high species richness of natural forests in Papua New Guinea rendered the IPCC standard factors invalid, and no country-specific data were available;
- Papua New Guinea did not report GHG emissions from forestry in their National Communication to the UNFCCC in 2002;
- There was an ITTO Diagnostic Mission to Papua New Guinea in 2007. The massive areas under Forest Management Agreements (FMAs) coupled with inadequate logistics render the working conditions for field officers almost impossible;
- Papua New Guinea has indicated interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **some national capacity** for forest inventory in Papua New Guinea.

Capability gap

- Papua New Guinea has a forested area of 29.4 Mha, about 60% the size of the reference scenario;
- There is little inventory capacity;
- Investment required to achieve inventory capacity is estimated as 60% of the reference scenarios.

Table 41 Estimated costs to achieve capacity

Tier 2, approach A	£340,500 one-off cost
Tier 2, approach B	£84,000 recurring annually
Tier 3, approach A	£340,500 in first year £114,000 recurring annually
Tier 3, approach A, including degradation	£396,000 in first year £132,000 recurring annually

Remote sensing

National capacity

- Papua New Guinea scores poorly (2) for remote sensing capacity. For FRA 2005, statistics on land-cover were extracted from the FIMS described above. This GIS was constructed by external consultants, and includes land-cover mapping derived from air surveys in 1975 and satellite imagery in 1996;
- There appears to be **little national capacity** for remote sensing forest monitoring in Papua New Guinea.

Capability gap

- The forested land area of Papua New Guinea is about 60% of the reference scenario, requiring about 120 Landsat scenes. Annual data purchase costs (Landsat) would be about £36,000;
- Cost estimates:
  - ⇒ First year: £520,000 + £36,000 data costs;
  - ⇒ Annual recurring: £126,000 + £36,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*).

Thailand

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- The natural ecology was a mix of wet, moist and dry tropical forest covering the bulk of the country. Natural disturbance levels are low to moderate. This valuable and diverse resource has been extensively cleared and severely degraded. Settlement continues and fires are an increasing problem;
- There is a ban on cutting in natural forests although “enriched” natural forests may be cut. There is an extensive and mature plantation resource that can be cut;
- Despite recognition of the need for forest restoration, progress has been very slow;
- Degradation of forest and protected areas, including illegal logging, persists
- There is scope and provision for community engagement in forest restoration and management, which would be highly appropriate given the population density, high rural population and high forest dependency;
- Adequate technical knowledge exists for effective restoration of most forest types through artificial and guided natural means but whether institutional capacity is available is open to question;
- Government institutions remain weak in some areas; a protracted decentralisation process is incomplete.

Table 42 Basic Statistics

GDP per cap (2006) US$	3,251	Forest, ha per cap	0.23	Tropical % *of which*	100
HDI (2005)	0.78	Average volume m^3/ha	17	Rainforest %	23
Land Area 000ha	51,089	Annual change forest %	- 0.4	Moist forest %	21
Population 000s (2004)	62,387	Annual plantation %	0.03	Dry forest %	54
Pop density / km^2	122.1	Primary %	44.4	Mountain forest %	2
% rural population	67.8	Modified natural %	34.2	Other %	
Forest area 000ha (2005)	14,520	Semi-natural %		Sub-tropical % *of which*	
Forest Cover %	28.4	Plantation %	21.3	Humid	
Closed forest 000ha (2000)	10,127			Dry	
Closed forest %	19.8			Mountain	
Protected areas %	23			Other	

The topography of the main part of the country is a relatively flat plain with occasional hills. The north west is much more hills and broken and this broken country extends along most of the border with Myanmar.

More than half of the forest is dry type with extensive evergreen forest in the south west. The climate is monsoonal with a distinct dry season. There was a substantial teak resource. Forest cover has been seriously depleted and loss continues, albeit at a lower rate than during the 1990s; this has been accompanied by severe degradation from (often illegal) logging, conversion and, increasingly, fire. Thailand has also hosted a huge refugee population from Cambodia and other regional conflicts and still has refugees from Myanmar, which is an ongoing and increasing problem.

Logging in natural forests was banned in 1989 (in mangroves in 1996) and wood is now supplied legally only from the extensive plantations except for teak which is still also cut from “modified natural” forests. To replace the loss of natural forest material, rubber wood and, increasingly, trees from farmland are also used. Thailand has a large secondary wood processing industry although this relies heavily on imported wood from neighbouring countries and further afield.

Population density is high and surprisingly rural with significant forest dependency. Partly as a reflection of this, there is a massive area of degraded forest in Thailand, including extensive settlement within formal forest areas. Protected Areas occupy almost one quarter of the land area although there are problems with both settlement within these areas and fragmentation leading to non-viable conservation units.

Despite a pragmatic policy and institutional framework with a focus on conservation and restoration, progress with the latter has been slow. National civil society is active and draft legal provision exists for effective community engagement in forest restoration and management. There are conflicts over tribal forest claims in some areas.

It seems unlikely that the trend to plantation supply for timber and ultimately restoration of degraded forest lands will be reversed and it also seems inevitable that private and community level interventions will be required to secure domestic produce. There is ample familiarity with planting practices and considerable experience of research scale restoration through natural and mixed methods.

In terms of capacity and capability, Thailand should have adequate national resources but the changes in the sector and the reduction in management planning has led to a reduced inventory capacity. The process of decentralisation and debate over tenure seems to be stalling progress. A well-conceived sector master plan finalised in 1995 with Finnish support has been accepted in principle but not implemented. There are very sound training and education institutions in Thailand.

Forest inventory

National capacity

- Thailand scores 3 for the availability of forest inventory data in FRA 2005, as there has been a single forest inventory, carried out in-house. However, this inventory was performed some time ago (1992 – 1996);
- Carbon stocks were estimated in the FAO FRA 2005 using Tier 1 default factors;
- Thailand did report GHG emissions from forestry in their National Communication to the UNFCCC in 2000;
- There was an ITTO Diagnostic Mission to Thailand in 2006. In general, technical skills of forestry staff were found to be lacking, and coordination of work within and among forest agencies was poor;
- Thailand has indicated interest in participating in the World Bank FCPF initiative;
- Thailand has submitted information on REDD to the UNFCCC SBSTA. Satellite monitoring is being used to evaluate the success of reforestation initiatives. Field-based and remote sensing methods for monitoring GHG emissions from forests are being investigated;
- There is **little active national capacity** for forest inventory in Thailand.

Capability gap

- Thailand has a forested area of 14.5 Mha, about 1/3 the size of the reference scenario;
- There is little inventory capacity;
- Investment required to achieve inventory capacity is estimated as 33% of the reference scenarios.

Table 43 Estimated costs to achieve capacity

Tier 2, approach A	£190,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£190,000 in first year £63,000 recurring annually
Tier 3, approach A, including degradation	£220,000 in first year £73,000 recurring annually

Remote sensing

National capacity

- Thailand scores 3 for remote sensing capacity, as a land-cover map was constructed in-house from Landsat imagery. However, the map lacks adequate ground-truthing and deviates substantially from other estimates of forest land-cover;
- There appears to be **limited national capacity** for remote sensing forest monitoring in Thailand.

Capability gap

- The forested land area of Thailand is about 1/3 of the reference scenario, requiring about 66 Landsat scenes. Annual data purchase costs (Landsat) would be about £20,000;
- Although there is evidence of limited in-house capacity for remote sensing, the low quality of the outputs available for the FRA 2005 suggest this capacity would not offset the costs of establishing adequate monitoring services;
- Cost estimates:
  - ⇒ First year: £520,000 + £20,000 data costs;
  - ⇒ Annual recurring: £126,000 + £20,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*).

Baseline modelling capacity

- Thailand has a low rate of deforestation (-0.4%), and therefore would benefit from a modelling approach to establishing a forest emissions baseline;
- Modelling capacity: £37,500.

Vietnam

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- The original very diverse, rich natural closed forest cover has been substantially lost and what remains is severely degraded. It is unclear whether Protected Areas are well controlled but the evidence suggest they are under extreme pressure;
- There is strong pressure from a largely rural population with high forest dependency;
- Forest loss has now apparently been reversed in national terms although locally conversion continues. There is large and growing plantation resource base;
- A large number of very small private forest owners has been created but there is restricted capacity to engage with these to provide advice and ensure good management;
- Restoration through artificial means is well established but the potential for natural restoration is more limited in part due to the highly degraded nature of the remaining forest;
- Technical capacity in the country is high.

Table 44 Basic Statistics

GDP per cap (2006) US$	673	Forest, ha per cap	0.16	Tropical % *of which*	98
HDI (2005)	0.73	Average volume m³/ha	38	Rainforest %	26
Land Area 000ha	32,549	Annual change forest %	1.9	Moist forest %	38
Population 000s (2004)	82,162	Annual plantation %	1.0	Dry forest %	16
Pop density / km²	252.4	Primary %	0.7	Mountain forest %	10
% rural population	73.8	Modified natural %	78.5	Other %	8
Forest area 000ha (2005)	12,931	Semi-natural %		Sub-tropical % *of which*	2
Forest Cover %	39.7	Plantation %	20.8	Humid %	2
Closed forest 000ha (2000)	7,312			Dry %	
Closed forest %	22.5			Mountain %	
Protected areas %	6			Other %	

Vietnam was originally a heavily forested country lying along the eastern seaboard of Indochina; this location gives a bimonsoonal rainfall pattern and a higher proportion of wet and most forest than in neighbouring countries. With the exception of Mekong delta in the south and the Red River plain in the north the topography is broken with steep karst formations. The north west is mountainous. Overall natural disturbance levels are moderate, with flood and wind influences.

There is a high, largely rural, population density with high forest dependency. Loss of forest cover has been substantial and what remains is severely degraded. This loss has now been reversed according to national statistics. There is a very large plantation base.

Institutional capability in Vietnam is generally high but a significant area of degraded forest and some plantations have been allocated to individual households. The number of these, planned to be more than 0.5 million, has not been matched by appropriate support capacity. This means the potential for engaging with these forest smallholders is presently limited. Although commercial scale plantations are relatively effective, this is less so with small private tree planting and some schemes are essentially failures due to lack of inputs, which is linked with lack of extension capacity.

There is practically no primary forest remaining and the coverage of protected areas is low. The degraded forest resource base is highly modified and plantations are the major strategy to overcome this. This has implications for both conservation and dependency but also suggests that restoration through artificial means is well established while some semi-natural restoration may also be possible in selected areas.

There appears to be a distinct boundary between private and state controlled forest and the opportunity for community level engagement seems limited in view of the preference for individual ownership. The lack of community level forestry support means that the scope for effective decentralised natural forest management will be limited.

Forest inventory

National capacity

- Viet Nam scores highly (4) for the availability of forest inventory data in FRA 2005. Multiple national forest inventories have been undertaken;
- Carbon stocks were estimated in the FAO FRA 2005 using IPCC GPG factors;
- Viet Nam reported GHG emissions from forestry in their National Communication to the UNFCCC in 2003;
- Viet Nam is not a member of ITTO but has shown interest in joining;
- Viet Nam has not indicated interest in participating in the World Bank FCPF initiative;
- Viet Nam has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **significant and well-established national capacity** for forest inventory in Viet Nam.

Capability gap

- Viet Nam has a forested area of 12.9 Mha, about 25% the size of the reference scenario;
- There is very good forest inventory capacity, but Tier 2 has not been achieved;
- Forested area is 25% of the reference scenario, but the maximum discount for small area is 66%. We offset a further 50% of the remainder to credit existing capacity, leaving 16.5% of the reference scenario. This is our estimate of investment required to achieve Tier 2;
- We estimate cost to achieve Tier 2 (approach B) at 33% the reference scenario. As noted in Annex 4 however, we feel this scenario is unlikely in most situations;
- We estimate Tier 3 year 1 cost as 33% the reference scenario, minus the offset already calculated (1/6 of £567,500) for Tier 2 approach A to credit existing capacity. Recurring costs are 33% the reference scenario;
- The same calculation as above is applied for the scenario with degradation.

Table 45 Estimated costs to achieve capacity

Tier 2, approach A	£94,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£94,000 in first year £63,000 recurring annually
Tier 3, approach A, including degradation	£315,000 in first year £73,000 recurring annually

Remote sensing

National capacity

- Viet Nam showed no evidence of capacity to use remote sensing in FRA 2005. Statistics on land-cover are collected at a local level and then reported upwards to the central forestry authority;
- There appears to be **no national capacity** for remote sensing forest monitoring in Viet Nam.

Capability gap

- The forested land area of Viet Nam is about 25% of the reference scenario, requiring about 50 Landsat scenes. Annual data purchase costs (Landsat) would be about £15,000;
- Cost estimates:
  - ⇒ First year: £520,000 + £15,000 data costs;
  - ⇒ Annual recurring: £126,000 + £15,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar etc).

Cameroon

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Good ecological potential for natural forest management across much of the tropical moist forest zone, natural ecology is one of very low disturbance;
- Forest disturbance and degradation is widespread in accessible areas and forest loss is significant overall; there is some loss from mining and the oil pipeline;
- Substantial areas of well-stocked forest remain, protected areas have fair to good integrity. Widespread overcutting and major breaches of concession terms;
- Low population density and forest dependency over much of tropical moist forest zone, significant bushmeat trade;
- Plantations in the moist and wet zones have generally failed, some potential for mixed cropping systems in settled areas;
- Potential exists for community forests but unresolved governance issues at all levels surround these;
- Despite often well-trained personnel, institutions are weak and often ineffective in the face of deep-seated corruption.

Table 46 Basic Statistics

GDP per cap (2006) US$	1019	Forest, ha per cap	1.30	Tropical % *of which*	100
HDI (2005)	0.53	Average volume m³/ha	135	Rainforest %	81
Land Area 000ha	46,540	Annual change forest %	-1.0	Moist forest %	16
Population 000s (2004)	16,400	Annual plantation %	0	Dry forest %	2
Pop density / km²	35.2	Primary %	n.a.	Mountain forest %	1
% rural population	47.9	Modified natural %	n.a.	Sub-tropical %	
Forest area 000ha (2005)	21,245	Semi-natural %	n.a.		
Forest Cover %	45.6	Plantation %	n.a.		
Closed forest 000ha (2000)	19,985				
Closed forest %	42.9				
Protected areas %	11				

Cameroon lies entirely within the tropics although it has huge diversity of forest types from dense tropical wet evergreen forest to Sahel savanna. Population distribution is also highly varied. The wet and moist forest zone has low population but does have important forest dwelling communities. The volcanic highlands of the Northwest carry very dense populations in a highly altered landscape. Access to significant areas of the tropical moist forest zone is poor.

Mount Cameroon, the Bamenda Higlands and Adamoua Plateau are the main topographic features; the tropical forest zone is dissected but generally flat. Rainfall is highest in the SW corner and diminishes to the east and to the north. Major rivers form distinct ecological boundaries in places due to fire.

Natural disturbance processes are very low and there is a substantial area of stable climax forest (*e.g.* Korup NP). Highly varied settlement patterns have led to areas of forest devastation in the coastal region and between Dowala and Yauondé. Forest dependency is also variable with localised concentrations. Bushmeat is the predominant non-timber benefit sought. The tropical moist forest zone should be managed by well-controlled polycyclic felling on a minimum 30 year cycle with diameter limits, silvicultural rules and restrictions on tree selection.

Commercial timber concessions occupy much of the closed tropical forest zone although not all are active. Despite management plans of acceptable quality being written, control is weak with overcutting, re-entry and other breaches of legislation common.

Plantations in the highlands and savanna zones are generally effective, including some plantations of higher value timber species. Plantations in the wet and moist zones are ineffective except on a research scale and restoration other than through assisted natural regeneration will be very difficult due to soil characteristics and copious weed growth.

Stocking levels are generally good despite overcutting while lack of access has helped secure the integrity of protected areas in the forest zone (such as Dja).There is evidence of illegal felling being targeted on high value species. Chainsaw lumbering occurs but not extensively, land conversion is the main cause of loss but large areas remain relatively intact in the south east.

Community based approaches are possible under forest legislation; existing community areas are highly degraded and often subject to corrupt practices. Tree crops and intercropping practices are known and used.

Forest inventory

National capacity

- Cameroon scores 3 for the availability of forest inventory data in FRA 2005, as there has been a single forest inventory, carried out in-house (and recently), with assistance from FAO;
- There is a large volume of historical data from the 1980's, mostly little used;
- Carbon stocks in the FAO FRA 2005 report were estimated using Expert Opinion – i.e. there was no use of IPCC factors, scoring 0 for IPCC factor;
- Cameroon's national forest programme has been under implementation since 2004. The programme includes a significant monitoring and evaluation component (COMIFAC 2004, Ulloa et al 2006). COMIFAC (Commission for the Forests of Central Africa) represents a first step towards implementing an effective monitoring regime (Dutschke & Wolf, 2007);
- Cameroon did not include forestry GHG estimates in its National Communication to the UNFCCC in 2005;
- There has not been an ITTO Diagnostic Mission to Cameroon;
- Cameroon has indicated its interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **significant national capacity** for forest inventory in Cameroon.

Capability gap

- Cameroon has a forested area of 21.2 Mha, about 2/5 the size of the reference scenario;
- There is significant existing forest inventory capacity. This has been developed very recently with assistance from FAO, and we assume IPCC Tier 2 has been achieved;
- To achieve Tier 3, a small increase in effort is required, to re-measure a proportion of the permanent sample plots each year. This is estimated at 2/5 the annual recurring cost for the reference scenario;
- To achieve Tier 3 plus degradation monitoring, a larger increase in effort is required, because additional strata must be added to the sample scheme. This is estimated at 2/5 the annual recurring cost for the reference scenario.

Table 47 Estimated costs to achieve enhanced capacity

Tier 2, approach A	Capacity exists.
Tier 2, approach B	Capacity exists.
Tier 3, approach A	£36,000 recurring annually.
Tier 3, approach A, including degradation	£88,000 recurring annually.

Participatory forest inventory

- Cameroon has a low per capita GDP;
- The NGO sector is able to operate effectively within the country;
- There is a large rural population;
- Institutions are unable to sustain a forest inventory;
- Cameroon's forests are generally accessible;
- A participatory forest inventory approach may be the only sustainable method of establishing a permanent forest inventory capacity.

Remote sensing

National capacity

- Cameroon scores zero for the use of remote sensing in FRA 2005. Forest extents were extracted from a preliminary report of the national forest inventory being compiled with assistance from FAO;
- It may be that remote sensing capacity is part of the FAO-assisted forest inventory project, but we have no data;
- Various donor projects have mapped Cameroon's forests (e.g. Mertens et al 2007) but national capacity has not benefited from these projects;
- There appears to be **no current national capacity** for remote sensing forest monitoring in Cameroon, although it existed in the past.

Capability gap

- The forested land area of Cameroon is about 2/5 that of the reference scenario. Annual data purchase costs (Landsat) would be about £24,000;
- Cost estimates:
  - ⇒ First year: £520,000 + £24,000 data costs;
  - ⇒ Annual recurring: £126,000 + £24,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar etc).

Congo Republic

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Extensive closed tropical forest resource in two blocks, natural disturbance levels moderate;
- low population pressure and limited loss and degradation mean country is forest rich some damage from savanna fires;
- Much of the forest is relatively unaffected by human intervention and the north remains unfragmented, there is a fair growing stock volume;
- Moderate national wealth but low HDI score; forest dwellers in north may be vulnerable;
- Considerable scope for further plantation development in south for restoration and as a complement to agriculture, scope for natural restoration less but extensive *Aucoumea* areas possible through planting or natural regeneration. Forest dependency limited;
- Community based approaches legally possible but quite restricted opportunities.

Table 48 Basic Statistics

GDP per cap (2006) US$	1946	Forest, ha per cap	5.83	Tropical % *of which*	100
HDI (2005)	0.55	Average volume m^3/ha	132	Rainforest %	95
Land Area 000ha	34,150	Annual change forest %	-0.1	Moist forest %	
Population 000s (2004)	3,885	Annual plantation %	0	Dry forest %	5
Pop density / km²	11.3	Primary %	33.2	Mountain forest %	
% rural population	46.1	Modified natural %	66.6	Sub-tropical %	
Forest area 000ha (2005)	22,471	Semi-natural %			
Forest Cover %	65.8	Plantation %	0.2		
Closed forest 000ha (2000)	22,000				
Closed forest %	64.4				
Protected areas %	14				

Congo is entirely tropical with a simple topography and two separate blocks of closed forest. The Mayombe and Chaillu mountains in the south were covered with valuable mixed moist forest and savanna areas, the central Bateke is mainly savanna while the low lying northern half of the country carries closed tropical moist forest and is very sparsely populated although there are forest dependent pygmy peoples. The plantation resource is mainly clonal *Eucalyptus* and tropical pines for pulpwood on the coastal sands at Pointe Noire. *Terminalia* has been successful in Mayombe. *Aucoumea* has not been very successful, possibly due to poor site selection.

The forest resource in the south has been heavily cut and degraded and this area is home to the bulk of the urban and rural population with land now being lost to agriculture. The relatively intact northern forest is rich in commercial timber species although almost half is seasonally flooded. Degradation is mainly through land conversion for farming following heavy overcutting in the south, as well as fires particularly from the savannas.

The natural disturbance level is low to moderate, with seasonal flooding a feature in the north; the species composition in the closed forest of the north is consistent with past disturbance. The southern forests have been heavily cut. Most of the remaining forest has 40% canopy cover or more and the standing volume is good. Some *Aucoumea* is now into a fourth cutting cycle.

There is extensive commercial logging in the north including a significant certified area (CIB). The closed forest is managed with polycyclic felling with a site specific return cycle of between 25 and 50 years and silvicultural rules including more enrichment planting than in other countries in the region. *Terminalia superba* and *Aucoumea klaineana* both occurred extensively in the southern forests and are good plantation species, the former being highly suitable for farm planting and undercropping.

Forest loss and degradation is significant in the south much less so in the north although improved access renders this increasingly likely. Oil revenues, low population and population concentration in the south, as well as ecological differences, mean Congo needs to be considered as having two distinct forest zones, each with variation within it. Despite the relative wealth, rich resources and low pressures, as well as a long history of sound forest research, institutional capability in matters such as inventory and planning seems to be low. Management plans only cover one-sixth of the concession area.

Protected Areas are significant and reportedly linked by corridors. They include more than 2 million ha of lowland tropical rain forest. Their current status is not known but should be good in view of the limited pressures and solid international support.

Opportunities for plantations, in association with farmers and communities should be available in the south. Restoration opportunities through natural processes seem to be limited. Community based options are possible under the legislation but the structure of the resource and settlement pattern suggest this could not be a major strategy unless a different financing system were available.

Forest inventory

National capacity

- Congo scores 3 for the availability of forest inventory data in FRA 2005, as reporting was based on a single forest inventory, carried out in-house in 2004;
- There have been effective inventories in the past, but institutions are not using available skills;
- Carbon stocks in the FAO FRA 2005 report were estimated using IPCC Tier 1 factors;
- Congo, like Cameroon, is a participant in the regional COMIFAC initiative. COMIFAC has been active since 2004, but it is not clear how much progress has been achieved in this relatively short period towards enhancing national capabilities for forest monitoring;
- Congo did not include forestry GHG estimates in its National Communication to the UNFCCC in 2001;
- Congo has indicated its interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **significant national capacity** for forest inventory in Congo, although it is being under-used at present.

Capability gap

- Congo has a forested area of 22.5 Mha, about 1/2 the size of the reference scenario;
- There is significant existing forest inventory capacity, but Tier 2 has not been achieved;
- To estimate the cost of achieving Tier 2 inventory, we start with an estimate of 50% of the reference scenario, to allow for the smaller area of forestry. Then we apply a further 50% discount to account for existing inventory capacity, arriving at an estimate of 25%;
- We estimate cost to achieve Tier 2 (approach B) at 50% the reference scenario. As noted in Annex 4 however, we feel this scenario is unlikely in most situations;
- We estimate Tier 3 year 1 cost as 50% the reference scenario, minus the offset already calculated for Tier 2 approach A to credit existing capacity. Recurring costs are 50% the reference scenario;
- The same calculation as above is applied for the scenario with degradation.

Table 49 Estimated costs to achieve enhanced capacity

Tier 2, approach A	£142,000 one-off cost.
Tier 2, approach B	£70,000 recurring annually.
Tier 3, approach A	£142,000 one-off cost. £95,000 recurring annually.
Tier 3, approach A, including degradation	£188,000 one-off cost. £110,000 recurring annually.

Remote sensing

National capacity

- Congo scores reasonably well (3) for the use of remote sensing in FRA 2005. Satellite images (Landsat) were analysed in-house in 2004;
- There is **significant national capacity** for remote sensing forest monitoring in Congo.

Capability gap

- The forested land area of Congo is about 50% that of the reference scenario. Annual data purchase costs (Landsat) would be about £30,000;
- We estimate additional costs as 1/3 the reference scenario, to fund improvements to existing capacity including specialised carbon monitoring training and addition of 1 analyst to existing capacity:
  - ⇒ First year: £175,000 + £30,000 data costs;
  - ⇒ Annual recurring: £42,000 + £30,000 data costs.

- Congo has recent in-house experience of analysing Landsat data. Congo's forests are relatively simple and probably not extensive enough to benefit from the use of coarse resolution imagery to focus on areas undergoing rapid change. Congo should continue to develop its experience with Landsat-type imagery, focussing on using automated methods to classify land-cover and to identify areas undergoing change;
- In the longer term, having gained significant experience with optical imagery, the use of radar data in place of optical data should be investigated. This would provide benefits principally in terms of cloud-free imagery. The cost of radar imagery is expected to fall in the medium term, so data acquisition costs may not be impacted.

Baseline modelling capacity

- Congo has a low rate of deforestation (-0.1%), and therefore would benefit from a modelling approach to establishing a forest emissions baseline;
- Modelling capacity: £37,500.

Democratic Republic of Congo (DRC)

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- The size and diversity of DRC can make national level statistics misleading, disaggregation is essential for effective intervention targeting;
- Forest area is predominantly closed forest with large areas lacking access but there is substantial localised degradation and conversion on the coastal plains and in the east;
- There are substantial areas that are “geographically protected” due to lack of access and broken topography;
- Forest restoration with natural processes is likely to be much more widely useful than plantations although the latter will have a role in certain localities. There was a significant plantation sector some years ago;
- Control of degradation through small-scale illegal activities may be more pressingly required than control of commercial activities but lack of rational land use planning system is critical constraint;
- Capacity for information gathering and reporting are close to zero on a national scale;
- There are numerous forest dwelling communities in the wet and moist forest zones;
- Community based approaches may have value in selected localities but would need outside support as national institutions lack capacity and local presence.

Table 50 Basic Statistics

GDP per cap (2006) US$	136	Forest, ha per cap	2.44	Tropical % *of which*	100
HDI (2005)	0.41	Average volume m³/ha	133	Rainforest %	82
Land Area 000ha	226,705	Annual change forest %	-0.2	Moist forest %	15
Population 000s (2004)	54,775	Annual plantation %	0	Dry forest %	
Pop density / km²	24.2	Primary %	n.a.	Mountain forest %	3
% rural population	67.7	Modified natural %	n.a.	Sub-tropical %	
Forest area 000ha (2005)	133,610	Semi-natural %	n.a.		
Forest Cover %	58.9	Plantation %	0		
Closed forest 000ha (2000)	126,236				
Closed forest %	55.7				
Protected areas %	9				

The huge size and diversity of DRC make generalisations difficult. Similarly, national level statistics tend to mask major differences and percentage figures may mislead due to the sheer size of the country. Effective discussion on DRC is best reflected through dis-aggregation

DRC is a massive tropical country dominated by the Congo Basin. The tropical evergreen forest occupies lower elevations, including some 20 million ha (one-sixth) of swamp forest. Closed tropical moist semi-deciduous forest accounts for much of the remainder with closed savanna along the northern boundaries and in the south and mountain forest in the east. Very substantial areas of the forest area are inaccessible due to steep and/or broken topography and much of the country lies above 1000 metres.

The natural disturbance levels in the closed forest vary. There are extensive areas of climax forest although traded timber records suggest that some of this is being quite heavily cleared and converted (*Gossweilerodendron*). Natural disturbance in the mountain region of the east is moderate to high but over most of the forest human intervention is the main factor affecting forest structure.

Most of the forest should be managed through polycyclic felling on a rotation of around 30 to 40 years but there are no detailed prescriptions in force, only diameter limits. Despite the existence of sound legislation from 2002, application is close to zero with little control on the ground other than that given by some of the concessionaires themselves, including some interest in certification.

In addition to large-scale degradation and locally significant forest conversion, there has been very widespread chainsaw lumbering, supplying local markets and those to the east. The size of this trade is undocumented but likely to have been many times the officially recorded production and export figures.

Protected areas are poorly managed although loss of forest cover from these is less significant than the loss of wildlife. The protected areas in the mountain forests are under heavy pressure because of their fertility. These areas have the highest biodiversity values. There are important forest dwelling communities across the wet and moist forest zones with high forest dependency.

There are few plantations and no recent ones, no reliable figures exist. There is good plantation potential in parts of the semi-deciduous and wetter savanna zones but in the main forest restoration is likely to depend on natural regeneration processes.

Community management is possible under current legislation. The security situation, low population over large areas and lack of technical support mean that such an approach could only be used in selected localities.

Forest inventory

National capacity

- DR Congo scores 0 for the availability of forest inventory data in FRA 2005. Reporting relies on a single synthesis report from 1999, which summarises data collected from several sources;
- No use is being made of inventory from the 1980's;
- Carbon stocks were estimated by expert opinion in the FAO FRA 2005 report (i.e. IPCC Tier 1 factors were not employed);
- DR Congo submitted a National Communication to the UNFCCC in 2000;
- There has not been an ITTO Diagnostic Mission to DR Congo;
- DR Congo has indicated interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **no national capacity** for forest inventory in DR Congo.

Capability gap

- DR Congo has a forested area of 133.6 Mha, about 2.7 times the size of the reference scenario;
- There is little or no existing forest inventory capacity;
- Estimated costs are 2.7 times the reference scenario.

Table 51 Estimated costs to achieve capacity

Tier 2, approach A	£1,532,000 one-off cost
Tier 2, approach B	£378,000 recurring annually
Tier 3, approach A	£1,532,000 in first year £513,000 recurring annually
Tier 3, approach A, including degradation	£1,782,000 in first year £594,000 recurring annually

Participatory forest inventory

- DR Congo has a low per capita GDP;
- There is a large rural population;
- Institutions are unable to sustain a forest inventory;
- Important regions are inaccessible with very poorly educated populations;
- A participatory forest inventory approach may be the only sustainable method of establishing a permanent forest inventory capacity. However, large areas of the country are difficult to work in and resident communities may be difficult to recruit and train.

Remote sensing

National capacity

- DR Congo showed no evidence of using remote sensing in FRA 2005;
- There appears to be **no national capacity** for remote sensing forest monitoring in DR Congo.

Capability gap

- The forested land area of DR Congo is about 2.7 times that of the reference scenario, requiring about 540 Landsat scenes. Annual data purchase costs (Landsat) would be about £162,000;
- Cost estimates:
  - ⇒ First year: £520,000 + £162,000 data costs;
  - ⇒ Annual recurring: £126,000 + £162,000 data costs.

- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*).

Baseline modelling capacity

- DR Congo has a low rate of deforestation (-0.2%), and therefore would benefit from a modelling approach to establishing a forest emissions baseline;
- Modelling capacity: £37,500.

Equatorial Guinea

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Ecological potential is closed wet tropical forest with low natural disturbance on the coastal plain, disturbed semi-deciduous forest on the plateau, with significant proportion of *Aucoumea*. The islands have high biodiversity value including endemic species;
- Loss of forest has been mainly in west, as result of earlier logging and conversion, some secondary forest;
- High rural population and moderate ongoing forest loss rate;
- High forest dependency and high pressure on protected areas, little evidence of effective implementation of basically sound policy or legislation;
- Restoration through natural processes may relatively easy technically in some areas but very difficult in others and effective plantation establishment very hard in these, too;
- No evidence of effective reporting nor of engagement in international processes since 1990;
- Community involvement would appear to be very challenging given the poor governance framework.

Table 52 Basic Statistics

GDP per cap (2006) US$	19,166	Forest, ha per cap	3.23	Tropical % *of which*	100
HDI (2005)	0.64	Average volume m³/ha	93	Rainforest %	100
Land Area 000ha	2,805	Annual change forest %	-0.9	Moist forest %	
Population 000s (2004)	506	Annual plantation %	0	Dry forest %	
Pop density / km²	18	Primary %	n.a.	Mountain forest %	
% rural population	51.0	Modified natural %	n.a	Sub-tropical %	
Forest area 000ha (2005)	1,632	Semi-natural %	n.a		
Forest Cover %	58.2	Plantation %	0		
Closed forest 000ha (2000)	1,774				
Closed forest %	63.2				
Protected areas %	11				

Equatorial Guinea lies between Cameroon and Gabon. The topography is characterised by a narrow coastal plain rising gently eastwards to a gently undulating plateau flat at around 600 metres elevation with inselbergs. The climate is perhumid. The natural vegetation is predominantly wet evergreen forest with a drier forest type on the plateau. The country includes a pleistocene refuge of high biodiversity value.

The timber species traded (*Lophira alata and Aucoumea klaineana*) are both pioneers which suggests that the forest has been substantially disturbed. The former is a species of wet evergreeen forest and swampy areas while the latter is a species of drier profiles.

There has been considerable loss of forest to other land uses, especially in the western half of the country. Despite the oil-based national wealth there is huge disparity leading to heavy forest dependency for bushmeat and other non-timber forest products. Protected areas are reported to be under heavy human pressure, including illegal logging.

The drier forest could be managed with polycyclic felling on a 40-year cycle and the presence of *Aucoumea* as in Gabon means there is potential for natural restoration on at least some of the degraded area although parts are also likely to be highly challenging. Plantations are likely to be very difficult except on selected sites in the east, which presently has fair to good forest cover. There may also be potential on coastal sands as in Congo. No current information has been found on silvicultural prescriptions nor on management planning, although this existed both nationally and regionally years ago. There are indications that little progress has been made with formal planning and control but despite this there is significant timber production and export, mainly logs to Asia. This was a major economic activity pre-oil, further study is required as to the efficacy of regeneration on sites logged in earlier decades, but much regional information is directly applicable.

There seems to be little or no national capacity for action on most of the activities required for either forest management or for reporting of either forestry or REDD. There are major governance issues to be resolved.

Forest inventory

National capacity

- Equatorial Guinea scores 0 for the availability of forest inventory data in FRA 2005. Reporting relies on a single FAO report from 1993;
- Carbon stocks were estimated by expert opinion in the FAO FRA 2005 report (i.e. IPCC Tier 1 factors were not employed);
- Equatorial Guinea has not submitted a National Communication to the UNFCCC;
- Equatorial Guinea is not a member of ITTO and has shown no interest in joining;
- Equatorial Guinea has not indicated interest in participating in the World Bank FCPF initiative;
- Equatorial Guinea has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **little or no national capacity** for forest inventory in Equatorial Guinea, despite some earlier training.

Capability gap

- Equatorial Guinea has a forested area of 1.6 Mha, about 3% the size of the reference scenario;
- There is little or no existing forest inventory capacity;
- Estimated costs are 1/3 the reference scenario;
- As explained in Annex 4, cost savings from reduced extent of forestry are small or zero below about 1/3 the forest area reference scenario;
- Equatorial Guinea should investigate the option of forming a regional forest inventory capability, to share costs.

Table 53 Estimated costs to achieve capacity

Tier 2, approach A	£190,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£190,000 in first year £63,000 recurring annually
Tier 3, approach A, including degradation	£220,000 in first year £73,000 recurring annually

Remote sensing

National capacity

- Equatorial Guinea showed no evidence of using remote sensing in FRA 2005;
- There appears to be **no national capacity** for remote sensing forest monitoring in Equatorial Guinea.

Capability gap

- The forested land area of Equatorial Guinea is about 3% that of the reference scenario, requiring about 6 Landsat scenes. Annual data purchase costs (Landsat) would be about £1,800;
- Cost estimates:
  - ⇒ First year: £520,000 + £1,800 data costs;
  - ⇒ Annual recurring: £126,000 + £1,800 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar etc);
- As explained in annex 4, there are no cost savings available because of the small area to cover. The smallest sustainable team requires 3 analysts, and the range of analyses are no different from a larger country;
- Equatorial Guinea should investigate the possibility of forming a regional remote sensing capacity, to share costs.

Gabon

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Natural ecology is closed tropical forest over most of the country with low natural disturbance, pleistocene refuge in coastal forest;
- Very heavy overcutting for timber in coastal areas and along lines of access but much of the forest is in reasonable condition and natural regeneration is widely effective, cover loss very low leading to suppression in cut over areas;
- Oil rich economy with low and largely urban population. Little political interest in forestry;
- Extensive and valuable forest resource with some degraded areas;
- Forest dependency locally high in very limited locations but there is extensive hunting;
- Plantation potential with *Aucoumea* on coastal plain using well-known techniques;
- Community based approaches not likely to be extensively useful;
- Application of forest planning and management effective in some areas but not universally applied adequately.

Table 54 Basic Statistics

GDP per cap (2006) US$	7,245	Forest, ha per cap	15.85	Tropical % *of which*	100
HDI (2005)	0.68	Average volume m³/ha	128	Rainforest %	99
Land Area 000ha	25,767	Annual change forest %	0	Moist forest %	
Population 000s (2004)	1,374	Annual plantation %	0	Dry forest %	1
Pop density / km²	5.3	Primary %	n.a.	Mountain forest %	
% rural population	15.6	Modified natural %	n.a.	Sub-tropical %	
Forest area 000ha (2005)	21,775	Semi-natural %	n.a.		
Forest Cover %	84.5	Plantation %	0.2		
Closed forest 000ha (2000)	21,800				
Closed forest %	84.6				
Protected areas %	16				

Gabon is a relatively rich country with a low but largely urban population and very extensive forest cover lying entirely within the tropics.

The topography is mainly flat with an extensive central plateau area and some isolated hills. The Bateke Plateau in the east is savanna and there are small pockets of coastal savanna. The bulk of the forest is closed tropical rainforest of different types and includes a pleistocene refuge in the coastal forest with high biodiversity. Along the coast, heavy cutting in accessible areas has led to secondary forest dominated by *Aucoumea klaineana.* This secondary forest species is unusual in that it is a valuable and abundant timber species. The eastern forests are drier and contain species such as *Terminalia superba* and *Triplochiton scleroxylon.*

Forest cover is generally good despite heavy cutting in accessible areas. There are substantial differences between the volume per ha reported by FRA 2000 and ITTO 2005, the latter at 220 m^3/ha being almost twice the former. Swamp areas exist near the coast and in the north east.

Natural disturbance levels are low overall and apart from localised timber harvesting, there is relatively little human impact. The coverage of concession areas by management plans is around one-third but there is a significant certified area. Protected areas are not well managed with extensive poaching but forest cover is largely intact. Access other than by the railway is generally restricted. A special silvicultural system exists to maintain *Aucoumea* production, elsewhere a low intensity polycyclic system is used.

Although there is degradation from overcutting, forest cover loss is very low. Gabon is one of increasingly few exporters of logs. Provision exists for community management but the low rural population and lack of access suggest that this is unlikely to be a major strategy in the immediate future.

In respect of plantations, *Aucoumea* is likely to be useful on appropriate sites in the west. The semi-deciduous forest region in the north east would have potential for undercropping systems within plantations using indigenous species, including *Terminalia superba*. In the main, natural regeneration is the main technique used in Gabon and this is likely to continue in the foreseeable future. Simple silviculture could much enhance the success.

Forest inventory

National capacity

- Gabon scores 0 for the availability of forest inventory data in FRA 2005. Reporting relies on a single report on commercial species produced by FAO in 1999;
- Carbon stocks were not reported in the FAO FRA 2005 report;
- Gabon did not include forestry GHG estimates in its National Communication to the UNFCCC in 2002;
- Gabon has indicated its interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **little or no national capacity** for forest inventory in Gabon, although the skills do existbut do not seem to be usefully applied.

Capability gap

- Gabon has a forested area of 21.8 Mha, about 50% the size of the reference scenario;
- There is little or no active forest inventory capacity;
- Estimated costs are 50% the reference scenario.

Baseline modelling capacity

- Gabon’s forest area is stable, and therefore Gabon would benefit from a modelling approach to establishing a forest emissions baseline;
- Modelling capacity: £37,500

Table 55 Estimated costs to achieve capacity

Tier 2, approach A	£285,000 one-off cost
Tier 2, approach B	£70,000 recurring annually
Tier 3, approach A	£285,000 in first year £95,000 recurring annually
Tier 3, approach A, including degradation	£330,000 in first year £110,000 recurring annually

Remote sensing

National capacity

- Gabon showed no evidence of using remote sensing in FRA 2005;
- There appears to be **no national capacity** for remote sensing forest monitoring in Gabon.

Capability gap

- The forested land area of Gabon is about 50% that of the reference scenario. Annual data purchase costs (Landsat) would be about £30,000;
- Cost estimates:
  - ⇒ First year: £520,000 + £30,000 data costs;
  - ⇒ Annual recurring: £126,000 + £30,000 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*).

Ghana

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- Ecological potential is for low natural disturbance closed forest over at least the southern half of country but has been much altered for many generations;
- Highly disturbed, degraded and fragmented forest resource base low standing volume;
- Many Forest Reserves and Protected Areas badly degraded;
- Increasing risk of fire damage in moist and even wetter forest areas;;
- High current rate of forest cover loss;
- High population pressure, low economic development level but improving, especially around urban areas;
- Heavy pressure and high dependency on remaining forest including reserved and protected areas;
- Good plantation potential in moist and semi-deciduous zones, some restoration potential, considerable potential for increasing standing volume in remaining forests;
- Community based approaches may have considerable potential.

Table 56 Basic Statistics

GDP per cap (2006) US$	532	Forest, ha per cap	0.26	Tropical % *of which*	100
HDI (2005)	0.55	Average volume m³/ha	49	Rainforest %	47
Land Area 000ha	22,754	Annual change forest %	-2.1	Moist forest %	32
Population 000s (2004)	21,053	Annual plantation %	0.36	Dry forest %	21
Pop density / km²	92.5	Primary %	6.4	Mountain forest %	-
% rural population	54.2	Modified natural %	90.7	Sub-tropical %	0%
Forest area 000ha (2005)	5,517	Semi-natural %	-		
Forest Cover %	24.2	Plantation %	2.9		
Closed forest 000ha (2000)	1,634				
Closed forest %	7.2				
Protected areas %	9				

Ghana lies entirely within the tropics. The forest type changes northwards from wet tropical forest in the south along the coastal area through moist and semi-deciduous zones to the savanna regions, which occupy roughly half the country. There has been severe loss of the original forest cover and degradation of what remains. Many Forest Reserves and Protected Areas are heavily degraded mainly from overcutting especially pre 1995. Standing wood volume is less than half that of well-stocked forests in the region.

The topography is dissected, there are no major massifs but some steep scarps. There is relatively easy access throughout the forest zone and illegal chainsaw lumbering is a severe problem. The protected areas are generally degraded. There is relatively little forest with cover of 40% or greater, this is mainly in Forest Reserves. The average volume per hectare is low compared with other countries in the region.

The natural disturbance level in the forest is low and without human interference, apart from in the savanna zone, the forest structure would be more stable with a dense canopy and only small gaps. Forest cover has been heavily disturbed and fragmented. Degraded forest and short-term fallow areas are rapidly colonised by secondary forest but fire is an increasing problem, even in wetter areas. There is an ongoing wildfire control programme.

Despite the limited forest resource area per capita, loss of forest cover remains high and is far from balanced by restoration or plantation development. The low level of economic development and high proportion of rural dwellers with few opportunities emphasises the high level of forest dependency.

The high forest should be managed by polycyclic felling on a 40-year or longer cycle with silvicultural rules but overall control of forest resources remains challenging. In the 1980s, there was a period when a return cycle of 15 years was used to remove “overstocking” and much of the forest has not yet fully recovered from this. Capability and capacity for inventory and management planning is good but not always used creatively. There is a network of permanent sample plots and an extensive history of inventory, growth and yield studies although donor support has now ceased for these.

There is substantial potential for forest restoration and reforestation through plantations, with an active programme ongoing. Degraded forests in the wetter zones are challenging for plantations due to highly acidic, compacted soils and heavy weed growth. The potential for assisted natural regeneration is low other than for creating secondary forest due to degradation restricting the diversity of the seed rain. Line planting showed considerable promise in some areas. Some forest reserves are effectively islands with many species now too infrequent to regenerate. Connectivity between reserved areas is poor.

Community approaches are possible and may represent a good entry point if the ownership issues can be fully resolved; local farmers grow tree crops and do use tree-based intercropping.

Forest inventory

<u>National capacity</u>

- There were three DFID funded projects between 1985 and 1995 on inventory, management planning, growth and yield studies, as well as related inputs including forest botany, ecology, biogeography and biodiversity studies;
- Ghana scores very low (1) for the availability of forest inventory data in FRA 2005. Data relied on two reports produced by external agencies, with no land-cover map;
- IPCC Tier 1 factors were used to estimate carbon stocks;
- Ghana has provided forestry GHG estimates in its National Communication to the UNFCCC in 2001;
- There has not been an ITTO Diagnostic Mission to Ghana;
- There appears to be **little active national capacity** for forest inventory in Ghana. Existing capacity is not harnessed to generate national level data suitable for international reporting;
- Ghana has indicated its interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically). This may indicate sufficient interest at the institutional level to support a sustained monitoring capability.

Capability gap

- Ghana has a relatively small forested area (5.5 Mha), a complex and fragmented forest resource, and little active forest inventory capacity;
- Estimated costs are 1/3 the reference scenario, plus a 50% increment to account for the complexity of the forest resource in Ghana.

Table 57 Estimated costs to achieve capacity

Tier 2, approach A	£300,000 one-off cost
Tier 2, approach B	£75,000 recurring annually
Tier 3, approach A	£300,000 in first year £90,000 recurring annually
Tier 3, approach A, including degradation	£330,000 in first year £105,000 recurring annually

Participatory forest inventory

- Ghana has a low per capita GDP. Educational levels are relatively good;
- The NGO sector is able to operate effectively within the country;
- There is a large rural population;
- Institutions are unable to sustain a forest inventory;
- There is existing inventory expertise, although not harnessed at present;
- Ghana's forests are accessible;
- A participatory forest inventory approach may be feasible.

Remote sensing

National capacity

- Ghana scores zero for the use of remote sensing in FRA 2005. Forest extents were extracted from a report produced by an external contractor – a land-cover map was not available to the reporter;
- There appears to be **no national capacity** for remote sensing forest monitoring in Ghana.

Capability gap

- The small land area of Ghana (22.8 Mha) is covered by 4 Landsat scenes, costing £1,200 for annual data purchase (Landsat);
- Cost estimates are provided, but it would be more efficient if Ghana could share costs with a regional remote sensing capacity:
  - ⇒ First year: £520,000 + £1,200 data costs;
  - ⇒ Annual recurring: £126,000 + £1,200 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*).

Liberia

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- The natural forest ecology is low disturbance wet and most evergreen grading to a moist semi-deciduous type with relatively low proportion of valuable timber species;
- In the aftermath of the civil war the whole forest sector is stalled and under review;
- Liberia suffered a high rate of forest cover loss for more than 20 years as well as severe forest degradation from overcutting. Lack of control and a short return cycle have further prejudiced regeneration and future productivity. A moratorium on logging is in place;
- High population pressure and economic stagnation have led to heavy forest dependency and forest fragmentation due to subsistence agriculture for survival;
- Effective forest restoration through natural processes will be difficult but there is no experience of restoration through planting or of plantations. Liberia has a major rubber plantation industry so there is experience of tree crops;
- Institutional capacity is extremely low in part due to the civil war although there are now large donor programmes;
- Community engagement other than for domestic products has no track record nor is it allowable under current legislation although this is under review and revision.

Table 58 Basic Statistics

GDP per cap (2006) US$	192	Forest, ha per cap	0.51	Tropical % *of which*	100
HDI (2005)	0.32	Average volume m³/ha	143	Rainforest %	99
Land Area 000ha	9,632	Annual change forest %	-1.9	Moist forest %	1
Population 000s (2004)	3,449	Annual plantation %	0	Dry forest %	
Pop density / km²	35.8	Primary %	4.1	Mountain forest %	
% rural population	52.7	Modified natural %	95.7	Sub-tropical %	
Forest area 000ha (2005)	3,154	Semi-natural %			
Forest Cover %	32.7	Plantation %	0.3		
Closed forest 000ha (2000)	32.7				
Closed forest %	42.8				
Protected areas %	1.0				

Liberia has recently emerged from a protracted civil war and the effects of a corrupt and violent dictatorship during which commercial timber was extensively liquidated to buy arms and fund the regime. This has had a profound effect on forest cover and composition.

The topography is characterised by a hilly coastal plain and inland plateau and low mountains in north bordering Guinea and Sierra Leone. The natural forest is wet evergreen forest in the east grading to moist and semi-deciduous closed forest as the rainfall drops. It is less rich in timber species than the forests of Central Africa. The natural disturbance levels are generally low but the forest has been hugely impacted by human activity.

Forest loss has been very rapid with fragmentation and uncontrolled conversion and over 40% of the forest area has been lost in just over 20 years. The Liberian Selected Logging System used in the past operated with an overly short (25 year) return cycle. This is certainly too short to secure regeneration and, combined with lack of control, this means that any logged forest will have been seriously overcut and require a long regeneration period. There is now a very high level of forest dependency for subsistence and uncontrolled logging roads have facilitated extensive access into the forest.

Although there are extensive rubber plantations, Liberia has little experience of plantation forestry. Restoration through planting is likely to be ecologically difficult in the wetter zones due to species limitations as well as fragmentation. Combined with uncontrolled past felling, this will also mean that natural regeneration will result in low value secondary forest in most areas. Strong donor presence may result in improved management practice.

There is estimated to be some 3 million ha of relatively intact forest but there are neither recent inventory figures nor national capacity to gather these. A substantial proportion of this forest may be redeemable but this will be a long-term challenge.

At present, there is a moratorium on commercial logging and the whole forestry sector is under review with substantial donor interest led by USAID and WB. The review will include revision of policy and ultimately legislation. At present, although provision exists for community forests these are for domestic use only and communities could not it seems be engaged in restoration and management. This may be resolved in the review of legislation now underway.

Forest inventory

National capacity

- Liberia scores 1 for the availability of forest inventory data in FRA 2005. Data were reported from an external consultant report of 1989;
- Carbon stocks were estimated in the FAO FRA 2005 report using a single conversion factor of 50%;
- Liberia has not submitted a National Communication to the UNFCCC;
- There was an ITTO diagnostic mission to Liberia immediately after the civil war and a new one is under discussion to take account of recent changes;
- Liberia has indicated interest in participating in the World Bank FCPF initiative;
- Liberia has not submitted views on REDD to the UNFCCC SBSTA;
- There is **little or no national capacity** for forest inventory in Liberia.

Capability gap

- Liberia has a forested area of 3.2 Mha, about 6% the size of the reference scenario;
- There is little or no existing forest inventory capacity;
- Estimated costs are 1/3 of the reference scenario;
- As explained in Annex 4, cost savings from reduced extent of forestry are small or zero below about 1/3 the forest area reference scenario;
- Liberia should investigate the option of forming a regional forest inventory capability, to share costs.

Table 59 Estimated costs to achieve capacity

Tier 2, approach A	£190,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£190,000 in first year £63,000 recurring annually
Tier 3, approach A, including degradation	£220,000 in first year £73,000 recurring annually

Participatory forest inventory

- Liberia has a low per capita GDP. Educational levels are relatively good;
- The NGO sector is able to operate effectively within the country;
- There is a small rural population;
- Institutions are unable to sustain a forest inventory;
- Liberia's forests are generally accessible;
- A participatory forest inventory approach may be feasible, but the sparse rural population could be a limiting factor.

Remote sensing

National capacity

- Liberia showed little evidence of capacity to use remote sensing in FRA 2005. Forest areas were taken from a satellite analysis performed by an external consultant in 2004;
- There appears to be **no national capacity** for remote sensing forest monitoring in Liberia.

Capability gap

- The forested land area of Liberia is about 6% of the reference scenario, requiring about 12 Landsat scenes. Annual data purchase costs (Landsat) would be about £3,600;
- Cost estimates:
  - ⇒ First year: £520,000 + £3,600 data costs;
  - ⇒ Annual recurring: £126,000 + £3,600 data costs.
- We do not provide estimates for advanced capabilities (LiDAR, radar etc);
- As explained in Annex 4, there are no cost savings available because of the small area to cover. The smallest sustainable team requires 3 analysts, and the range of analyses are no different from a larger country;
- Liberia should investigate the possibility of forming a regional remote sensing capacity, to share costs.

Sierra Leone

Capability and cost assessment to measure and monitor forest carbon

Overview

Key Issues

- The natural forest ecology is coastal evergreen and mangrove forest grading quite rapidly inland into savanna but with low natural disturbance;
- The remaining forest, apart from some mangrove areas is highly disturbed and degraded with low standing volume;
- Increased risk of fire damage in degraded and fragmented forest and extensive damage from mining – gold, diamonds, iron and titanium ores;
- High continuing rate of degradation and loss of forest cover despite rapid recolonisation by secondary species;
- High forest dependency across most of the country;
- Restoration through natural processes will be difficult, little recent experience of plantations or artificial restoration but technically not difficult;
- Weak and under resourced institutions;
- Limited possibilities for community led approaches without major intervention, many NGOs operating.

Table 60 Basic Statistics

GDP per cap (2006) US$	318	Forest, ha per cap	0.51	Tropical % *of which*	100
HDI (2005)	0.34	Average volume m³/ha	143	Rainforest %	40
Land Area 000ha	7,162	Annual change forest %	- 0.7	Moist forest %	59
Population 000s (2004)	5,436	Annual plantation %	0	Dry forest %	
Pop density / km²	75.9	Primary %		Mountain forest %	1
% rural population	60.5	Modified natural %	99.9	Sub-tropical %	
Forest area 000ha (2005)	2,754	Semi-natural %			
Forest Cover %	38.5	Plantation %	0.1		
Closed forest 000ha (2000)	725				
Closed forest %	10.1				
Protected areas %	5%				

Sierra Leone is characterised by a hilly coastal plain with extensive mangroves, a flatter plateau inland and low mountains in the north east. The natural forest ecology is wet and moist forest along the coast rapidly grading to savanna northwards. Natural disturbance levels are low in the wet and moist forest but fire is an increasing hazard with degradation and fragmentation. This hazard is exacerbated by the intense dry season, which is influenced by the Harmattan. There is also long-standing agrarian/pastoral conflict.

The country suffered from a vicious civil war during which forest and mining concessions were given out in lieu of payments for mercenary services. There has been extensive degradation and little fully intact forest remains. Outside the mangrove areas, the predominant forest cover is secondary forest. The FAO standing volume figure seems very optimistic, a figure less than half of the quoted 143m³/ha may be more accurate.

Population density is high throughout the forest zone and there is high forest dependency for livelihood support and domestic produce. Access is generally fairly easy which has exacerbated forest degradation and conversion. There is extensive large and small-scale mining, which impacts directly on the forest through stripping of cover, spoil and hydrological disturbance. Massive laterite has been exposed by some mining processes and shows little sign of natural revegetation after several decades.

Forest legislation from 1988 underwent revision in 1992 but there is little control at field level. There is considerable conflict over the authority of local chiefs to issue concessions and permits. Even in the flagship Gola forest, under a conservation concession, there is extensive illegal chainsaw lumbering and the level of control in protected areas is low.

It is extremely doubtful whether any blocks of forest remain that could be sustainably harvested on a commercial scale. Community level management would be feasible under present regulations but the capacity of communities, and of supporting institutions, is very weak. There is little international support for the forestry sector other than an EU funded voluntary partnership agreement for internationally traded timber. There are a number of national and international voluntary organisations operating in the wider environment sector.

The most conspicuous large tree in many areas is now *Ceiba pentandra*. Effective forest restoration through natural processes is likely to be extremely difficult in most localities due to severe degradation of the species base and ecosystem functional capacity as well as high pressure on remaining patches. There has been limited plantation experience in the past but the costs of artificial restoration, especially on mine spoil, are high and there is little technical expertise available.

There is no capacity for large-scale formal inventory and no permanent sample plots exist as far as is known. Basic inventory skills remain and are used in connection with “informal” concessions.

Forest inventory

<u>National capacity</u>

- Sierra Leone scores 0 for the availability of forest inventory data in FRA 2005. Reporting relies on a single FAO report reviewing available forest data sources for Sierra Leone in 1996 but changes since then render it of little value;
- Carbon stocks were not reported in the FAO FRA 2005 report;
- Sierra Leone did not include forestry GHG estimates in its National Communication to the UNFCCC in 2002;
- Sierra Leone is not a member of ITTO but has expressed interest in joining;
- Sierra Leone has indicated its interest in participating in the World Bank FCPF initiative, and has submitted views on REDD to the UNFCCC SBSTA (although not discussing existing monitoring capacity specifically);
- There is **little or no national capacity** for forest inventory in Sierra Leone.

<u>Capability gap</u>

- Sierra Leone has a forested area of 2.8 Mha, about 5% the size of the reference scenario;

- There is little or no existing forest inventory capacity;
- Estimated costs are 1/3 the reference scenario;
- As explained in Annex 4, cost savings from reduced extent of forestry are small or zero below about 1/3 the forest area reference scenario;
- Sierra Leone should investigate the option of forming a regional forest inventory capability, to share costs.

Table 61 Estimated costs to achieve capacity

Tier 2, approach A	£190,000 one-off cost
Tier 2, approach B	£47,000 recurring annually
Tier 3, approach A	£190,000 in first year £63,000 recurring annually
Tier 3, approach A, including degradation	£220,000 in first year £73,000 recurring annually

Participatory forest inventory

- Sierra Leone has a low per capita GDP. Educational levels are relatively good;
- The NGO sector is able to operate effectively within the country;
- There is a small rural population;
- Institutions are unable to sustain a forest inventory;
- Liberia's forests are generally accessible;
- A participatory forest inventory approach may be feasible, but the sparse rural population could be a limiting factor.

Remote sensing

National capacity

- Sierra Leone showed no evidence of using remote sensing in FRA 2005;
- There appears to be **no national capacity** for remote sensing forest monitoring in Sierra Leone.

Capability gap

- The forested land area of Sierra Leone is about 5% that of the reference scenario, requiring about 10 Landsat scenes. Annual data purchase costs (Landsat) would be about £3,000;
- Cost estimates:
  - ⇒ First year: £520,000 + £3,000 data costs;
  - ⇒ Annual recurring: £126,000 + £3,000 data costs.

- We do not provide estimates for advanced capabilities (LiDAR, radar *etc*);
- As explained in Annex 4, there are no cost savings available because of the small area to cover. The smallest sustainable team requires 3 analysts, and the range of analyses is no different from a larger country;
- Sierra Leone should investigate the possibility of forming a regional remote sensing capacity, to share costs.

Annex 1 Terms of Reference

Terms of Reference

Capability and cost assessment of the major forest nations to measure and monitor their forest carbon

Objective

To assess the capability and associated data and infrastructural cost required for defined scenarios for measuring and monitoring the major forest nations' forest carbon.

Background

The Eliasch Review is an independent review that will report to the Prime Minister on the role of global forests in tackling climate change through existing and new financing mechanisms.

The Prime Minister has appointed Johan Eliasch as his Special Representative on deforestation and clean energy. It is in this capacity that Mr Eliasch has been commissioned to undertake this review by summer 2008. The Eliasch Review team is based in the Office of Climate Change (www.occ.gov.uk).

The ability to accurately measure and monitor forest carbon has been highlighted as a key barrier to forest nations' controlling deforestation and degradation. Furthermore, it also limits their capacity to take part in a potential future international mechanism to provide incentives for forest protection. Many forest nations have processes in place to monitor their forests, yet the accuracy and consistency is variable.

The review team requires an overview assessment from existing analysis and information on the capability (skill and infrastructural) and associated data and infrastructural cost for a representative sample of forest nations[2] to fulfil the requirements of defined measurement and monitoring scenarios.

Suppliers are invited to bid for all or parts (split by forest nation or parts), depending on their expertise and availability

Outputs

Forest nations to be covered:

Africa:	Cameroon, Congo Brazzaville, DR Congo, Equatorial Guinea, Gabon, Ghana, Liberia, Sierra Leone
Americas:	Bolivia, Brazil, Colombia, Costa Rica, Guyana, Mexico, Peru, Venezuela,
Asia:	Cambodia, China, India, Indonesia, Malaysia, Myanmar, Papua New Guinea, Thailand, Vietnam

1) A 2-4 page overview assessment of measuring capabilities for each scenario, including facts and figures on each forest nation and covering:

   i) Current measuring capability

[2] This list may be subject to minor changes before the start of the contract

ii) Capability gap to fulfilling each measuring scenario requirements
iii) The required additional cost and timings for capability to fulfil each scenario requirement.

Measurement scenarios based on IPCC tiers 2 and 3 and GOFC-GOLD sourcebook, see attached section 4.2:

a) Tier 2, approach A to stratification and generation of a national look-up table
b) Tier 2, approach B to stratification and generation of a national look-up table
c) Tier 3 and generation of a national look-up table

50-100 pages in total

2) A 1-2 page overview assessment of capabilities for using each technique in a national annual monitoring system, including facts and figures on each forest nation and covering:

i) Current measuring capability
ii) Capability gap to fulfilling each measuring scenario requirements
iii) The required additional cost and timings for capability to fulfil each scenario requirement.

Monitoring techniques:

a) Visual interpretation of satellite data
b) Indirect approaches on satellite data to detect degradation
c) Mixture models of satellite data (e.g NDFI)
d) Radar use
e) Lidar use

25-50 pages in total

3) One 2-5 page summary note on data costs per area unit:

i) Coarse resolution satellite data (250-1000m) e.g. MODIS
ii) Mid resolution satellite data (10-60m) e.g. Landsat
iii) High resolution data (< 5m) e.g. IKONOS, QuickBird
iv) Radar data
v) Lidar data

Timing

1st draft submitted to Review Team by cop on Thursday 27 March. Final draft by cop 4th April.

Project management

The OCC contact on the review is Chris Westrop:
chris.westrop@occ.gsi.gov.uk, 0207 238 4208.

Annex 2 Main Documents Consulted

FAO (2001). Global Forest Resources Assessment 2000: main report. FAO Forestry Paper 140. FAO, Rome.

FAO (2005). FRA 2005 – Country Reports. FAO, Rome.

FAO (2006). Global Forest Resources Assessment 2005: progress towards sustainable forest management. FAO, Rome.

FAO (2006). State of the World's Forests 2005

FAO (2008). State of the World's Forests 2007

ITTO (2001). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Indonesia – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2002a). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Brazil – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2002b). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Congo – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2003a). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Peru – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2003b). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Guyana – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2004). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Cambodia – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2005). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Gabon – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2006). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Thailand – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2005). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Mexico – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2005). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Liberia – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2006). Achieving the ITTO Objective 2000 and Sustainable Forest Management in India – Report of the Diagnostic Mission. International Tropical Timber Council.

ITTO (2006). Status of Tropical Forest Management 2005

ITTO (2007). Achieving the ITTO Objective 2000 and Sustainable Forest Management in Papua New Guinea – Report of the Diagnostic Mission. International Tropical Timber Council.

Annex 3 Summary of Statistical Information Abstracted

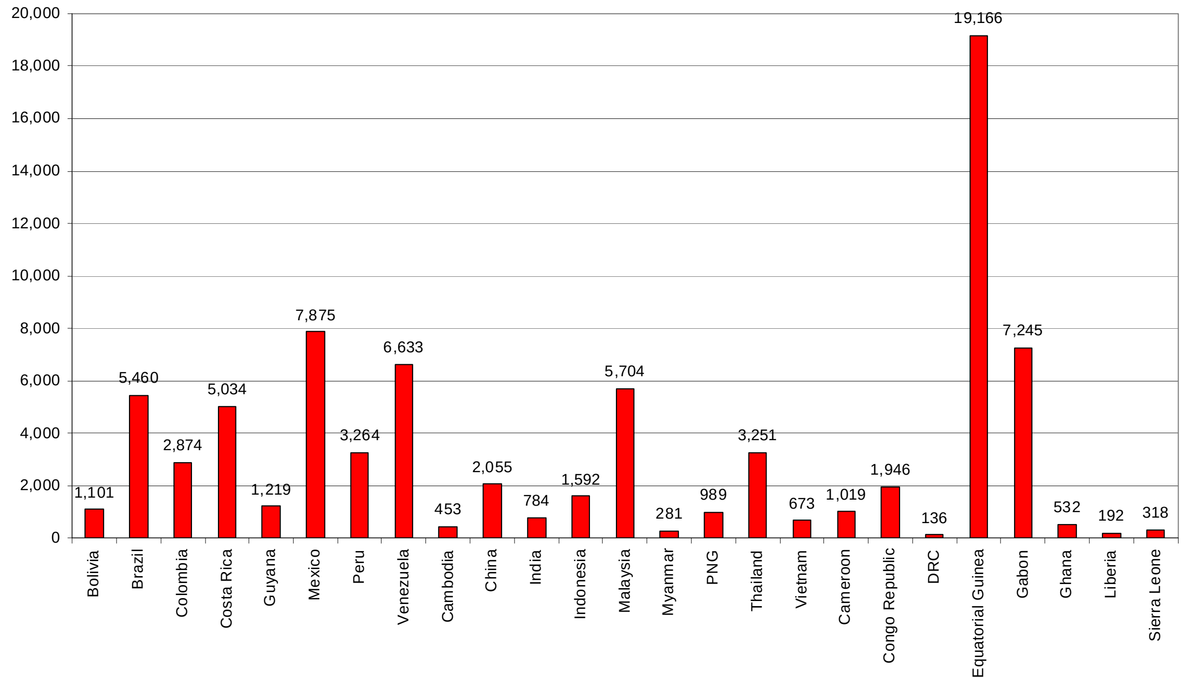

Figure 7 GDP per capita - 2006 (US$)

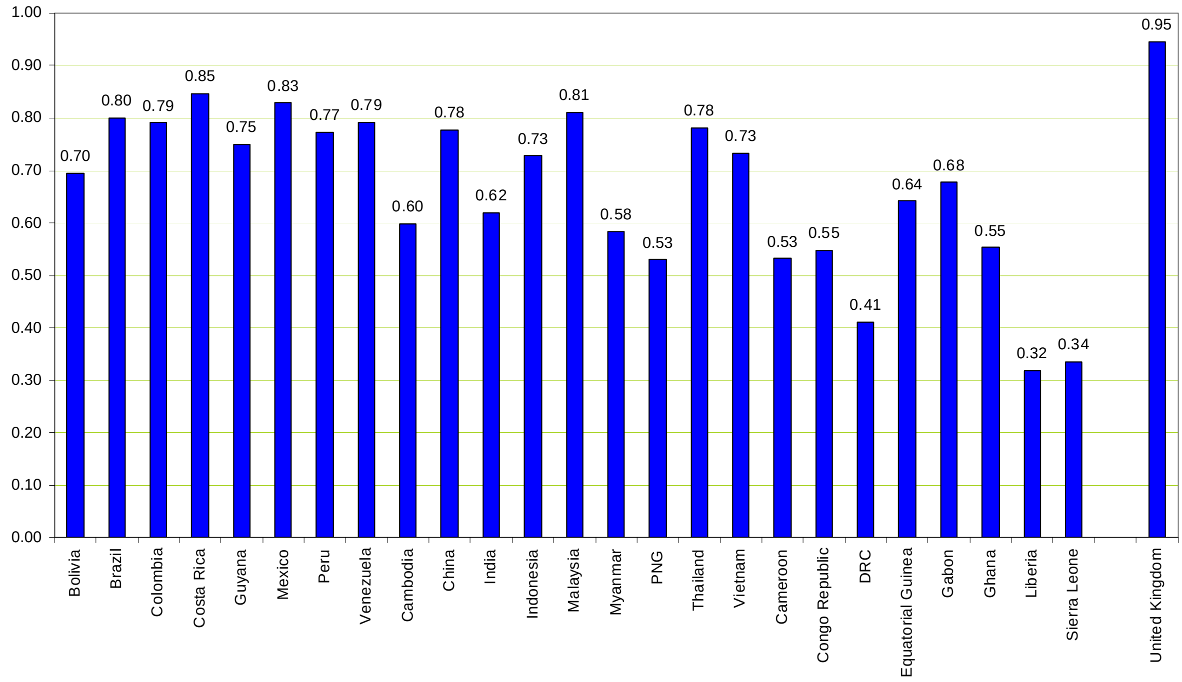

Figure 8 Human Development Index 2005

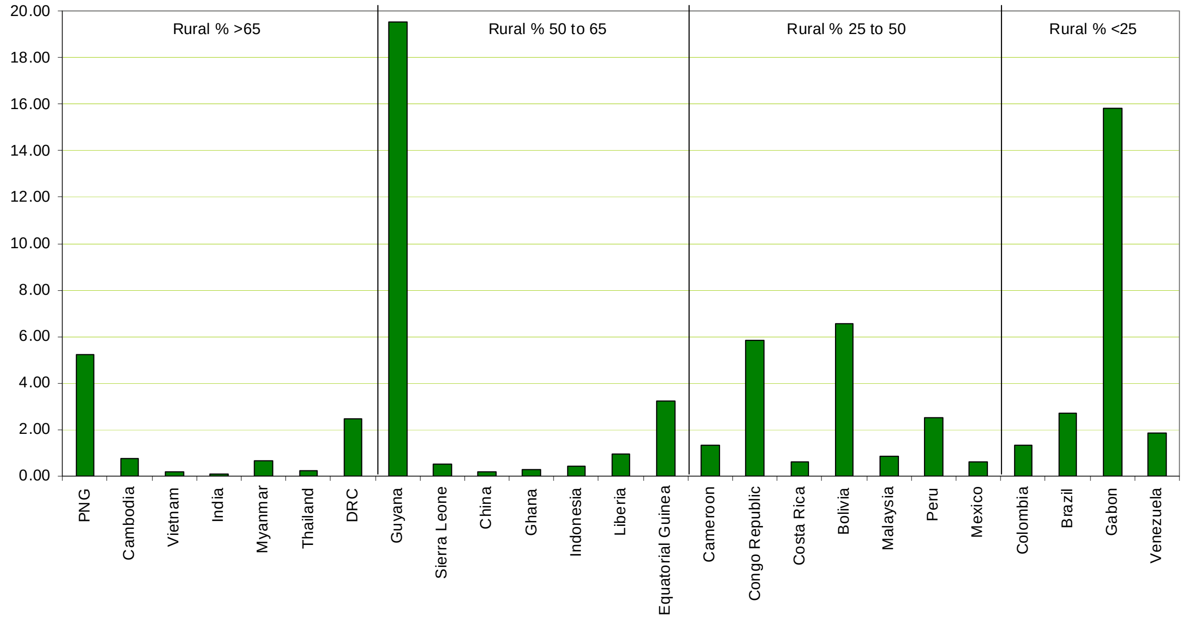

Figure 9 Forest Area (ha per cap) and % Rural Population

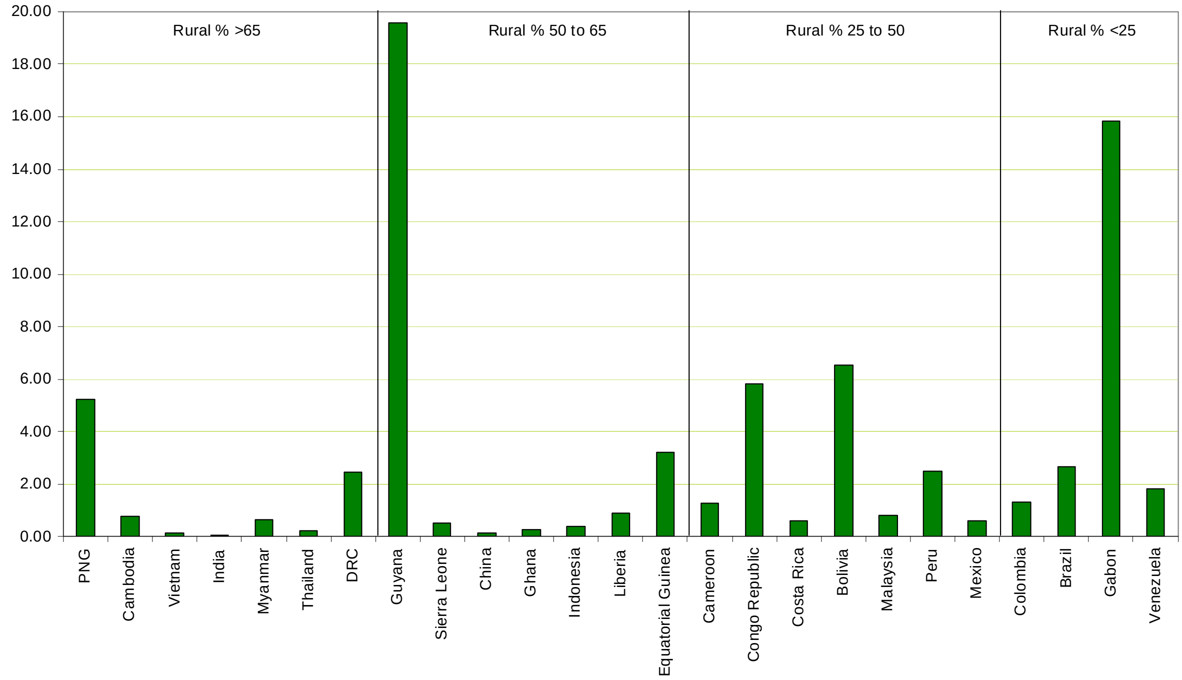

Figure 10 Changes in Forest Area based on 2005 Figures

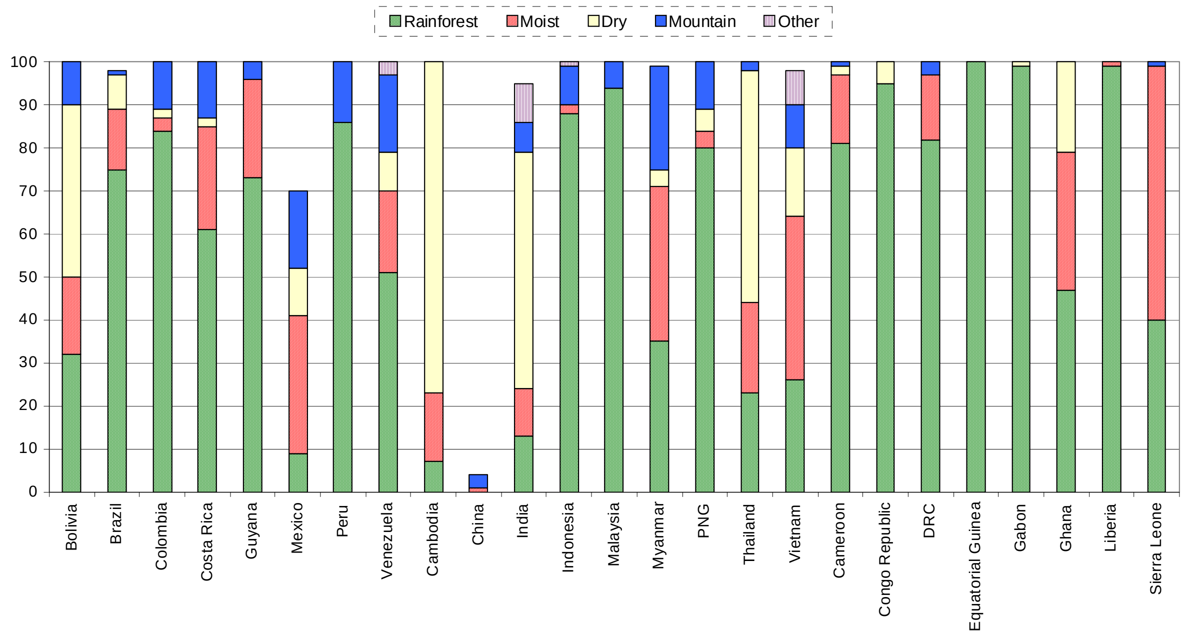

Figure 11 Tropical Forest Types (%)

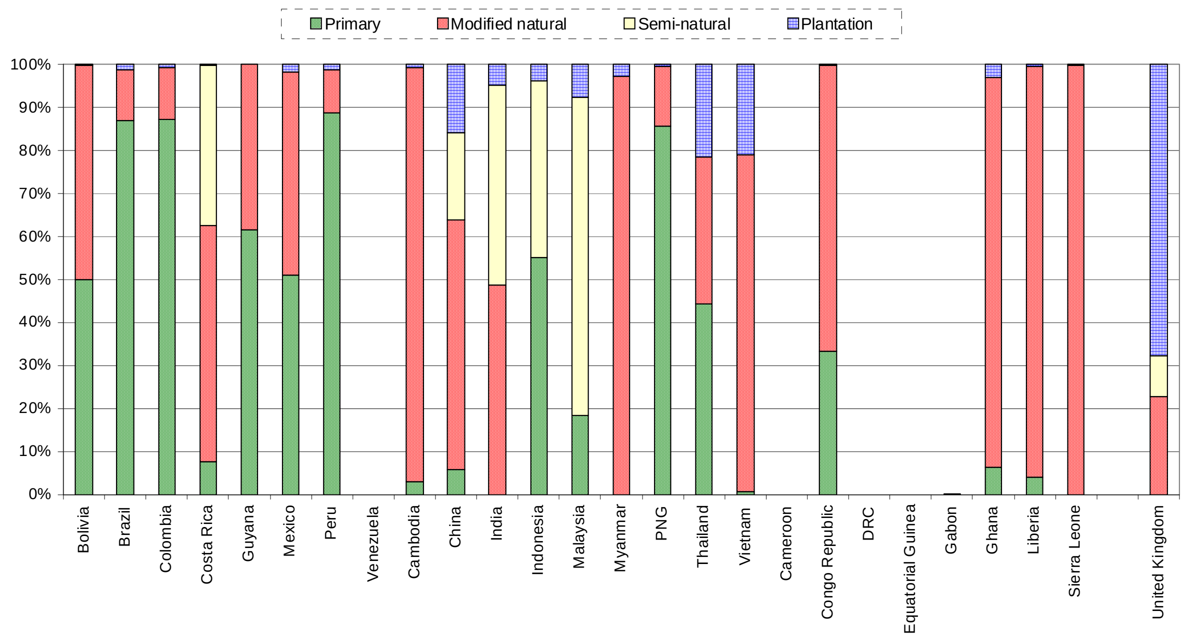

Figure 12 Forest Composition

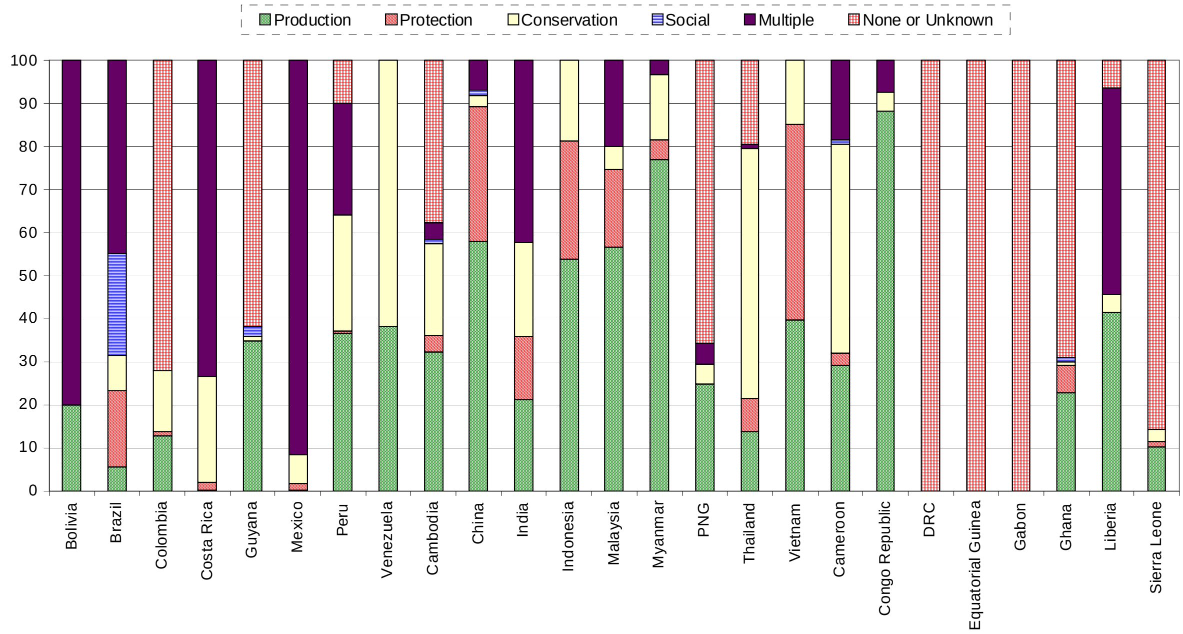

Figure 13 Forest Primary Use

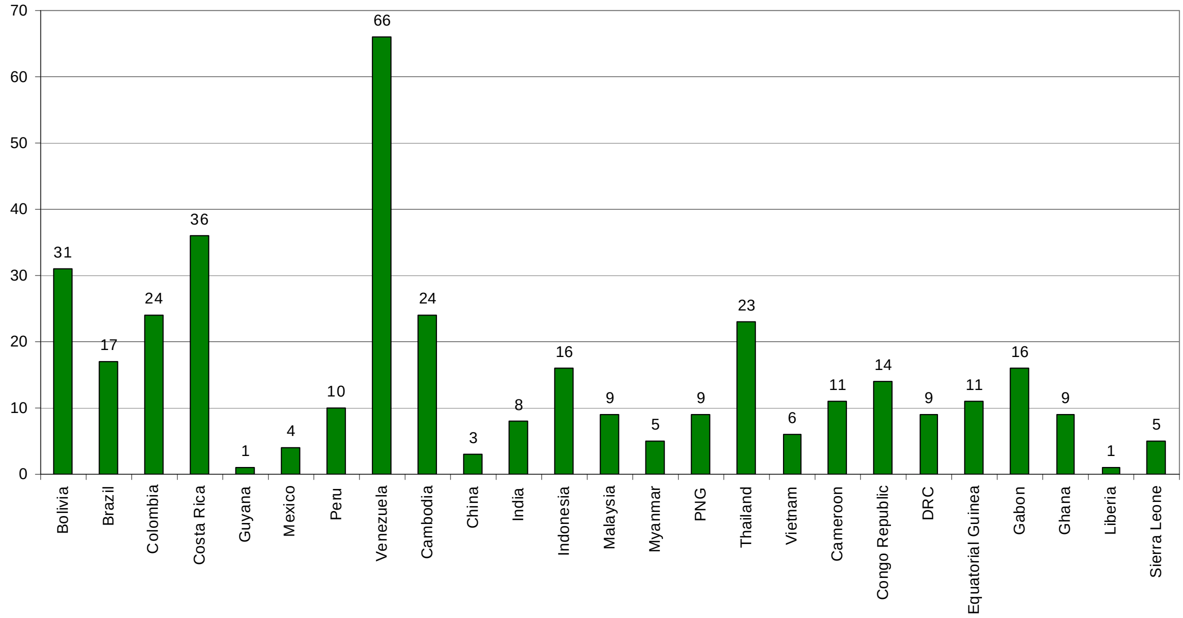

Figure 14 Forest in Protected Areas

Country	Annual change - forest		Annual change - plantations	
	Annual 000 ha	% total 2005 area	Annual 000 ha	% total 2005 area
Bolivia	-270	-0.5%	0.0	0.00%
Brazil	-3,103	-0.6%	21.0	0.00%
Colombia	-47	-0.1%	14.9	0.02%
Costa Rica	3	0.1%	0.2	0.01%
Guyana	0	0.0%	0.0	0.00%
Mexico	-260	-0.4%	0.0	0.00%
Peru	-94	-0.1%	7.8	0.01%
Venezuela	-288	-0.6%	0.0	0.00%
Cambodia	-219	-2.1%	-2.6	-0.02%
China	4,058	2.1%	1,489.0	0.75%
India	29	0.0%	84.2	0.12%
Indonesia	-1,871	-2.1%	79.4	0.09%
Malaysia	-140	-0.7%	-17.2	-0.08%
Myanmar	-466	-1.4%	30.6	0.09%
PNG	-139	-0.5%	2.0	0.01%
Thailand	-59	-0.4%	4.4	0.03%
Vietnam	241	1.9%	129.0	1.00%
Cameroon	-220	-1.0%		0.00%
Congo Republic	-17	-0.1%	0.0	0.00%
DRC	-319	-0.2%		0.00%
Equatorial Guinea	-15	-0.9%		0.00%
Gabon	-10	0.0%	0.0	0.00%
Ghana	-115	-2.1%	20.0	0.36%
Liberia	-60	-1.9%	0.0	0.00%
Sierra Leone	-19	-0.7%	0.08	0.00%
United Kingdom	10	0.4%	-2.0	-0.07%

Sources of Information

FAO FRA 2000
FAO FRA 2005
SOFO 2005 and 2007

Note that “Forest Area” is for areas with canopy cover 10% or more while “Closed Forest” has canopy cover 40% or more

Definitions of Forest Types and so on are as used by FAO

Country	GDP/cap 2004	GDP/cap 2006	HDI 2005	Land Area 000 ha	Population (000s) 2004	Population density / km²	% rural	Forest Area 000 ha (2005)	Closed Forest 000ha (2000)	Open Forest 000ha (2000)	Forest Cover %	Closed forest %	Ha/cap	Vol / ha
Bolivia	1036	1101	0.70	108,438	8,986	8.3	36.1	58,740	47,999	6,589	54.2	44.3	6.54	114
Brazil	3675	5460	0.80	845,942	178,718	21.1	16.4	477,698	564,581	1,335	57.2	66.7	2.67	131
Colombia	2069	2874	0.79	103,870	45,300	43.6	23.1	60,728	51,437	14,075	58.5	49.5	1.34	108
Costa Rica	4534	5034	0.85	5,106	4,061	79.5	38.8	2,391	2,058		46.8	40.3	0.59	211
Guyana	962	1219	0.75	19,685	772	3.9	62.0	15,104	16,916		76.7	85.9	19.56	145
Mexico	5968	7875	0.83	190,869	103,795	54.4	24.2	64,238	33,613	24,835	33.7	17.6	0.62	52
Peru	2207	3264	0.77	128,000	27,547	21.5	25.8	68,742	64,204	2,431	53.7	50.2	2.50	158
Venezuela	4575	6633	0.79	88,205	26,127	29.6	12.1	47,713	49,926		54.1	56.6	1.83	134
Cambodia	328	453	0.60	17,652	13,630	77.2	80.8	10,447	5,500	3,921	59.2	31.2	0.77	40
China	1162	2055	0.78	932,742	1,326,544	142.2	60.4	197,290	110,172	5,616	21.2	11.8	0.15	52
India	538	784	0.62	297,319	1,079,721	363.2	71.5	67,701	38,223	25,506	22.8	12.9	0.06	43
Indonesia	906	1592	0.73	181,157	217,588	120.1	53.3	88,495	100,382		48.8	55.4	0.41	79
Malaysia	4221	5704	0.81	32,855	25,209	76.7	35.6	20,890	19,148		63.6	58.3	0.83	119
Myanmar		281	0.58	65,755	49,910	75.9	70.0	32,222	25,177	10,081	49.0	38.3	0.65	33
PNG	622	989	0.53	45,286	5,625	12.4	86.8	29,437	30,150	829	65.0	66.6	5.23	34
Thailand	2399	3251	0.78	51,089	62,387	122.1	67.8	14,520	10,127	2,845	28.4	19.8	0.23	17
Vietnam	500	673	0.73	32,549	82,162	252.4	73.8	12,931	7,312	940	39.7	22.5	0.16	38
Cameroon	651	1019	0.53	46,540	16,400	35.2	47.9	21,245	19,985	4,015	45.6	42.9	1.30	135
Congo Republic	956	1946	0.55	34,150	3,855	11.3	46.1	22,471	22,000		65.8	64.4	5.83	132
DRC	89	136	0.41	226,705	54,775	24.2	67.7	133,610	126,236	14,400	58.9	55.7	2.44	133
Equatorial Guinea	3989	19166	0.64	2,805	506	18.0	51.0	1,632	1,774		58.2	63.2	3.23	93
Gabon	3859	7245	0.68	25,767	1,374	5.3	15.6	21,775	21,800		84.5	84.6	15.85	128
Ghana	285	532	0.55	22,754	21,053	92.5	54.2	5,517	1,634	5,001	24.2	7.2	0.26	49
Liberia	120	192	0.32	9,632	3,449	35.8	52.7	3,154	4,124		32.7	42.8	0.91	201
Sierra Leone	206	318	0.34	7,162	5,436	75.9	60.5	2,754	725		38.5	10.1	0.51	143
United Kingdom	26,506	33,238	0.95	24,088	59,405	246.6	10.8	2,845	2794		11.8	11.6	0.05	120

Country	Tropical Rainforest	Tropical Moist	Tropical Dry	Tropical Mountain	Tropical Other	Subtropical Humid	Subtropical Dry	Subtropical Mountain	Subtropical Other	Temperate Oceanic	Temperate Continental	Temperate Mountain	Boreal & Other
Bolivia	32	18	40	10									
Brazil	75	14	8	1		2							
Colombia	84	3	2	11									
Costa Rica	61	24	2	13									
Guyana	73	23		4									
Mexico	9	32	11	18				20	10				
Peru	86			14									
Venezuela	51	19	9	18	3								
Cambodia	7	16	77										
China		1		3		36		22			17	9	12
India	13	11	55	7	9			5					
Indonesia	88	2		9	1								
Malaysia	94			6									
Myanmar	35	36	4	24				1					
PNG	80	4	5	11									
Thailand	23	21	54	2									
Vietnam	26	38	16	10	8	2							
Cameroon	81	16	2	1									
Congo Republic	95		5										
DRC	82	15		3									
Equatorial Guinea	100												
Gabon	99		1										
Ghana	47	32	21										
Liberia	99	1											
Sierra Leone	40	59		1									
United Kingdom										84		2	14

Country	Protected Area %	Protected Area control	Production	Protection	Conservation	Social	Multiple	None or Unknown	Primary	Modified natural	Semi-natural	Plantation
Bolivia	31		20				80		50.0%	50.0%	0.0%	0.0%
Brazil	17		5.5	17.8	8.1	23.8	44.8		87.1%	11.8%	0.0%	1.1%
Colombia	24		12.7	1	14.1			72.2	87.4%	12.1%	0.0%	0.5%
Costa Rica	36	Good	0.1	1.9	24.5		73.5		7.5%	55.2%	37.1%	0.2%
Guyana	1	Good	34.9		1	2.4		61.7	61.7%	38.3%	0.0%	0.0%
Mexico	4		0.1	1.5	6.8		91.6		51.1%	47.2%	0.0%	1.6%
Peru	10		36.7	0.5	26.9		26	9.9	88.8%	10.1%	0.0%	1.1%
Venezuela	66		38.1		61.9				0.0%	0.0%	0.0%	0.0%
Cambodia	24	Poor	32.3	3.9	21.3	0.9	3.9	37.7	3.1%	96.4%	0.0%	0.6%
China	3		58	31.3	2.7	1.2	6.8		5.9%	58.0%	20.3%	15.9%
India	8		21.2	14.8	21.7		42.3		0.0%	48.7%	46.6%	4.8%
Indonesia	16	Poor	53.9	27.5	18.6				55.0%	0.0%	41.1%	3.8%
Malaysia	9	Good	56.6	18.2	5.4		19.8		18.3%	0.0%	74.2%	7.5%
Myanmar	5		76.9	4.7	15.2		3.2		0.0%	97.4%	0.0%	2.6%
PNG	9		24.8		4.6		4.9	65.7	85.6%	14.0%	0.0%	0.3%
Thailand	23	Good	13.8	7.6	58.2		1.1	19.3	44.4%	34.2%	0.0%	21.3%
Vietnam	6		39.8	45.5	14.7				0.7%	78.5%	0.0%	20.8%
Cameroon	11	Fair	29.3	2.7	48.6	1	18.4		0.0%	0.0%	0.0%	0.0%
Congo Republic	14	Fair	88.2		4.4		7.4		33.2%	66.6%	0.0%	0.2%
DRC	9	Poor						100	0.0%	0.0%	0.0%	0.0%
Equatorial Guinea	11							100	0.0%	0.0%	0.0%	0.0%
Gabon	16	Good						100	0.0%	0.0%	0.0%	0.2%
Ghana	9	Poor	22.7	6.4	0.8	1.2		68.9	6.4%	90.7%	0.0%	2.9%
Liberia	1	Poor	41.5		4.1		48.2	6.2	4.1%	95.7%	0.0%	0.3%
Sierra Leone	5	Poor	10.3	1.2	2.8			85.7	0.0%	99.9%	0.0%	0.1%
United Kingdom	23	Excellent	33.7	0.2	5.1	3.7	53.1	4.2	0.0%	22.7%	9.7%	67.6%

Annex 4 Basis of the Reference Scenario

Introduction

In this annex, a reference monitoring capacity is described for a medium-sized country (about) starting with zero technical capacity and with no internal GIS/RS or forest inventory sector (for instance, within educational institutions) to draw on. Costs and timescales for individual countries can be assessed by comparing existing capacity and forest extent to this reference scenario.

Remote sensing capacity

Personnel who acquire GIS and remote sensing analysis skills are highly employable across a number of sectors within developing countries, including other arms of government, resource extraction industries (oil, minerals, logging), and within conservation, environmental, development, and relief NGOs. Any program of capacity building for monitoring REDD must therefore include the capability to train new recruits to the required technical standards. Recruitment and training should be an ongoing and permanent activity of the REDD monitoring organisation, to ensure its sustainability over the long term.

A team of three full-time GIS/RS skilled technicians would probably be sufficient. This would provide some leeway to absorb staff turnover, and some capacity for more experienced team members to provide training in advanced techniques to new recruits. One new recruit should be trained each year.

<u>Setup phase</u>

Startup team

In the first year, a team of 3 international consultants would be hired to:

1) establish the baseline scenario
2) specify methodology for annual monitoring
3) specify methodology for updating the baseline
4) write technical manuals
5) provide training to national team

The international team would provide training to the national team when the first cohort of trainees return from training (see below).

International consultants: 3 x 6 months x £20,000 = **£360,000**

Permanent team

To establish the national capacity, three trainees would be recruited and sent for training at an advanced facility. For instance, M.Sc. level training would be suitable. As an indicator, Edinburgh University postgraduate fees are £12,500 per annum. A similar sum would be required for living costs:

Training in 1st year: 3 x £25,000 = £75,000

With travel costs and incidentals, this may be rounded up to **£100,000.**

Hardware, software and office facilities

Equipment would include: 3 workstations, 1 file server, 1 tape backup machine, 1 printer, 1 map printer, 3 ARC-GIS software licences, 3 image analysis software licences, consumables, office rent and furnishing.

Total: £60,000

Data purchases

While Landsat data for the baseline studies are freely available (1990, 2000 and 2005 datasets from USGS), annual monitoring will require the purchase of up-to-date Landsat or equivalent imagery.

A large country would require in the order of 200 scenes x £300 each = **£60,000**.

Just for comparison, IKONOS coverage of the same area, at £15 per km^2, would cost about £12,500,000.

MODIS and other coarse resolution data are available free of cost.

<u>Ongoing running costs</u>

Recruitment:	£33,000	(1 new trainee sent for MSc training)
Data purchases:	£60,000	
Salaries:	£60,000	(3 x £20,000)
CPD:	£10,000	(Continuing Professional Development)
Travel:	£3,000	(attendance at international meetings)
Office:	£20,000	(hardware, software, consumables, office)

Total: £186,000 annually

<u>Summary of costs</u>

First year:	£520,000 + £60,000 data costs
Annual recurring:	£126,000 + £60,000 data costs

Apart from data costs, these estimates are fixed for all sizes of country. A team of 3 is the smallest unit that can be considered sustainable, and the complexity of analytical tasks are broadly similar across different geographical extents.

<u>Alternative approaches</u>

A country may choose to contract this component out to a technology supplier. For instance, the GMES Service Element "Forest Monitoring" is available to supply monitoring programmes specifically geared towards monitoring forests for REDD accounting. Indonesia has used this service in a pilot study of five sites (GMES 2006).

The cost should be broadly equivalent to the international consultants component of the scheme described above, plus data costs – that is, about **£580,000**. This would be a recurring annual cost.

Field survey capacity

Land-cover mapping and identifying change

Remote sensing is capable of monitoring change with minimal input from field sampling. Land-cover mapping at the chosen resolution can be constructed using remotely sensed sample data at higher resolution, or by carrying out fieldwork to identify land-cover classes at sample locations. This is a relatively straightforward effort, and the major requirement occurs during the first iteration. Future updates to the map require much smaller fieldwork components. This type of fieldwork would most likely be undertaken by the remote sensing team directly.

Carbon measurements

Assessments of carbon fluxes require a significant input from field studies to achieve either Tier 2 or Tier 3 accuracy. The amount of fieldwork required to support a monitoring programme depends on:

1) the extent of forests
2) stratification
3) the chosen tier

Major drivers of cost

1) Forest extent

The study countries range in size from Equatorial Guinea (27,289 km^2) to Brazil (8,550,192km^2) and China (9,268,615km^2). Forested area ranges from 27,289 km^2 (Equatorial Guinea) to 5,485,399km^2 (Brazil). We take 500,000km^2 as an indicative figure, which can be scaled up or down as required.

The REDD sourcebook suggests a sampling intensity of about 3%. That is, sample data should represent about 3% of the land area within each stratum. Each sample location is a 10x10km square. Sampling consists of extracting remote sensing imagery covering the area, and carrying out a ground-based carbon survey at a representative location within the block. The required 3% coverage would therefore be achieved with about 150 sample locations. However, this must be modified in the light of stratification requirements.

2) Stratification

The range of forest types is an important factor to consider. DR Congo's forests are all "tropical & subtropical moist broadleaf forests" (CIESIN 2002, FAO 2001), and are relatively undisturbed and uniform. India, Indonesia, Mexico and Myanmar on the other hand have a significant proportion of their represented by each of four or more forest types, each of which must be sampled independently to arrive at robust carbon calculations for each category.

Further sampling stratification will be required to account for country-specific differences in land-use, such as degraded forests, forestry in protected areas, forestry under different logging regimes etc., and for characteristics such as elevation gradients or other major ecological drivers. We assume a stratification of 6 categories, which is likely to be an under-estimate in most cases.

Approaches to stratification

The REDD sourcebook describes two approaches to stratification, depending on whether a country has produced an accurate land-cover map or not.

Approach A uses the map to identify different sampling strata. Each stratum should supply at least 50 sample locations, even if this level of effort exceeds the 3% recommendation, to provide sufficient data to support statistical analyses. Therefore this reference scenario will assume 300 sample plots.

Approach B suggests a strategy to follow when no land-cover map is available. Activity data are assembled during a monitoring iteration, and then carbon measurements are made only in the locations where change has been identified. Nearby pixels with similar reflectance profiles to the target pixels *before* the change are inventoried to provide a reference carbon stocking level. Then the pixels where change was identified are inventoried. The difference between the two measurements provides the estimated carbon emissions.

It seems unlikely that any country reporting within a REDD mechanism would not have access to a suitable land-cover map. The requirements from the map are straightforward, and even in the absence of national land-cover mapping, can generally be supplied using a combination of global land-cover maps (e.g. the Global Land Cover 2000 product – Fritz et al. 2003) and supplementary data (elevation maps, transportation networks, towns and villages, soil types, climatic variables etc).

However, a country may select approach B for financial reasons. Approach A involves a large, one-time effort at the start of the monitoring programme, whereas approach B involves a smaller effort, but repeated with each monitoring iteration.

Approach A is the only option under Tier 3.

3) IPCC Tier

Tier 1 reporting uses default values (provided in IPCC guidelines) for estimating carbon fluxes from unit areas of different broad types of forestry. Carbon stocks using Tier 1 factors have already been computed at a national level for all tropical nations (Gibbs et al 2007). However, Tier 1 estimates necessarily involve a large range of error – +/- 50% or more in the case of forestry (REDD sourcebook, Brown et al 2007), and are therefore not suitable for reporting within a REDD framework.

Tier 2 factors (Mean Annual Increment, biomass densities, carbon densities) must be determined within each country, and may be compiled from existing data (e.g. forest inventories), or by carrying out field sampling. These factors must be measured separately for each stratum in the sample scheme. Default values may be used for non-tree pools in most circumstances (e.g. soil, deadwood etc.), as long as carbon fluxes are reported conservatively. Tier 2 factors are not re-calculated over time i.e. subsequent monitoring cycles do not need to re-measure the conversion factors.

Tier 3 factors are monitored by repeat measurements in permanent plots through time e.g. at the start of each iteration of the monitoring cycle. Data for non-forest pools may use defaults for each stratum, or they may be derived from process models, or from direct measurement like the forestry component. The use of permanent plots also assists the independent verification of field measurements (Pearson et al 2005).

Effort and costs

Tier 2, approach A

All carbon measurements would be performed once, at the start of the monitoring programme. Future monitoring iterations would assess activity data (i.e. location and extent of forestation/deforestation/degradation) from RS data. Minimal field work would be required after the initial exercise.

Each of the 300 field sample locations is roughly at the centre of a 10x10km block that will be sampled using remotely sensed imagery. Some of these blocks may require multiple sample locations to account for multiple strata occurring within the block, but for purposes of estimation we assume a single sample event within each sample block.

Effort required to undertake a field survey programme is modified from Kleinn et al (2001) and MINEF/FAO (2006).

Table 62 Effort to sample a single location

Activity	Person days
Preparation	1
Field:	
Planning	0.5
Contacts and interviews with locals	2.5
Travel	3
Measurements	4
Supervision	4
Office:	
Data input (Excel, GIS, photos, databases) and analysis	4
Total:	**19 person days**

Total manpower: 300 x 19 days = 5,700 is about 30 working years. 20% of this is supervisor effort, the remainder are field crews. Say £10,000 annual salary for field crew, and £20,000 annual salary for supervisors: £240,000 + £120,000 = £360,000.

Additional costs

- 3 vehicles - £60,000
- laboratory costs (£7.50 per sample x 1,000 samples) - £7,500
- field equipment - £20,000
- external consultants: primarily for training, planning, and verification – 6 x 1 month x £20,000 = £120,000

Total: £567,500

Existing forest inventory data can be used if available. As long as it's reasonably recent (< 10 years), the quality of such data is likely to be sufficient, because they were collected for commercial reasons. The corollary is that these data, if available, are only likely to be available for economically important strata. We assume no such data are available for this reference case.

Tier 2, approach B

Field carbon measurements would be performed on an *ad hoc* basis, as and when the activity monitoring identifies locations undergoing change. The ongoing costs of the fieldwork would of course depend on the amount of change detected during each monitoring iteration. If we assume that the rationale for choosing approach B is cost (i.e. the lower up-front cost justifies the higher long term costs), then we can say that this approach would be followed if it were found that the required sampling intensity was below, say, 25% of the intensity required under approach A.

For countries with uniform forests undergoing relatively little change, such as DR Congo, it seems likely that the required effort under this scenario would be very small.

Tier 3, approach A

Tier 3 measurements require annual re-measurements made in permanent sample plots. However, it would not be necessary to re-sample at the full intensity. Permanent monitoring of about 1/3 of the original sample locations would seem to be ample to monitor changes in carbon stocks in each stratum over time. This reduction in effort would also be justified because over time, some strata will be seen to have very stable carbon stocks (e.g. mature undisturbed primary forest), and will require minimal re-sampling.

Adding in degradation

The indirect approach to measuring degradation involves applying an extra binary stratification to the sample scheme – intact vs. non-intact forests (REDD sourcebook, Brown et al 2007). This would require some extra plots to be added to the field survey, but perhaps not very many. Since we already have a robust sample system, representing at least 3% of the country's land surface, and divided among about 6 strata, statistical techniques can be used to support a moderate extra level of stratification. It is unlikely that the intact/non-intact stratification would need to be applied to each of the existing 6 strata. In practice, adding degradation to the stratification may only add 3 strata to our reference case. We might plan to add about 50 sample sites to support this – adding 1/6 to the first year and ongoing costs.

An alternative approach – participatory community forest inventory

Recent work to develop community participation in sustainable forestry has demonstrated how the judicious use of technology (field GIS systems) and effective approaches to training and stakeholder involvement, can build operational forest monitoring systems fully up to IPCC technical standards, delivered by local communities (Murdiyarso & Skutsch 2006, McCall & Minang 2005, Minang & McCall 2006).

If such an approach could be tied to the delivery of financial benefits back down to the community, and could be developed at a national level, significant REDD benefits could be realised without the necessity of institutional effort on the behalf of governments. This would be an attractive proposition in countries where institutional capacity or motivation for organising complex national programmes is lacking.

The costs involved in such a programme would in general be greater than those for a centrally organised system. Although wages of field survey staff would be saved, there would need to be significant investment in a nationwide training programme, and this would most likely be delivered at least in part using international staff. There would also be significant costs associated with ongoing coordination of the scheme.

Effort and costs

Minang et al (2007) review the costs of community participatory forest inventory for a number of CDM projects in Senegal, Tanzania, Nepal and India. Costs varied from £0.75 ha^{-1} yr^{-1} to £10 ha^{-1} yr^{-1}, suggesting a range of £2,250,000 - £30,000,000 (300 sample blocks of 10x10km or 10,000ha). However, the intensity of survey effort per ha required under the

CDM for individual projects is much higher than that required for national inventories. A CDM project must accurately measure carbon throughout a single block of forest, whereas a national inventory operates by taking a few accurate samples within many forest blocks.

To establish a national participatory inventory scheme, capable of providing sample data from 400 sample locations (300 plus a buffer of 100), will require 200 communities to be recruited to the scheme. Each community carries out inventory measurements within 2 sample blocks.

A central coordinating organisation is responsible for recruiting the communities, delivering training, collating data, sending samples to laboratories for destructive C content analyses, calculating allometric relationships for Tier 2 and Tier 3 factors, monitoring the effectiveness of each community, and administering the distribution of benefits to each community.

Communities must be paid for participating. The payment would be drawn from the carbon credits earned by the country for reducing deforestation. This is different from CDM projects, which are paid by selling their own carbon credits. It may be attractive to develop community based forest management programmes in parallel with the community based forest inventory described here, but the cost estimates provided here are purely for the inventory activity.

Table 63 Participatory inventory - setup phase

Task/item	Cost basis	Cost
Project manager	12 months	£60,000
Data analyst	12 months	£40,000
Accountant	6 months	£15,000
Identify 250 target communities	Project manager	£0
Recruit local trainers (10)	Project manager	£0
Train the trainers	1 month expert	£20,000
Trainers visit target communities to recruit them to the scheme	200 weeks	£40,000
Trainers visit recruited communities and provide training	300 weeks	£60,000
3 vehicles		£60,000
200 field data/GPS units	£500 unit cost	£100,000
Software development – customised interface		£10,000
Rewards to communities	£1,000 per community in 1st year	£200,000
	Total:	**£605,000**

Table 64 Participatory inventory - ongoing costs

Task/item	Cost basis	Cost
Project manager	12 months	£60,000
Data analyst	12 months	£40,000
Accountant	12 months	£30,000
Recruit and train 20 new communities each year	50 weeks	£10,000
Visit each community to monitor standards and continue/update training	200 weeks	£40,000
Replacement field data/GPS units (20)	£500 unit cost	£10,000
Rewards to communities	£2,000 per community	£400,000
	Total:	**£590,000**

There is no prior practise to draw upon. A country-wide participatory forest inventory has not been implemented anywhere. These cost estimates must therefore be viewed as significantly more uncertain than other estimates in this report. Furthermore, the level of reward offered to communities is the main cost driver, and is likely to vary among countries. We therefore do not include these costings in our individual country analyses. However, it may be assumed that participatory inventory will always be significantly more expensive than a national approach.

Summary of inventory costs

Table 65 Forest inventory reference scenario costs

Tier 2, approach A	£567,500 one-off cost
Tier 2, approach B	£140,000 recurring annually
Tier 3, approach A	£567,500 in first year £190,000 recurring annually
Tier 3, approach A, including degradation	£660,000 in first year £220,000 recurring annually
Participatory	£605,000 in 1st year £590,000 recurring annually

For larger countries, these costs would increase in proportion to the increased forest area.

For smaller countries, costs would fall in proportion to the decreased forest area, down to a minimum of about 1/3. This assumes that the number of strata would also be reducing at the same rate. It seems very unlikely that any country would have fewer than 2 strata, requiring 100 survey points.

Capacity for modelling future emissions

Measurements of reduced emissions must be made against a reference standard in order to quantify the reduction that will be made available for carbon trading. Several options have been discussed for establishing this standard (DeFries et al 2006, Olander et al 2006, Olander et al 2007, WHRC/IPAM 2007, Herold et al 2006, Herold et al 2007), but no official policy guidance has been published by the IPCC. COP13 (Bali, December 2007) has asked the SBSTA to examine the issue of reference emissions levels and to report back to COP14 in December 2008.

Approaches to baselines

There are two broad approaches to baselines – historical baselines and modelled projections. However they are established, specification of baselines will also require negotiations among the Parties (Olander et al 2006, IFCA 2007), for instance to take development status into account.

The GOFC-GOLD REDD sourcebook only discusses methods for assessing historical baselines. Despite discussion of alternatives at GOFC-GOLD REDD workshops (Herold et al 2006, 2007), they were not included in the current version of the sourcebook.

1. Historical baseline

A measurement of actual carbon emissions during a reference period in the recent past is used as the standard against which emissions measured at a later date are assessed.

Advantages

Remote sensing data are already available to derive the baseline. Methods are documented in the REDD sourcebook and have been demonstrated in multiple studies. The method is transparent and easily verified, and is consistent with the Kyoto Protocol. The baseline sets a clear guideline for policy interventions.

Disadvantages

Historical baselines are very sensitive to the dates chosen as the reference period. For instance, in a pilot study in Indonesia, a 2000-2005 baseline predicts total loss of forests 34 years earlier than a 2004-2005 baseline (IFCA 2007).

Most critically, the historical baseline approach is disadvantageous to nations with large forests, undeveloped economies and low rates of deforestation, such as DR Congo (WHRC/IPAM 2007). As their economies develop, pressure to deforest will increase, but future deforestation will be compared against a baseline of very low deforestation. Few if any benefits would accrue from efforts to reduce deforestation, even if such efforts were successful.

Costs

The costs of establishing a historical baseline scenario have already been incorporated in the cost estimates for establishing remote sensing capacity. Even if a modelling approach is to be taken, the work of establishing a historical baseline must be undertaken, as past rates of deforestation are required as inputs to the model.

2. Modelled projections

Advantages

For nations with expanding economies, low rates of deforestation or positive reforestation, a fairer approach may be to predict the level of deforestation associated with predicted future economic activity, and then to reward deforestation rates that are lower than predicted (WHRC/IPAM 2007, Ulloa et al 2006).

Disadvantages

Constructing such models is difficult to do well (DeFries et al 2006). Multiple deforestation drivers must be incorporated, such as roads, other infrastructure, international economic demands, national economic situation, policy interventions, enforcement, population growth, etc. (DeFries et al 2006, Geist & Lambin 2002, IFCA 2007, Pontius et al 2001, Hall 2002). The models are very sensitive to behavioural assumptions.

A modelling approach is also vulnerable to abuse. If the model predicts an unrealistically high level of deforestation, then actual deforestation rates will be lower than predicted with no need for any policy intervention.

Costs

Case studies have been established in Cameroon (Ulloa et al 2006) and Indonesia (IFCA 2007). In both pilot studies, the GEOMOD software was used to model future deforestation and carbon emissions. This has been under development since the mid 1990s and is a robust platform that is capable of delivering accurate predictions (Hall 2002, Pontius et al 2001).

To establish the model, expertise in economics and land use is required, as well as GIS technical support. The remote sensing component of the monitoring capacity can provide the GIS support. In many countries, economists and land use experts will be available. In others, international experts can be contracted.

The modelling exercise should be repeated at least every 2 years, to re-calibrate predictions against changing circumstances.

Table 66 Inputs required for modelling the baseline

Personnel		Using national experts		Using international experts	
Expert	**Time**	**rate‡**	**cost**	**rate‡**	**cost**
Economist	2 months	£7,500	£15,000	£15,000	£30,000
Land use	2 months	£7,500	£15,000	£15,000	£30,000
GIS	1 month	£5,000	£5,000	£15,000	£15,000
Total:			£35,000		£75,000
Annual:			**£17,500**		**£37,500**

‡ - international consultant costs are assumed to be £15,000 per month. National consultant costs are assumed to be half this. The national GIS expert cost is derived as a proportion of the annual ongoing cost of the remote sensing capacity set out previously in this annex.

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